The Economic and Social Impact of Software & Services on Competitiveness and Innovation (SMART 2015/0015)

FINAL REPORT

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by:

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Digital Single Market

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Abstract

The software industry is one of the most dynamic industries. As a prime industrial differentiator and the basis for a growing range of innovations, software can significantly increase Europe's industrial competitiveness and largely contribute to Europe's growth. But with new opportunities has come a range of challenges that software companies must meet. Against this background, and on behalf of the European Commission, the project consortium consisting of Pierre Audoin Consultants (PAC), Le CXP and Fraunhofer ISI has (again) taken a closer look at the European software and software-related services industry and its economic and social impact. The project team i) shows the current and expected future growth and structure of the European software and IT services market; ii) carves out the current and potential future economic and/or social impact of the European software and IT services industry specifically on Europe; iii) identifies and describes the key drivers for the industry's growth and competitiveness; iv) takes a specific look at the extent and role of in-house software development; and v) derives policy recommendations to remove barriers and foster the development of the European software industry.

Abstract

Le secteur des logiciels compte parmi les branches les plus dynamiques de notre économie. Facteurs clés de différenciation industrielle et vecteurs d'innovations de plus en plus diverses, les logiciels sont en mesure d'améliorer considérablement la compétitivité de l'Europe et d'apporter une contribution notable à sa croissance. Cependant, de ces nouvelles opportunités naît également toute une série de défis que les éditeurs de logiciel doivent aujourd'hui relever. C'est dans ce contexte et pour le compte de la Commission européenne que le consortium de projet composé de Pierre Audoin Consultants (PAC), Le CXP et Fraunhofer ISI a (une fois encore) étudié de près le secteur européen des logiciels et des services qui s'y rapportent, ainsi que leur impact aux niveaux social et économique. L'équipe du projet i) présente la croissance et la structure actuelles et prévues du marché européen des logiciels et des services IT ; ii) détermine l'impact social et/ou économique qu'a pour le moment et que pourrait avoir à l'avenir le secteur européen des logiciels et des services IT, en particulier en Europe ; iii) identifie et décrit les principaux moteurs de croissance et de compétitivité du secteur ; iv) s'intéresse tout particulièrement à l'étendue et au rôle du développement de logiciels en interne ; et v) présente des recommandations de politique afin de supprimer les divers obstacles et de stimuler le développement du secteur européen des logiciels.

Executive Summary

The software industry is one of the most dynamic industries. But with new opportunities has come a range of challenges that software companies must meet. These challenges are specific and varied for European companies, but have to be evaluated in the context of the global ecosystem that makes up the IT market and its links with other industries.

The overall software and software-based services (SSBS) market in the EU28 region was worth EUR 229 billion in 2009 and grew by a yearly average of 1.5% until 2015. Its average yearly growth is expected to accelerate to 2.9% between 2015 and 2020. Thus, by 2020, the SSBS market will amount to nearly EUR 290 billion.

Software-related segments such as infrastructure software & platforms and application software products will grow only slightly between 2009 and 2020. One main reason is the maturity of these segments in various European countries. Growth in these areas comes from investments by medium-sized businesses, which, in many cases, do not have the same level of maturity as large enterprises. In addition, software markets are increasingly under pressure as more and more companies are shifting towards using cloud-based solutions. The market share of cloud computing will increase enormously by 2020 (around 18% of the SSBS market).

Services for the technical implementation of a software solution are hardly needed when companies start using a cloud service. This is one significant reason why the market for infrastructure-related IT services has been declining. Application-related IT services became the largest SSBS market segment in 2015. This segment will remain of importance because these services are needed for changes, improvements, upgrades, maintenance and management of existing solutions.

The global games market is prospering as a result of a range of innovations: powerful smartphones enable mobile gaming, improved broadband and infrastructure capacities allow high-performance online gaming, and innovative revenue and digital distribution models have greatly expanded the addressable market.

Economic and social contribution of the software industry

The economic and social contribution of the SSBS industry in the EU is significant and can be measured in terms of number of employees and productivity, for example.

The **workforce** in the EU SSBS industry was more than 3.1 million in 2013, which was about 2.4% of the total business economy or 2.3% of the overall economy. Software sector employment in the EU grew by 16.1% between 2008 and 2013, as opposed to a decline in employment in the total business economy of about 3.4%. Almost half of the workforce in the SSBS market is concentrated in three countries: France, Germany and the UK.

High **productivity** (measured in value added per employee) characterizes the SSBS companies. It averaged about EUR 70,500 per employee in 2013, which was about 50% higher than the productivity of EUR 46,800 for the total business economy. However, the growth in SSBS productivity was lower (3.3%, compared with 4.4% for the overall economy). This means that while the number of employees and value added in the SSBS market have been growing significantly, valued added per employee has been less dynamic.

Key technological trends

Numerous technology trends may have a major impact on the development of the SSBS market in the coming years. Depending on their benefits, their cost and their level and pace of adoption by end users (niche or mass market), they may more or less help to accelerate the growth of the overall SSBS market. The following topics represent highly dynamic market segments, often with new, innovative players entering and challenging traditional providers. In addition, these are areas where IT user companies are currently investing the most. Thus they are seen to be **key drivers** of the European software industry.

- **Digital transformation:** For companies in all industries digital transformation has become a primary strategic focus over the past months, and they want to support their digital initiatives with software. Software providers both in Europe and worldwide are therefore currently faced with highly dynamic market conditions and have to find appropriate ways to address these.
- **Analytics/big data:** Business analytics has been of high relevance for European companies for over a decade now – be it business intelligence (BI), big data or any type of analytical applications. This is because companies see great benefits from these solutions as they help them to improve their decision-making.
- **Mobility:** For European software vendors, mobility is a key topic and many have started to embrace it by adding mobile or any-device features to their products. They have the opportunity to grow their business by reaching out to mobile users as a new customer segment.
- **Social collaboration:** Time to market and short innovation cycles are key competitive factors in all industries today. In addition, the relevance of knowledge work in developed economies is rapidly increasing. As a consequence, social collaboration is becoming a key productivity driver and an integral part of business processes.
- **DevOps:** There is a strong need for more agility from the IT department in digitally transforming companies. In addition, companies recognized the lack of interaction between siloed IT operations and application development in complex IT organizations. Therefore the relevance of DevOps is rising.
- **Cloud computing:** Digital technologies entail a deep transformation of the business models for a lot of European end-user companies, but also in IT providers' organizations. The main catalyst for this evolution is cloud computing. Thus there is a dynamic market for such solutions in Europe.

- **Cyber security:** Demand for cyber security solutions is growing due to the increasing proliferation of web-based digital services, the intensified use of mobile devices and the rising number of attacks from cyber criminals.
- **Internet of Things (IoT):** The IoT provides enormous business potential for European companies. It will be a major driver for cloud computing, such as cloud-based platforms to process and analyse machine data. The market is in its early stages and new business models are evolving.
- **Open source software** has become a relevant part of the software industry and a number of software ecosystems. It has become an alternative to commercial software in various areas and is already included in many commercial software products.

Understanding the role of in-house software development

Recently, software-related make-or-buy decisions have shown a stronger tendency towards the 'make' side, especially when it comes to product development. For many companies, software has become a critical success factor for products and services and is regarded as an innovation enabler. Therefore, the question of whether to buy or make software is becoming increasingly strategic and is currently being discussed at board level in many companies.

In order to understand the impact of these trends on the software industry and to assess the change in the industry's structure, it is mandatory to understand the influencing factors of make-or-buy decisions that are currently at work. Based on sector-specific data and expert interviews, the project team's research finds that in general, companies show a stronger tendency to conduct in-house software development if

- They are active in a sector where the level of maturity is generally low with regard to the use of standardized, off-the-shelf software solutions.
- The general quality and availability of a specific external solution is rather low (e.g. because the company is active in a small market segment).
- Their software requirements are too specific (e.g. because they are highly innovative and/or pioneers in digital transformation, or because they work in a highly specialized market segment).
- They do not want to give sensitive internal process know-how to external software partners.
- They have doubts about a quick and efficient communication with external software providers around software development and adjustment.
- They have a pronounced R&D strategy and see in-house software development as a relevant part of it.
- Their supplier and partner network is not that complex.
- They have a certain size and have enough internal IT resources and competencies.
- They used to do it in the past and they do not see any reason why they should not continue to do so in the future.

According to PAC data, the total volume of internal software development expenditure is estimated to have been €52.3 billion in the EU28 in 2015. Given an

average yearly growth rate of 1.8%, this figure is expected to increase to €57.2 billion by 2020. Compared with total software and IT services (SITS) spending, in-house software development expenditure amounted to 20.3% in 2015. This figure will slightly decline to 19.5% by 2020 due to a strong increase forecast for total SITS expenditure, which will grow at faster rates than in-house software development spending.

Identification of key barriers to the competitiveness of the software industry

In addition to the key drivers, the project team identified a list of the most important barriers to the development of a strong European software industry. This includes the obstacles to the development of a genuinely European software sector:

- Lack of skills, lack of specialized IT and Internet experts
- Lack of entrepreneurial spirit
- Missing supporting services
- Market fragmentation
- Status quo orientation in the industry, incl. existing rules and governance structures in IT-using sectors
- Trust, privacy, security
- Policy strategies not suited to support ICT innovations
- Insufficient R&D
- Insufficient broadband availability
- Insufficient support for open source software

Top 5 policy recommendations to support the European software and software-based services industry

Against the background of the analysis and expertise brought together in this study, the consortium highlights the following five policy recommendations in support of the European software and IT services sector, as they provide important levers for the development of this sector in Europe:

1. **Enhance e-skills in Europe**

In addition to ongoing initiatives of the EU in education and job training the consortium recommends initiating an online platform to align supply and demand for IT experts across EU countries. This would give skilled IT people who cannot find a job in their home country the opportunity to find a job in IT companies in other European countries, working on short-term projects or permanently for these companies.

2. **Support the adoption of ICT in all sectors and remove governance barriers**

EU initiatives have just been started to tackle the topic of industrial IoT/Industry 4.0 and the Internet of Things (IoT). The consortium recommends extending the "Digitizing European Industry" initiative to all sectors and further developing the vision of "digital representation" for Europe. The term "digital representation" means that all physical objects as well as persons increasingly have

digital twins. The consortium believes that there is an opportunity for Europe to become the world-leading market for digital representation technologies and applications. The innovative combination of IoT, big data applications, artificial intelligence and digitalization in general can become a genuinely European strength. Thus, European policy should focus on enabling innovation in the field of digital representation in all application sectors.

3. **Support open source software in all sectors of the economy and in public administration**

Open source software can develop into a unique strength of the European software sector if supported accordingly. Although open source software is very well suited for applications in the commercial context, European companies, public administrations and users do not yet know enough about its advantages. Thus, the consortium recommends focusing on policy actions that strengthen the OSS knowledge base and the exchange of best practices between private and public organizations.

4. **Increase trust in cloud computing and IT infrastructures, privacy and security**

In the context of corporate use, and particularly for SMEs in their endeavor to digitize business processes, cloud security and trust play a increasingly important role. The consortium recommends continuing European Commission initiatives already underway in this area. The consortium is convinced that different, dedicated approaches are needed to build trust and enhance IT security in the diverse fields of activity and infrastructure.

5. **Increase public R&D spending in the ICT area**

It is obvious that IT-related engineering projects are underrepresented in Europe's research funding framework program. And in the few programs that support engineering research, such as the ICT-LEIT (Leadership in Enabling and Industrial Technologies) program, the current oversubscription is discouraging companies from applying. Thus the European Commission should substantially increase research funds for IT research, and especially for IT-related new and emerging technologies in order to keep Europe´s software industry competitive.

Résumé

Le secteur des logiciels compte parmi les branches les plus dynamiques de notre économie. Cependant, de nouvelles opportunités naît également toute une série de défis que les éditeurs de logiciel doivent aujourd'hui relever. Bien que les défis auxquels sont confrontées les entreprises européennes soient spécifiques et variés, il convient de les examiner dans le contexte de l'écosystème global qui compose le marché de l'IT et de ses liens avec d'autres secteurs.

En 2009, le marché des logiciels et des services basés sur les logiciels (software and software-based services – SSBS) de l'Europe des 28 représentait dans son ensemble un chiffre d'affaires de 229 milliards d'euros. Il a ensuite enregistré une croissance annuelle moyenne de 1,5 % jusqu'en 2015. Selon les estimations, cette croissance devrait s'établir à 2,9 % entre 2015 et 2020. En d'autres termes, le marché SSBS atteindra une valeur de près de 290 milliards d'euros d'ici 2020.

Les segments liés aux logiciels, tels que les plateformes et les logiciels d'infrastructure ou encore les logiciels d'application, ne progresseront que très légèrement entre 2009 et 2020. Ceux-ci ont en effet déjà atteint un degré de maturité élevé dans divers pays européens. La croissance dans ces domaines découle d'investissements consentis par les entreprises de taille moyenne qui, bien souvent, n'ont pas atteint le même niveau de maturité que les grandes organisations. Qui plus est, dans la mesure où les entreprises sont de plus en plus nombreuses à se tourner vers des solutions basées dans le cloud, les marchés des logiciels doivent désormais résister à une pression grandissante. La part de marché du cloud computing augmentera de manière considérable d'ici 2020 (aux alentours de 18 % du marché SSBS).

Lorsque les entreprises se mettent à utiliser des services cloud, ceux liés à la mise en œuvre technique d'une solution logicielle deviennent pour ainsi dire superflus. C'est là l'une des raisons majeures à l'origine du recul que connaît le marché des services IT liés à l'infrastructure. Les services IT liés aux applications sont devenus le premier segment de marché SSBS en 2015. Ces services étant nécessaires afin de modifier, d'améliorer, de mettre à niveau, d'entretenir et de gérer les solutions existantes, celui-ci conservera vraisemblablement toute son importance.

Soutenu par diverses innovations, le marché mondial des jeux vidéo prospère. Des smartphones puissants rendent possible le jeu sur appareil mobile, l'amélioration des bandes passantes et des capacités des infrastructures ouvre la porte au jeu en ligne à haute performance, et des modèles innovants de revenus et de distribution numérique ont considérablement étendu le marché potentiel.

Contribution socio-économique du secteur des logiciels

La contribution socio-économique du secteur SSBS au sein de l'UE est considérable et peut être mesurée en termes de travailleurs et de productivité, par exemple.

En 2013, le **nombre de travailleurs** actifs dans le secteur SSBS européen était de plus de 3,1 millions, ce qui représentait environ 2,4 % de l'économie marchande totale ou 2,3 % de l'économie globale. L'emploi au sein du secteur européen des logiciels a progressé de 16,1 % entre 2008 et 2013, tandis que l'économie

marchande totale enregistrait un recul de l'emploi d'environ 3,4 % au cours de la même période. Près de la moitié des travailleurs actifs sur le marché SSBS se concentrent dans trois pays : la France, l'Allemagne et le Royaume-Uni.

Les entreprises SSBS se distinguent par un niveau de **productivité** élevé (mesuré en valeur ajoutée par travailleur. Celui-ci s'élevait en moyenne à 70 500 euros par travailleur en 2013, soit environ une fois et demie le niveau de productivité de l'économie marchande totale (46 800 euros). L'augmentation de la productivité au sein du secteur SSBS (3,3 %) était néanmoins inférieure à celle de l'économie globale (4,4 %). Cela signifie donc que si le nombre de travailleurs et la valeur ajoutée augmentent significativement sur le marché SSBS, la valeur ajoutée par travailleur évolue en revanche de manière moins dynamique.

Tendances technologiques clés

Nombreuses sont les tendances technologiques qui pourraient avoir un impact majeur sur le développement du marché SSBS au cours des années à venir. Elles sont susceptibles, en fonction de leurs avantages, de leur coût et de leur degré et vitesse d'adoption par les utilisateurs finaux (marché de niche ou de masse), de contribuer plus ou moins à l'accélération de la croissance du marché SSBS global. Les activités ci-dessous constituent des segments de marché hautement dynamiques, sur lesquels se lancent souvent de nouveaux acteurs innovants venus concurrencer les fournisseurs traditionnels. Il s'agit par ailleurs des domaines dans lesquels les entreprises qui utilisent des solutions IT investissent pour le moment le plus. Elles sont donc considérées comme les **principaux moteurs** du secteur européen des logiciels.

- **Transformation numérique :** Ces derniers mois, la transformation numérique est devenue un objectif stratégique majeur pour les entreprises de tous les secteurs, qui entendent recourir à des logiciels afin de réaliser leurs projets numériques. En Europe comme partout dans le monde, les sociétés d'édition de logiciels sont dès lors confrontées à des conditions de marché hautement dynamiques et doivent trouver des manières d'y répondre correctement.
- **Analyse des données / big data :** Depuis plus de dix ans, la *business analytics* revêt une importance énorme pour les entreprises – qu'il s'agisse de l'informatique décisionnelle, du big data ou d'autres types d'applications analytiques. Les entreprises considèrent en effet que ces solutions, dans la mesure où elles contribuent à l'amélioration de leurs processus décisionnels, offrent des avantages considérables.
- **Mobilité :** Pour les entreprises européennes de vente de logiciels, la mobilité est une thématique essentielle. Nombreuses sont celles à avoir commencé à surfer sur cette vague en ajoutant à leurs produits des fonctionnalités spécialement conçues pour les appareils mobiles ou compatibles avec n'importe quel appareil. Ces dernières ont la possibilité de développer leurs activités en ciblant le nouveau segment de clientèle que composent les utilisateurs mobiles.
- **Collaboration sociale :** Le temps de mise sur le marché et les cycles courts d'innovation constituent aujourd'hui des facteurs de compétitivité

essentiels dans tous les secteurs de notre économie. Qui plus est, l'importance des activités basées sur les connaissances augmente rapidement dans les économies développées. La collaboration sociale devient dès lors un moteur de productivité crucial et s'intègre entièrement aux processus d'entreprise.

- **DevOps :** Les départements IT des entreprises en mutation estiment qu'un accroissement de l'agilité est impératif. Parallèlement, les entreprises ont reconnu qu'il existe un manque d'interaction entre les opérations IT cloisonnées et le développement d'applications au sein d'organisations IT complexes. Le DevOps gagne dès lors en importance.
- **Cloud computing :** Les technologies numériques entraînent une transformation radicale des modèles économiques de nombreuses entreprises européennes, mais aussi de fournisseurs de solutions IT. Le cloud computing est le principal catalyseur de cette évolution. Il existe donc en Europe un marché dynamique pour ce type de solutions.
- **Sécurité informatique :** Les solutions de sécurité informatique font l'objet d'une demande croissante, alimentée par l'augmentation exponentielle des services numériques en ligne, de l'intensification de l'utilisation des appareils mobiles et de la hausse du nombre d'attaques menées par des cybercriminels.
- **Internet des Objets (IdO) :** L'IdO recèle un potentiel économique gigantesque pour les entreprises européennes. Il deviendra un moteur de développement majeur pour le cloud computing, par exemple pour les plateformes cloud destinées au traitement et à l'analyse des données des machines. Le marché n'est en encore qu'à un stade précoce de son évolution et les nouveaux modèles d'entreprise sont en train de se transformer.
- **Les logiciels en open source** font désormais partie intégrante du secteur des logiciels et d'une série d'écosystèmes logiciels. Ils sont capables de remplacer les logiciels payants dans de nombreux domaines et ont déjà été intégrés à toute une série de produits logiciels commerciaux.

Comprendre le rôle du développement de logiciels en interne

Il semblerait que les entreprises soient depuis peu plus enclines à concevoir elles-mêmes leurs logiciels plutôt que de les acheter, surtout lorsqu'il est question de développement de produits. Pour bon nombre d'entre elles, les logiciels constituent désormais un facteur essentiel au succès de leurs produits et services et sont considérés comme des vecteurs d'innovation. La décision d'acquérir ou de concevoir ses propres logiciels revêt dès lors une importance stratégique croissante et fait l'objet de débats au niveau des organes exécutifs de nombreuses organisations.

Pour comprendre l'impact de ces tendances sur le secteur des logiciels et évaluer les changements affectant sa structure, il est essentiel de savoir quels sont les facteurs qui influencent actuellement de telles décisions. À la lumière des données sectorielles collectées et des interviews des spécialistes rencontrés, notre étude parvient à la conclusion qu'en règle générale, les entreprises sont plus enclines à développer elles-mêmes leurs logiciels si :

- Elles opèrent dans un secteur qui n'a généralement pas fort tendance à recourir à des solutions logicielles standardisées dites « sur étagère ».
- La qualité et la disponibilité générales d'une solution externe spécifique sont plutôt faibles (par exemple parce que l'entreprise opère dans un petit segment de marché).
- Leurs exigences en matière de logiciels sont très spécifiques (par exemple parce qu'elles innovent énormément et/ou sont à l'avant-plan de la transformation numérique, ou parce qu'elles opèrent sur un segment de marché hautement spécialisé).
- Elles estiment que le savoir-faire lié à leurs processus internes est précieux et ne souhaitent dès lors pas le partager avec des éditeurs de logiciels externes.
- Elles ont des doutes quant à l'efficacité et la rapidité de la communication avec des partenaires externes au sujet du développement des logiciels et des modifications à y apporter.
- Elles suivent une stratégie avancée en matière de R&D et considèrent que le développement de logiciels en interne en fait partie intégrante.
- Leur réseau de fournisseurs et de partenaires n'est pas d'une grande complexité.
- Elles disposent, en raison de leur taille, de suffisamment de compétences et de ressources internes dans le domaine de l'IT.
- Elles ont l'habitude de procéder de la sorte et ne voient pas pourquoi cela devrait changer.

Selon les estimations que PAC a réalisées à l'aide des données en sa possession, en 2015, le volume total des dépenses liées au développement de logiciels en interne se serait élevé à 52,3 milliards d'euros au sein de l'Europe des 28. Vu la croissance annuelle moyenne prévue de 1,8 %, ce chiffre devrait atteindre les 57,2 milliards d'euros d'ici 2020. En 2015, les dépenses liées au développement de logiciels en interne équivalaient à 20,3 % de l'ensemble des dépenses consacrées aux logiciels et services IT (software and IT services – SITS). Ce pourcentage devrait passer à 19,5 % d'ici 2020. Selon les prévisions, les dépenses SITS totales devraient en effet connaître une forte augmentation et progresser plus rapidement que les dépenses liées au développement de logiciels en interne.

Identification des principaux obstacles à la compétitivité du secteur des logiciels

Outre les principaux moteurs, l'équipe de projet a également identifié les entraves les plus importantes au développement d'un secteur des logiciels solide en Europe. Ceux-ci incluent les obstacles au développement d'un marché véritablement européen :

- Manque de compétences et de spécialistes de l'IT et de l'Internet
- Manque d'esprit d'entreprise
- Absence de services de support
- Fragmentation du marché
- Immobilisme du secteur, y compris concernant les règles et les structures de gouvernance en place dans les secteurs qui utilisent l'IT

- Confiance, confidentialité, sécurité
- Stratégies politiques inadaptées pour stimuler les innovations dans le domaine de l'ICT
- R&D insuffisante
- Disponibilité insuffisante de la bande passante
- Soutien insuffisant pour les logiciels en open source

Cinq grandes recommandations de politique afin de soutenir le secteur européen des logiciels et des services basés sur les logiciels

À la lumière de l'analyse et de l'expertise proposées par la présente étude, le consortium met en avant les cinq recommandations de politique suivantes. Celles-ci constituent d'importants leviers en faveur du développement du secteur européen des logiciels et des services basés sur les logiciels et permettraient dès lors de le soutenir.

1. **Améliorer les e-compétences en Europe**

En plus des activités qu'elle mène déjà dans le domaine de l'enseignement et de la formation professionnelle, le consortium recommande à l'UE de mettre en place une plateforme en ligne afin de permettre à l'offre et la demande d'experts de l'IT de se rencontrer à l'échelle transeuropéenne. Cette mesure offrirait aux spécialistes de l'IT qui ne parviennent pas à trouver un emploi dans leur pays la possibilité de travailler pour des entreprises IT situées dans d'autres pays européens, et ce, de manière permanente ou dans le cadre de projets à court terme.

2. **Encourager l'adoption de l'ICT dans tous les secteurs et éliminer les obstacles liés à la gouvernance**

L'UE vient de lancer des activités afin d'aborder la question de l'IdO industriel / de l'Industrie 4.0 et de l'Internet des Objets (IdO). Le consortium recommande d'étendre le projet « Digitising European Industry » (numérisation de l'industrie européenne) à tous les secteurs et de poursuivre le développement de la vision de la « représentation numérique » pour l'Europe. Le terme « représentation numérique » signifie que tous les objets tangibles et toutes les personnes possèdent des doubles numériques. Le consortium pense que l'Europe a la possibilité de devenir le premier marché mondial des technologies et des applications de représentation numérique. La combinaison innovante de l'IdO, des applications big data, de l'intelligence artificielle et de la numérisation en général peut devenir une force résolument européenne. La politique européenne devrait dès lors se concentrer sur la stimulation de l'innovation dans le domaine de la représentation numérique, et ce, au sein de tous les secteurs d'application.

3. **Encourager l'utilisation des logiciels en open source dans tous les secteurs de l'économie et au sein de l'administration publique**

S'ils bénéficient du soutien adéquat, les logiciels en open source peuvent devenir une corde précieuse à l'arc du secteur européen des logiciels. Bien que ces logiciels conviennent parfaitement aux applications utilisées dans un contexte commercial, les entreprises, les pouvoirs publics et les utilisateurs des États membres de l'UE

n'ont pas encore suffisamment connaissance de ses avantages. Le consortium recommande dès lors aux responsables des politiques européennes de concentrer leurs efforts sur des activités qui renforcent la base de connaissances liée aux logiciels en open source et l'échange des meilleures pratiques entre les organismes publics et privés.

4. **Améliorer la confiance envers le cloud computing et les infrastructures IT, la confidentialité et la sécurité.**

À une époque où les entreprises sont de plus en plus nombreuses à se tourner vers les solutions cloud et où les PME tentent de numériser leurs processus, la sécurité des services cloud et la confiance des utilisateurs jouent un rôle d'une importance grandissante. Le consortium conseille à la Commission européenne de poursuivre les activités qu'elle a déjà lancées dans ce domaine. Il est convaincu que des approches différentes et ciblées sont nécessaires afin de bâtir la confiance et d'améliorer la sécurité informatique dans les divers domaines d'activités et au niveau des infrastructures.

5. **Augmenter les dépenses publiques en R&D dans le domaine de l'ICT**

Les projets d'ingénierie liés à l'IT sont de toute évidence sous-représentés dans le programme-cadre pour le financement de la recherche en Europe. Quant aux quelques programmes qui soutiennent la recherche en ingénierie, comme le programme ICT-LEIT (Leadership in Enabling and Industrial Technologies – Primauté dans le domaine des technologies génériques et industrielles), le nombre de candidats est si élevé qu'il décourage les entreprises d'introduire une demande pour leur projet. Si elle entend préserver la compétitivité du secteur européen des logiciels, la Commission européenne devrait dès lors augmenter considérablement le montant des financements en faveur de la recherche, en particulier lorsqu'elle concerne les technologies nouvelles et émergentes liées à l'IT.

1. Introduction

The aim of this Final Study Report (D5) is to provide the final results of the analysis for the project "The Economic and Social Impact of Software and Services on Competitiveness and Innovation – SMART 2015/0015", which is being carried out by a consortium led by Pierre Audoin Consultants (PAC) in partnership with Le CXP and Fraunhofer ISI. This report covers various topics that are briefly described below.

Definition of the European software and services market

The first part of this report defines the relevant market for this study. Taking into account the latest market and software solution developments since the delivery of the SMART 2009/0041 study[1] (in the following often called "2010 study" or "2010 report"), the project team made some slight adjustments to the definition and methods where appropriate. The following segments are considered in this report:

- Software products (including infrastructure software & platforms, application software products);
- Software-related services (including application-related project services, application management, application hosting, infrastructure-related project services, infrastructure outsourcing);
- Cloud computing (paid web-based services consisting of IaaS, PaaS, SaaS);
- Games

Analysis of the European software and services market

The study provides market figures (volume and growth) for the European software and software-based services (SSBS) market (EU28 as a whole, as well as the key countries France, Germany, UK and Italy) and present the major players (top 10 in the EU28 and worldwide). In addition, it provides market figures for selected topics that are regarded as key drivers for the software market, such as big data, digital transformation, security and mobility. Besides presenting the figures, the project team explains the reasons for the market developments that can be observed.

In the study the project team compares the market data for the EU28 region with the markets in the US (mature market) and India (emerging market) in order to analyse differences in market shares and trends.

Additional data and information is provided about the number of IT companies in the region, R&D investments and innovation indicators.

Economic and social contribution of the software industry

Economic impact: The current as well as the future impact of the software industry on the economy of the EU28 region are described in terms of number of employees, value added or productivity.

[1] http://cordis.europa.eu/fp7/ict/ssai/study-sw-2009_en.html

Social impact: The study describes the current as well as the future contribution of the software industry to the EU society. For this purpose, the following 10 social domains are considered:

- E-access and e-government
- E-inclusion
- E-work
- Consumer benefits of the optimization of economic processes
- E-education
- E-health
- Smart energy
- E-security
- Sustainable development
- Transport and mobility

Identification of key drivers and opportunities for the software industry

Numerous technology trends may have a major impact on the development of the SSBS market in the coming years. Depending on their benefits, their cost and their level and pace of adoption by end users (niche or mass market), they may more or less help to accelerate the growth of the overall SSBS market.

Thus, in addition to the market figures presented in the first part of the D2 report, in a next step the project team explains and discusses the key drivers for the European software industry:

- **Digital transformation:** Although software-supported digitization was already taking place in 2009/10, digital transformation was not as much of a key trend as it is today. Today, the digital transformation journey has become much more of a structural and organizational – rather than a technological – topic. Software providers both in Europe and worldwide are therefore currently faced with highly dynamic market conditions and have to find appropriate ways to address these
- **Analytics/big data:** Business analytics has been of high relevance for European companies for over a decade now – be it business intelligence (BI), big data or any type of analytical applications. This is because companies see great benefits from these solutions as they help them to improve their decision-making. The strategic importance of business analytics has increased at a rapid pace and thus receives much more attention than in the previous study.
- **Mobility:** For European software vendors, mobility is a key topic and many have started to embrace it by adding mobile or any-device features to their products. They have the opportunity to grow their business by reaching out to mobile users as a new customer segment.

- **Social collaboration:** Time to market and short innovation cycles are key competitive factors in all industries today. In addition, the relevance of knowledge work in developed economies is rapidly increasing. As a consequence, social collaboration is becoming a key productivity driver and an integral part of business processes.
- **DevOps:** DevOps was only just beginning to become a topic in 2009/10. Today, there is a strong need for more agility from the IT department in digitally transforming companies. In addition, companies recognized the lack of interaction between siloed IT operations and application development in complex IT organizations. Therefore the relevance of DevOps is rising.
- **Cloud computing:** Cloud computing is an example of an emerging software technology that has remained strongly relevant as a key driver since 2010. Digital technologies entail a deep transformation of the business models for a lot of European end-user companies, but also in IT providers' organizations. The main catalyst for this evolution is cloud computing. Thus there is a dynamic market for such solutions in Europe.
- **Cyber security:** In our 2010 SMART study projections, we expected growth in security software. Demand for cyber security solutions is growing rapidly due to the increasing proliferation of web-based digital services, the intensified use of mobile devices and the rising number of attacks from cyber criminals.
- **Internet of Things:** The IoT provides enormous business potential for European companies. It will be a major driver for cloud computing, such as cloud-based platforms to process and analyse machine data. The market is in its early stages and new business models are evolving. The 2010 report focused on RFID as an enabler for the IoT. Nowadays, RFID is still relevant in the IoT and it is used in industrial manufacturing, retail and logistics, but it is one technology among many.
- **Open source** has become a relevant part of the software industry and a number of software ecosystems. It has become an alternative to commercial software in various areas and is already included in many commercial software products. The relevance of open source software has also increased since 2010 due to the rise of Linux, Apache and open source middleware as well as the use of open source software for the creation of cloud computing environments (private and public cloud), big data usage (Hadoop) and mobile devices proliferation (Android).

For each of these drivers the project team provides its view regarding:

- Its recent development;
- Its impact on the software value chain and ecosystems;
- Its impact on the provider landscape (especially European software vendors, software-related service providers and games developers);
- Its maturity; as well as

- An indicator of the competitiveness of the software industry in the EU28 region.

The role of "in-house software development"

Assessing the importance and growth trends of current in-house software development activities in European companies from different industries is another important step when analysing the trends in growth and competitiveness of the European software industry. For this study's analysis, the project team defined in-house software development as the development of software within a company, performed by employees and resulting in products that are not distributed externally as software products. In order to understand the impact of in-house development trends on the software industry, to judge the change in the industry's structure and to deduce potential policy measures, it is mandatory to understand the influencing factors of make-or-buy decisions that are currently at work. For the assessment, the project team conducted qualitative and quantitative analyses as described in detail in section 6.

Identification of key barriers to the competitiveness of the software industry

In addition to the key drivers a list of the most important barriers to the development of a strong European software industry is provided. This includes the obstacles to the development of a genuinely European software sector. The list of barriers is based on a first update of the list provided in the 2010 report, the results of further external studies, as well as additional background information and internal expertise. The list was finalized at an external expert workshop in April 2016. This report provides a description of each barrier and why the project team thinks it is worth considering.

Political initiatives

The last part of this Final Study Report deals with policy initiatives related to the barriers. In a first step the project team puts together a brief inventory of current EU policy measures and initiatives which are related to the software and Internet development in Europe. Then the project team carries out an ex ante impact assessment of the top-10 policy measures which are suited to overcome the barriers. By assessing the economic and societal impacts of selected policy measures the project team is able to prioritize the measures: Policy measures with a strong impact are those which need to be addressed with priority. In a third step, the suggested policy measures are contrasted with ongoing policy measures of the European Commission in order to find out what is already being done to overcome the barriers. Also, input from the expert discussion at the April-2016-workshop is integrated to identify relevant policy measures for the future.

Finally, with additional input from experts participating at the final conference in October 2016 in Brussels, the project team has grouped the top-10 policy recommendations into three broader areas:

A. For a more dynamic, innovative user landscape
B. For better framework conditions
C. Focus on enabling factors (spirit, SMEs, broadband and R&D)

After describing each of the top-10 policy recommendations in more detail the project team selects the five most relevant measures which – in the project team's view – provide important levers for the future development of the software and software-based services sector in Europe.

2. Definition of the European Software and Services Market

The first part of this report aims at defining the relevant market for the study. In a first step the project team will review the definitions and methods used in the SMART 2009/0041 study to measure the software and software-based services (SSBS) market. In a second step the project team will substantiate this review with its current research methodology and market segmentation and with reviews of external literature dealing with software market definitions. Taking into account the latest market and software developments, the project team made some adjustments to the definition and methods used in the SMART 2015/0041 study where appropriate.

2.1. The segmentation approach of the SMART 2009/0041 study

In line with the approach of SMART 2009/0041, the size and development of the software market should be evaluated by considering both the software market itself AND related services. The definition applied was based on two main axes:

1. Software types
2. Revenue models

Software types

The four types of software taken into account were:

- Applications
- Tools
- System infrastructure software (SIS)
- Games

According to the study definition, **software applications** are used directly by information workers and end users. There are as many types of applications as there are processes in companies and public organizations. The main role of these applications is to bring structure and a certain level of automation to business processes in these two kinds of organization.

Tools refer to the software mainly used by developers to model, plan, test, deploy, execute, and optimize business applications and processes. They are situated between system infrastructure software (SIS) and application software. Lately, with the advent of service orientation, they have become increasingly important in software-based value creation because they allow the composition, integration, agility, reuse and optimization of software applications.

System infrastructure software (SIS) represents the foundation of software stacks; it links, secures and manages hardware, networks, and software. The software, mainly used by system administrators, is rarely industry or function-specific and represents the infrastructure part of the middleware layer.

The **games market** refers to any form of electronic games involving interactions with a user interface offering some visual feedback on a video display. It includes both paid and ad-funded games. Games are ready-to-use packaged software and do not require associated IT services to be used.

Revenue models

In the study conducted in 2009/10, the following revenue models and related definitions were considered:

- License + standard maintenance by ISVs (independent software vendor)

Perpetual license or 'rent' – the end user of the software products (or the company they work for) pays a license fee to own the right to use the software. Annual maintenance fees usually accompany this license fee. As for open source software, customers pay a subscription fee for support and maintenance.

- Associated IT services

This revenue model includes payment for the human effort necessary to build, implement, and run/maintain the software. Custom software development is part of this segment.

- Paid web-based

This revenue model actually combines a revenue model and a delivery model. It refers to the cloud computing segments (SaaS, PaaS, IaaS, etc.) and consists of a 'pay-as-you-use' model, usually on a monthly basis. The delivery model is also important, for which there are two requirements: 1) Software is accessed through a web browser and 2) multi-tenant architecture as a single application instance that serves all customers.

This category additionally includes the paid web-based revenues generated from emerging segments such as mobile applications, M2M, and the Internet of Things.

A spin-off from the paid web-based model is freemium, which has become popular at the low end of the software market. Customers can use a certain set of features for free and have to pay for premium functions. Or customers can use a software for a certain period of time for free and have to pay if they want to continue using it afterwards.

- Online advertising

Online advertising in the context of the software and software-based services industry takes into account all forms of software and activities that were previously offered in an offline version, while excluding all online activities that are still included in their original market segment, such as content (video, games, press, music, etc.) or e-commerce. For this study, online advertising is, therefore, only included when related to specific web services, such as communication, search, or other software-based services.

2.2. Today's software market definition – The adjusted approach

Pierre Audoin Consultants (PAC) has been following the software and IT services industry for nearly 40 years. This experience has allowed PAC to develop a clear segmentation of the industry, including segments and different sub-segments within each category. The categories mentioned above are based on PAC's segmentation of the SSBS market (excluding games) valid in 2009 and thus applied in the SMART 2009/0041 study. In order to take into account recent market and technology developments and reach a more precise market characterization for the current study, the project team refrains from using the 'revenue model' segmentation because the boundaries are becoming increasingly blurred. Therefore the software and software-based services market is broken down as follows:

Software products (including infrastructure software & platforms, application software products; excl. SaaS)

Software-related services (including application-related project services, application management, application hosting, infrastructure-related project services, infrastructure outsourcing; excl. cloud services)

Cloud computing (paid web-based services consisting of IaaS, PaaS, SaaS)

Games

For the current project, the consortium therefore suggests the following SSBS market segmentation (largely based on PAC's market segmentation):

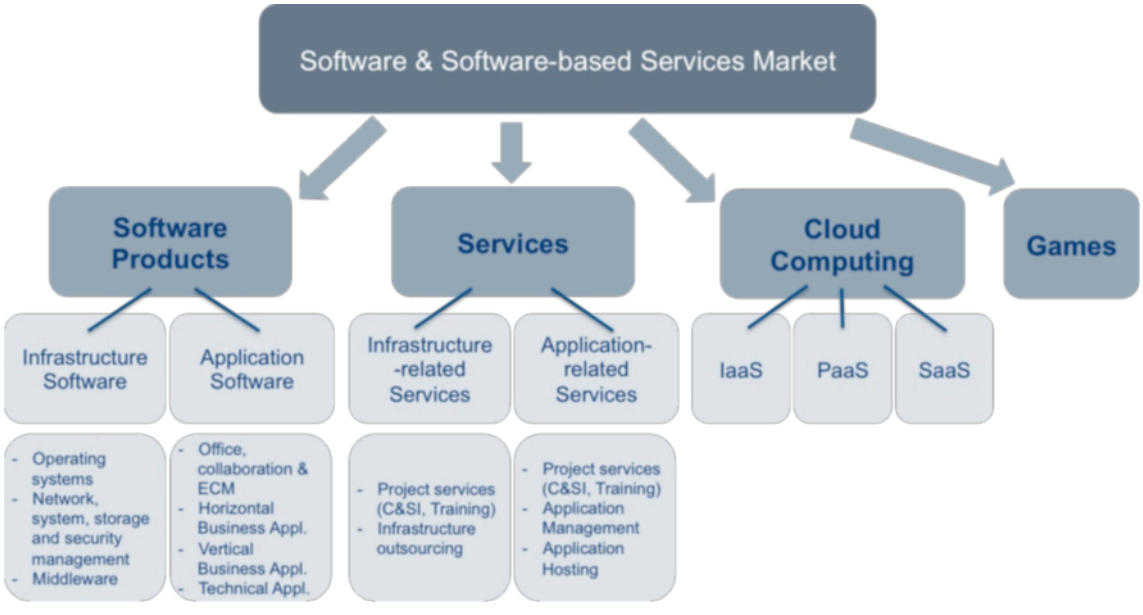


Fig. 1: Software market segmentation (SMART 2015/0015)

However, it should be noted that this segmentation is used to show the growth and trends for the different markets (based on the revenues generated in these segments) although there are overlaps between cloud computing/ games and the

software and IT services segments. This is why, for example, the project team has created a separate segment for cloud software and services in order to give a more detailed view on it.

The following sections describe the segmentation and its modifications in more detail.

Software products

The consortium will apply the following software product types:

1) Infrastructure software & platforms
2) Application software products

The following chart shows the relation between the segments before and after the adjustment that took place in 2013 (excl. games software).

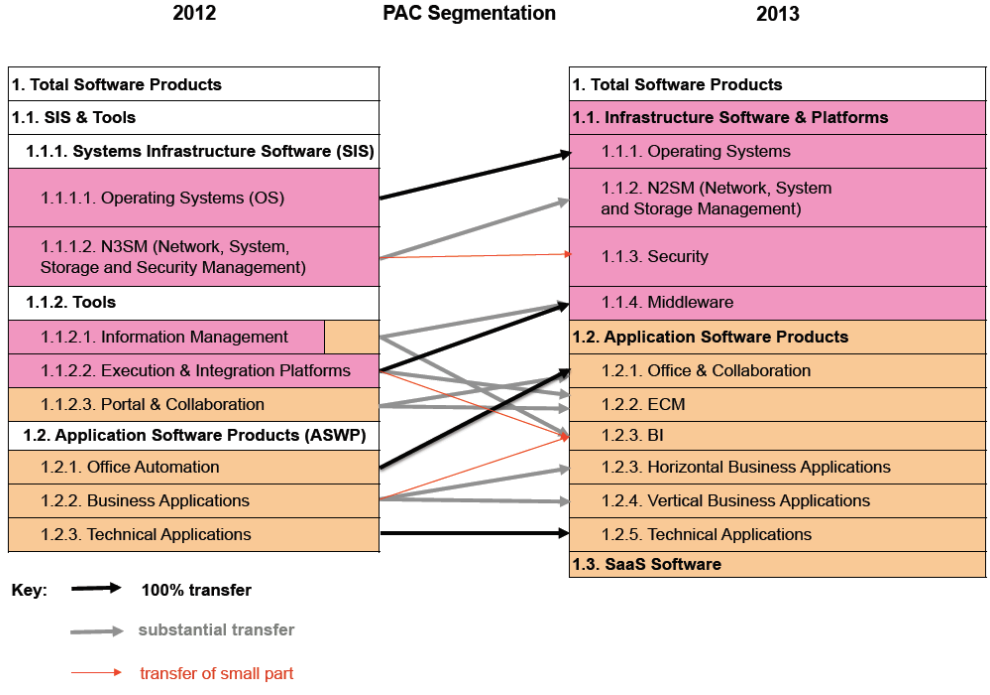


Fig. 2: Changes in PAC's software segmentation

Infrastructure software & platforms

PAC's figures for infrastructure software and platforms include a) operating systems, b) networks, system, storage, and security management (N3SM), and c) middleware. They only consider revenues from licenses and maintenance/support. All related revenues from implementation services (consulting, implementation/ customization, training) are booked as infrastructure-related services revenues according to PAC's definition. The breakdown into SIS (systems infrastructure software) and tools as used in the previous study will no longer be applied.

PAC includes highly industry-specific infrastructure software in the application software product category because it really is at the core of the respective

applications. This, for instance, applies to software products dedicated to the telecom sector in areas such as billing, telecom network management or platforms for enhanced services. Telecom network management clearly is an application area for a telecom operator, while traditional systems and network management software products are designed to help run an IT system and, as such, are considered infrastructure software by PAC.

Comparability with figures presented in the previous study: Due to the fact that the adjustments to PAC's segmentation were mainly made for sub-segments in this area (except for portal & collaboration and parts of information management), the project team will be able to compare the infrastructure software market outlook presented in 2010 with the current market development and discuss potential deviations caused by technological changes, for example.

Application software products

Application software products can be either out-of-the-box solutions, such as the majority of productivity software products and business applications for the small/home office market, or more complex/process-oriented solutions that require implementation and customizing services, such as business applications for the mid-market and for large enterprises. An overview of the sub-segments is provided in figure 2.

Application software products are often sold as packaged solutions including hardware and services, e.g. implementation services. The value of hardware and services resold is excluded from the application software market consideration if it can be determined.

Similar to the infrastructure software segment, PAC's figures for application software products only include revenues from licenses and maintenance/ support. All related revenues from implementation services (consulting, implementation/customization, training) are booked as application-related service revenues. SaaS revenues are considered separately (see below).

Comparability with figures presented in the previous study: Due to the fact that the adjustments to PAC's segmentation were mainly made for sub-segments in this area (except for portal & collaboration and parts of information management), the project team will be able to compare the application software market outlook presented in 2010 with the current market development and discuss potential deviations caused by technological changes, for example.

SaaS

For the purposes of this study, software as a service is considered within the cloud computing market segment and not as part of the software products (as mentioned in fig. 2).

In-house development

Many companies develop their own software with internal IT staff. Software developed internally are not considered as part of the software market if the resulting products are not distributed as software products. This also applies to

those companies from the manufacturing sector, for example, that develop software embedded in machines, vehicles, devices, etc.

However, the project team will describe and quantify this market segment, which is becoming increasingly important due to the proliferation of topics such as the Internet of Things and Industry 4.0. later in this report (see chapter 6).

Open source software (OSS)

Open source software is a relevant factor to consider in the software market because it is the foundation of various commercial software solutions and cloud environments. OSS can support the development of new software because companies can use existing software to create their software products. Therefore, it can be a catalyst for new software developments and the creation of new software companies.

However, the market is difficult to track, as little revenue is generated from software subscriptions and paid web-based contracts. Most of the revenue was originally generated from services (consulting, system integration, as well as SaaS) and commercial add-on solutions that are based on free-of-charge open source software. The market is now much more paid web-based, as OSS adopts cloud-based models or even merges with them. OSS can also be considered as an important factor in the value creation of other software, even if it is difficult to quantify. Today, OSS often replaces the standard middleware platform provided by a third party. It limits costs and, more importantly, dependency to some extent.

Open source is largely considered in the presented market figures. For example, the market volume and growth rates for infrastructure software take into account that open source competes with commercial software. Moreover, PAC directly records the revenues of open source software and service companies such as Rat Hat.

Services

Due to the emergence of new outsourcing approaches and cloud computing models, significant changes to software-related revenue models have been made since 2010. While some of these have gained in importance, others have lost relevance. Having reviewed the models described above (taken from the earlier study) and considering technological developments over the past few years, the project team considers the following software-related services when evaluating the SSBS industry:

1) **Infrastructure-related services** (including project services and infrastructure outsourcing)
2) **Application-related services** (including project services, application management and application hosting)

The definitions are as follows:

Infrastructure-related services

Infrastructure-related project services include IT consulting, systems integration (SI, including customized development) and IT training. SI includes both IT services invoiced on a time & material basis (also known as T&M, contract staff, staff augmentation, body shopping, etc.) as well as on a fixed-time/fixed-price basis.

Infrastructure outsourcing services are characterized by long-term contracts (3 to 10 years or even more) that often involve the takeover of the outsourcing customer's assets (human resources and/or infrastructure) by the outsourcer, the takeover of responsibility by the supplier, and a payment that is still very often on a fixed-price basis, albeit modular, in order to respond to the changes in customer requirements. Payment conditions are increasingly variable. Application hosting will not be considered in this segment, but in application-related services.

Application-related services

Application-related project services include IT consulting, systems integration (SI, including customized development), and IT training. SI includes both IT services invoiced on a time & material basis (also known as T&M, contract staff, staff augmentation, body shopping, etc.) as well as on a fixed-time/fixed-price basis.

Application management refers to the maintenance and enhancement of existing applications (custom development and/or customized software products) within the framework of a long-term (multi-year) contract, with a commitment to fulfilling pre-defined service level agreements on a fixed-price basis. Typically, application management is offered by external service providers for customers that own on-premise software. It is not the same as software maintenance, which is provided by the software vendor and/or their business partners (and which is included in the *application software product* segment according to PAC's definition).

Application hosting, including server/mainframe and basic system operation, is also considered in the application-related services segment. Application hosting is not the same as the cloud. Basically, it describes the provision of an IT infrastructure to operate client/server-based software. Typically, the customer owns the software but uses an external hosting provider for operations. In contrast, SaaS is the provision of cloud-based application software as a service via a cloud platform. The user pays a fee and does not pay for a license or software maintenance.

Comparability with figures presented in the previous study: The sum of infrastructure and application-related IT services as described above directly corresponds to the 'associated IT services' segment of the previous study.

Cloud computing

According to the definition and segmentation of the software and software-based services market, the consortium considers this segment to comprise the IaaS, PaaS, and SaaS models. These are defined as follows:

IaaS

Infrastructure as a service (IaaS) is the basis of the cloud architecture. It is the dynamic provisioning of computing, storage, and network resources. IaaS users, in particular system administrators and IT architects, can access these infrastructure resources as required.

PaaS

Platform as a service (PaaS) comes on top of the IaaS architecture and comprises the middleware and/or development platform, which enables IaaS users, in particular application developers and IT architects, to develop applications within the cloud and/or to operate them. It provides computational resources via a platform upon which applications can be developed and hosted.

SaaS

Software as a service (SaaS) is the uppermost layer of the cloud architecture, the actual business application (e.g. CRM, ERP, collaboration, etc.). SaaS provides applications/services using a cloud infrastructure or platform, rather than providing actual cloud features.

PAC's figures for SaaS provided as part of this project include both the software part (licenses and maintenance) of an SaaS agreement and the hosting part (operation of the solution and related infrastructure).

Comparability with figures presented in the previous study: The cloud computing segment described above directly corresponds to the 'paid web-based (PWB)' segment of the previous study or, in other words, to the 'software-based Internet services' segment, excluding online advertising. Due to restrictions in time and budget, the consortium does not consider online advertising in this mission.

Games

PAC does not consider gaming or entertainment software as part of its standard software market segmentation. This consumer-focused market segment is very specific and has completely different characteristics regarding providers and market structure, market development, etc.

However, the gaming market has become an important driver of the software industry worldwide. Besides the rapid developments in the B2C markets, so-called "serious games" are for instance gaining in importance in the business area in particular, e.g. for training activities or the visualisation of prototypes. Thus, this segment needs to be considered when defining and analysing the overall European software market. In addition to the data provided in the SMART 2009/0041 study, further external datasets and publications are used in the current project in order to define the European games software market and estimate its size and growth. Due to the project's budget and time limitations, the consortium has to restrict these analyses to the EU28 level. However, a rough estimate of the games market size and its share in software products (usually games do not require associated IT services to be used) is provided, so that this can be compared to the figures

presented in the previous study. In addition, the project team will take a look at the games market's impact on future developments in the European software market.

The devices most frequently used by gamers to play games are: PCs, dedicated game consoles, smartphones, wireless devices or dedicated handheld systems.

Consideration of key topics

Topics such as digital transformation, social, mobility, analytics, cloud and security (SMACS) are strongly driving the software market. The same holds for open source software, which comprises non-paid and freemium elements and increasingly provides the basis for cloud services, for example. Topics like these are covered in detail in the key driver examination of chapter 5. There the project team evaluates their impact on the software market of the EU28 today and over the coming years.

The topics mentioned above are already considered in the market segmentation provided above because each of them comprises part of the software and software-based services market, and also part of the cloud segment.

Software value chain

When analysing the topics in chapter 5, the project team provides insights into how they are already changing the software value chain or how this might be the case in the future.

In general, the different parts of the software value chain can be described as follows:

Development includes code development, release management, testing, etc. for software products as well as the related updates and patches.

Distribution comprises the selling of software, software updates, or new releases of software (including perpetual licenses, maintenance contracts, and software subscriptions, etc.) through the software producer or through an authorized partner. This includes selling via marketplaces or app stores.

Maintenance is a software-related service provided by a software producer or its partners and includes – depending on the contract – the provision of patches, new versions, or releases. Depending on the service level, continuous monitoring can be part of maintenance.

Like maintenance, **support** is a software-related service provided by a software producer or its partners. It can comprise hotline and helpdesk, access to a knowledge base, etc.

Software ecosystem

Furthermore, the success of a particular software depends on the software ecosystem. The project team's definition of the software ecosystem is: "A

commercial ecosystem that comprises the software producers, their business partners, and the software buyers or users." The software producer determines the technology, functionality and quality of the product, but the commercial success depends on the customers' buying behaviour, as well as the ability of the business partner network to resell and/or implement the software.

The relationships between software producers and their business partners are manifold. The following lists some examples of business partner relationships:

- Reseller: A business partner that sells/offers software or cloud services and related services such as maintenance/support
- Value-added reseller: Resells software/cloud services and provides additional services, add-ons, vertical solutions, etc. that complement the software product/cloud service
- System integrator: Installs/implements a software product/cloud service, provides customization services, offers consulting services around the software product/cloud service, and provides software management services (e.g. application management services)
- Training provider: Provides training and education services and/or relevant content
- Managed service or cloud provider: Offers hosting and operations for a software product/cloud service
- OEM partner: Incorporates a software product/cloud service within its own products
- Technology partner: Provides technology that complements a software product/SaaS service
- Marketplace: A marketplace offers a platform for the sale of software products/SaaS services as digital products

The buyer or user is also part of the ecosystem. Companies buy software products (licenses, subscriptions) and subscribe to software-related services from the software producer and/or its business partners. In addition, buyers or users influence the product roadmap and the portfolio of software-related services to a certain extent because they provide feedback, request features, etc.

We describe further down how provider landscapes are evolving around the described key topics. Established software vendors that transform their business towards the cloud, for example, need to adapt their software ecosystems as well. In addition, new software ecosystems are emerging as new players enter the market.

Evolution of the software ecosystems

Over the last few years, software has rapidly become an enabler for the business and is increasingly used for highly specific processes in different industries and lines of business. The project team believes that this trend will continue until 2020 and beyond. As a result, the need for software vendors to enhance their ecosystems and work with skilled partners becomes more urgent. At the same time, partners of

software vendors are evolving from being an additional sales and delivery capacity towards becoming a real consultant and advisor for customers. Consequently, partners require much more consulting and business skills in addition to the technical skills that are needed to implement a software product.

Another evolution the project team observe regarding the software market is the role of partners in the creation of intellectual property. Instead of just implementing existing software, the partners more and more develop their own solutions or add-on tools that are based on the software vendors' products. This way the partners become software providers themselves. The consortium believes that this is an important topic for the IT service providers in the EU28 region who partner with local and/or international software vendors.

3. Analysis of the European Software and Services Market

Based on the definitions given above, in this chapter the consortium analyses the current status and development of the software & IT services industry in Europe. The project team follows the market developments since 2009 and predict future trends up to 2020. With regard to geography, market data is provided for the EU28 region and for key countries. France, Germany, Italy and the UK together account for around two thirds of the total software and IT services market in the EU, which is why these large European IT markets are considered separately. In addition, international comparisons are made with the US market (which is a very mature market) and with the Indian market (which is a fast growing market).

The project team updates the market developments predicted in the SMART 2009/0041 study as comprehensively as possible, taking into account the adjustments made to the segmentation and definition of the industry. For this study, PAC's new segmentation for the analysis of software market size and structure is applied. Due to the fact that the changes in the segmentation mostly concern the sub-segments and the specific consideration of cloud figures, comparisons between total market figures and developments from the earlier and the current studies are justifiable. Based on this, the project team draws conclusions as to whether the developments predicted in the previous study really occurred or where significant new developments can be seen.

It has to be kept in mind that the focus of the previous study was on the EU27, while today the EU market has increased to EU28 since the entry of Croatia in 2013. However, the IT market of Croatia is relatively small and, as a result, the impact may not be significant.

3.1. Market volume and market growth by SSBS segments within the EU28

For the main market segments, software products (infrastructure software, application software), services (infrastructure-related, application-related), and cloud computing (IaaS, PaaS, SaaS), as well as games software the project team estimates the following:

- Market volume;
- Market growth;
- Market structure.

The estimates are based on data going back to 2009 and forecasts looking ahead to 2020.

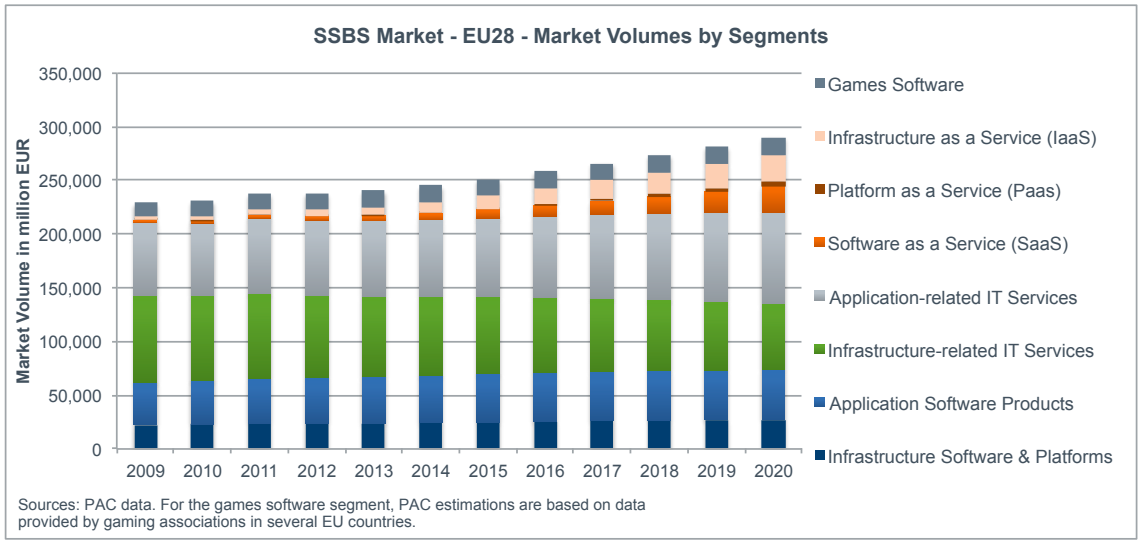


Fig. 3: SSBS market volumes by segments in the EU28, 2009-2020

Average yearly growth rates of SSBS segments (EU28)	CAGR 09/15	CAGR 15/20
Infrastructure Software & Platforms	1.8%	1.8%
Application Software Products	2.0%	0.6%
Infrastructure-related IT Services	-1.9%	-3.1%
Application-related IT Services	1.2%	3.0%
Cloud Computing	25.7%	16.9%
Games Software	2.8%	1.8%
Total SSBS	**1.5%**	**2.9%**

Fig. 4: CAGR of SSBS market segments in the EU28

The overall SSBS market in the EU28 region was worth EUR 229 billion in 2009 and grew by a yearly average of 1.5% until 2015. Its average yearly growth is expected to accelerate to 2.9% between 2015 and 2020. Thus, by 2020, the SSBS market will amount to nearly EUR 290 billion.

What can be observed and predicted for the development of the SSBS market in the EU28 by segments?

- Software-related segments such as infrastructure software & platforms and application software products will grow only slightly. One main reason is the maturity of these segments in various European countries. Companies replace and update existing software rather than extending their IT landscapes on a large scale. Growth in these areas comes from investments by medium-sized businesses, many of which are not at the same maturity level as large enterprises.
- In addition, software markets are increasingly under pressure as more and more companies move to cloud-based solutions. The market share of cloud

computing will increase enormously until 2020 (around 18% of the SSBS market).

- Application-related IT services have been the largest SSBS market segment since 2015. This segment will remain of importance even if there is far less dynamic growth in the application software market, because these services are needed for changes, improvements, upgrades, maintenance and management of existing solutions.
- Growth in cloud computing (IaaS, PaaS and SaaS) has two effects: One is the above-mentioned shift from traditional software to the cloud. The other is the fact that cloud services are consumed by companies that would not have invested into software products on a large scale – cloud services typically require neither large upfront investments nor complex implementation projects.
- The shift to cloud computing has a strong impact, particularly on infrastructure-related IT services. Services for the technical implementation of software are hardly needed when companies start using a cloud service. This is one significant reason why the market for infrastructure-related IT services is declining.
- The global games market is prospering as a result of a range of innovations: powerful smartphones enable mobile gaming, improved broadband and infrastructure capacities allow high-performance online gaming, and innovative revenue and digital distribution models have greatly expanded the addressable market.[2]

Comparison with 2010 study results:

- The growth expectations in the 2010 study were much more optimistic, particularly for the application-related software market. Unforeseeable developments regarding strong influencing factors, such as the recent financial and economic crisis resulting in a rather weak economic trend in many European countries, can now be taken into account for the years until 2015.
- Moreover, in 2010, the above-mentioned impact of cloud services on the existing software market was not yet as strong as it is today and was therefore underestimated for the years to come.

[2] Source: "Playable media is the next big thing in $74bn global games market", SuperData Research (2015), www.superdataresearch.com/blog/global-games-market-2015/

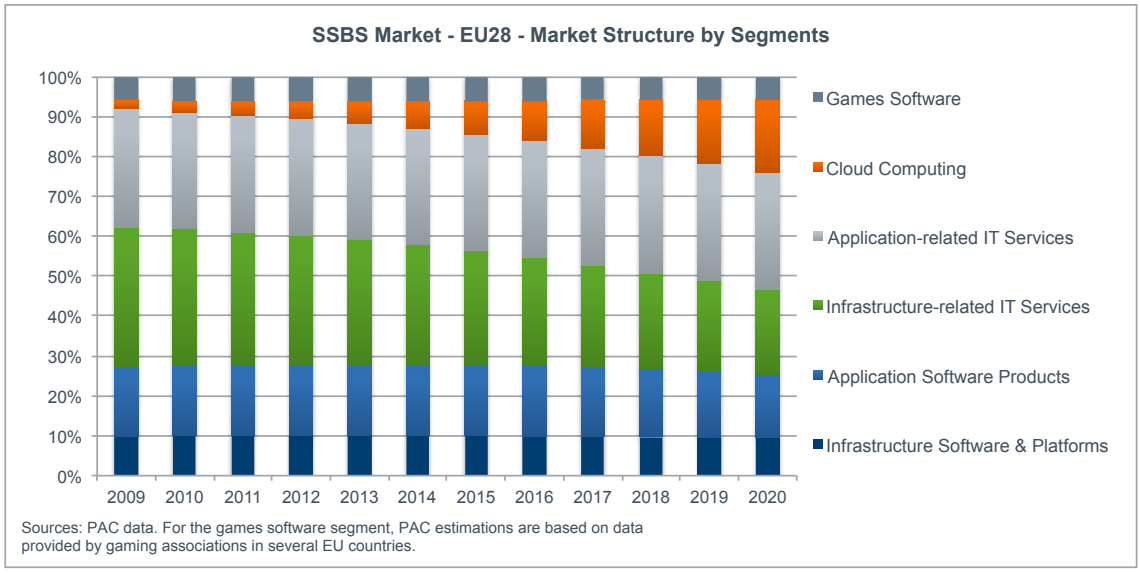


Fig. 5: SSBS market structure by segments in the EU28, 2009-2020

	Market Structure EU28		
	2009	2015	2020
Infrastructure Software & Platforms	9.9%	10.0%	9.5%
Application Software Products	17.3%	17.9%	15.9%
Infrastructure-related IT Services	35.1%	28.6%	21.2%
Application-related IT Services	29.7%	29.2%	29.3%
Cloud Computing	2.3%	8.3%	18.3%
Games Software	5.7%	6.1%	5.8%
Total SSBS	**100.0%**	**100.0%**	**100.0%**

Fig. 6: Market shares of SSBS segments in the EU28

3.2. International comparisons of SSBS market volume and market growth

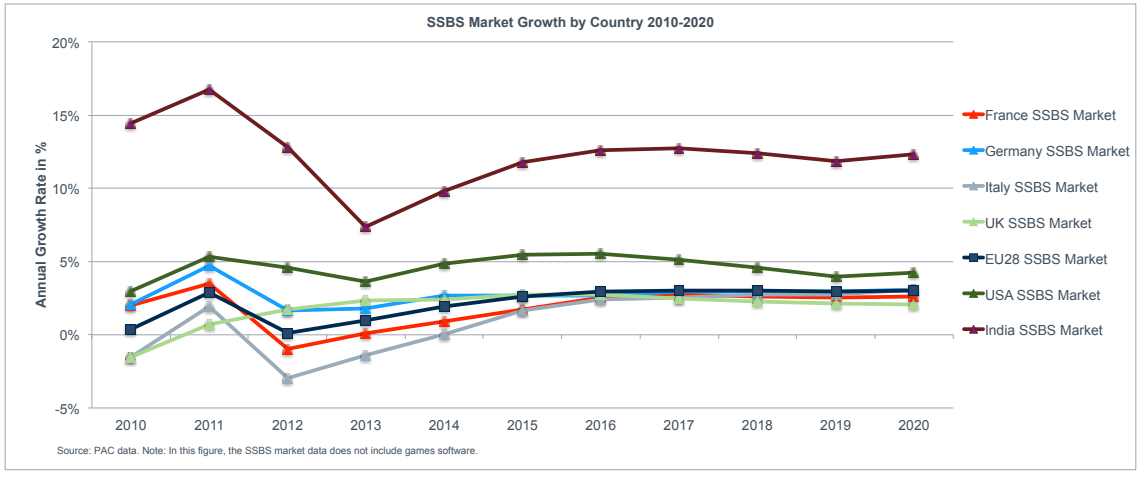


Fig. 7: SSBS market growth by country, 2010-2020

For the total SSBS market in the EU28, the major EU countries, India and the US the project team observes and predicts the following developments:

- Every year between 2010 and 2020, SSBS market growth in India and the US will be higher than in each of the major European countries.
- The financial crisis of 2011/12 led to a slowdown in SSBS market growth for EU countries. The UK SSBS market did not suffer in 2012 as the other European countries did, but it had suffered more strongly than the other countries in the years before.
- The US slowdown was less pronounced back then but lasted until 2013. It showed good GDP growth in 2012, as opposed to the weak growth rates in most EU countries (see figure below).
- Italy's SSBS market suffered most in 2012 compared with the other major European countries shown in the chart.
- The decline in India in 2012/13 was even stronger for IT services than for software. However, after the enormous investment growth rates in 2009-2011 (10%+), the slowdown can be seen as a healthy cooling-off following an overheated period. It was accompanied by a slowdown in economic growth (see next figure).

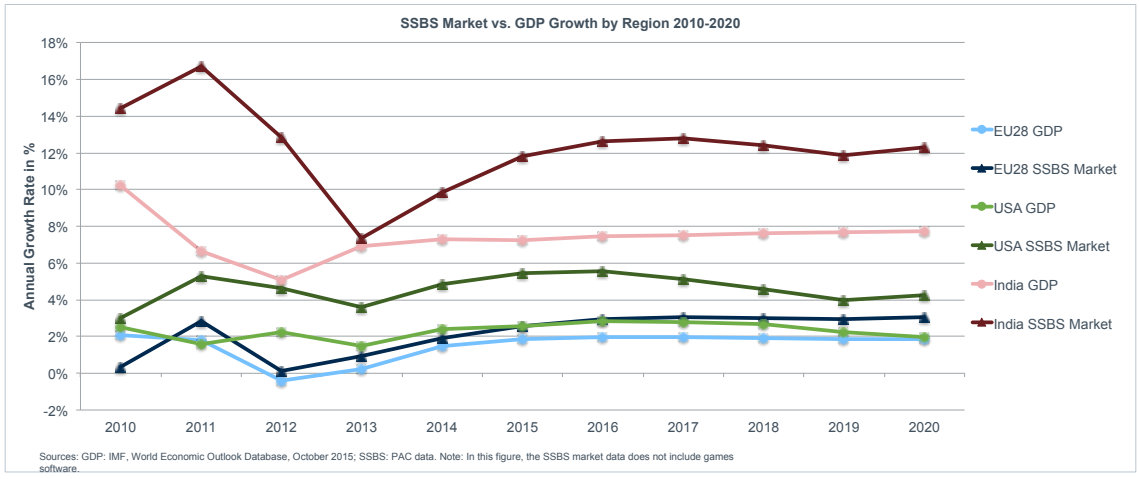


Fig. 8: SSBS market growth versus GDP growth by region, 2010-2020

When comparing the total SSBS market in the EU28, India and the US, as well as their GDP growth rates, the project team observes and predicts the following developments:

- Taking a look back: The European countries' and the US' GDP growth rates were far below zero in 2009 (not shown in the figure). In contrast, India's GDP growth was 8.5% in 2009.
- EU28 SSBS market growth was approximately zero in 2010 and 2012, as a result of the economic crisis.
- A slight increase in GDP growth in the US in 2012 dampened the slowdown in SSBS market growth there as opposed to Europe.
- Decreasing GDP growth rate in India after strong growth of more than 10% in 2010. With a one-year time lag, this had impacted the SSBS market as well.

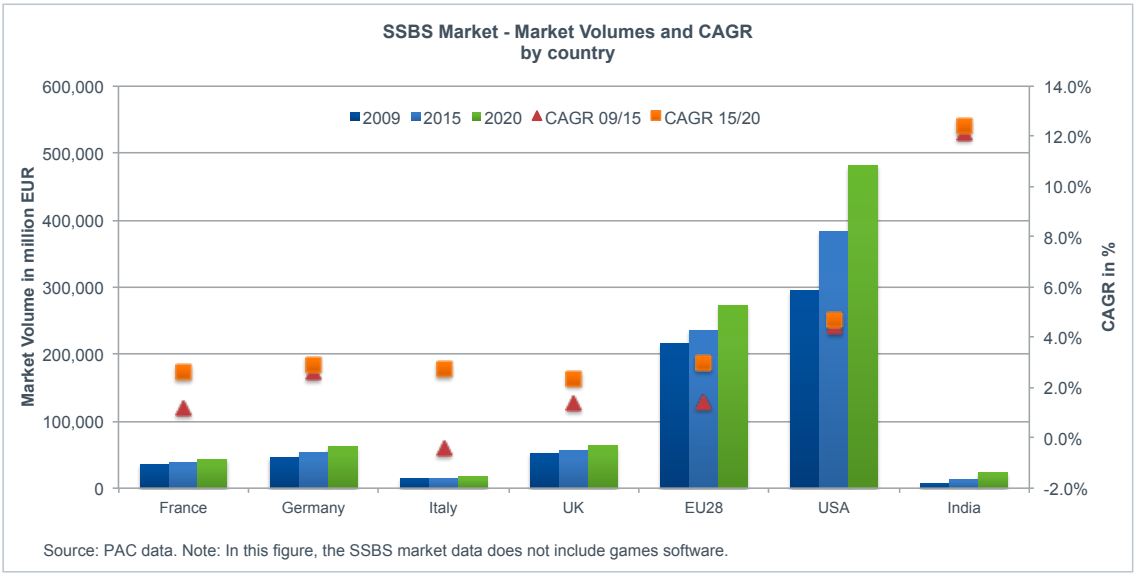


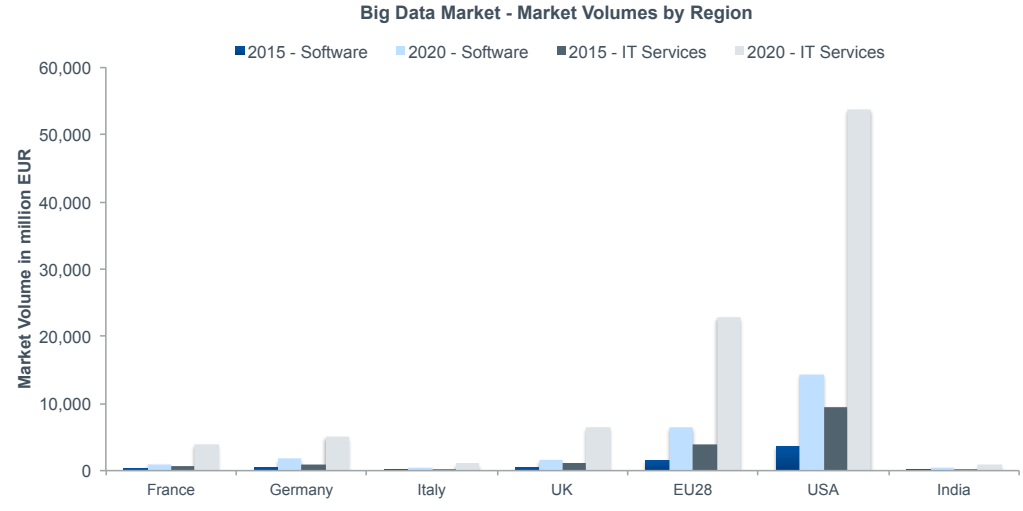
Fig. 9: SSBS market volumes and CAGR by region, 2009/2015/2020

- In every country analysed, the average yearly growth rate (CAGR) of the SSBS market (excl. games software) is higher in the 2015-2020 period than in the 2009-2015 period. This means growth is accelerating. This is particularly pronounced in Italy and France, but also in the EU28 as a whole.
- Average growth is particularly high in India. Although India's SSBS market volume is still rather small compared with the US market, it is rapidly catching up. According to PAC estimates, India's SSBS market volume will overtake that of Italy in 2020.

3.3. Market volumes 2015 and 2020 by key topics

In the following market analysis for four specific key topics, the project team compares the market volumes for software products (infrastructure software and application software) and those for IT services (application- and infrastructure-related services) for each topic. The market volumes are shown for 2015 and 2020 in order to follow predicted developments over the next few years. Segments such as games and cloud are not considered here. A detailed analysis of these key technological trends and their impact on the software value chain and ecosystems can be found in chapter 5.

Big data



Source: PAC data. Note: Data in this figure does not include games software

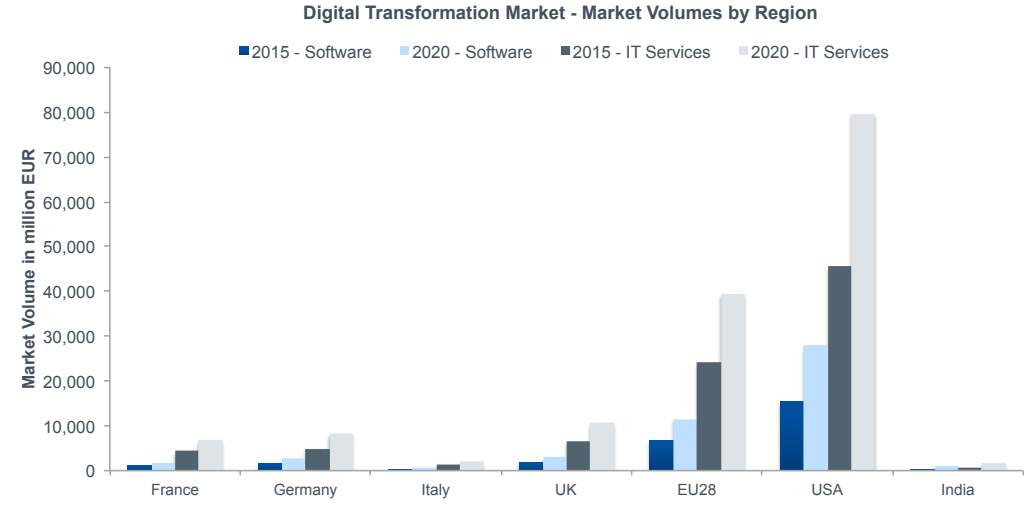
Fig. 10: Big data market volumes by region, 2015 and 2020

Considering market volume, big data is more of an IT services rather than a software market. This is because many big data implementations are customer-specific, which requires a large amount of related consulting and system integration services. In PAC's market segmentation, the development of customer-specific big data software is part of the IT services market. A considerable share of the big data software used is open source – Hadoop is a good example.

One of the fastest growing sub-segments within big data is hosting & support of big data infrastructure.

The big data software solutions market is very much dominated by US-based players. While several large software vendors offer big data software, many start-ups are currently also entering the European market. The competitiveness of EU28-based software providers has been rather limited so far. However, EU28-based IT service providers may play an important role: they deliver big data projects for their customers that are based on big data software.

Digital transformation



Source: PAC data. Note: Data in this figure does not include games software

Fig. 11: Digital transformation market volumes by region, 2015 and 2020

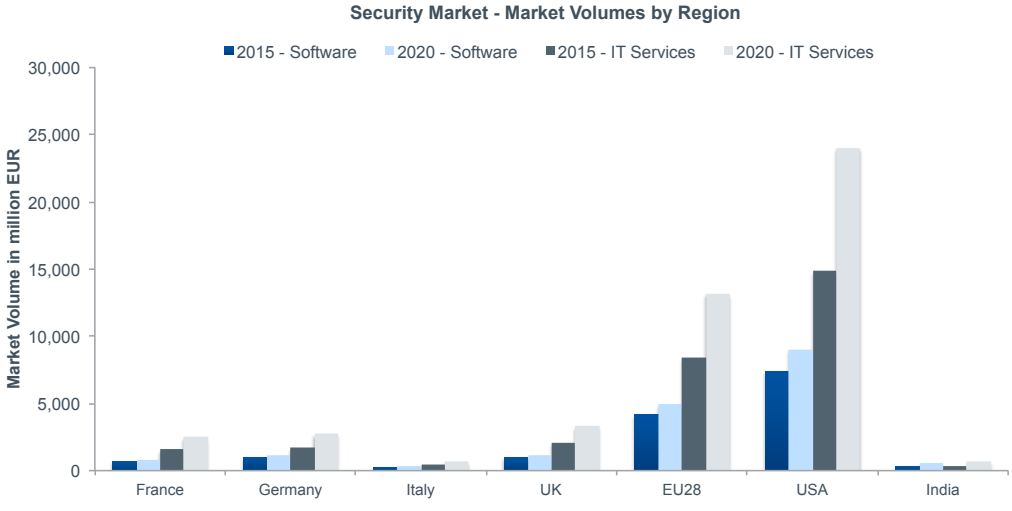
Digital transformation is a rapidly evolving market today and will be so in the near future. Many activities can be observed around digital frontend transformation. A large variety of software solutions are part of this segment and the market is expanding rapidly as many software vendors start to offer solutions.

Overall, the software market is growing a bit faster than the services market, which is a clear indicator of a newly emerging market where companies invest in new software to drive digital initiatives. At a later stage, companies tend to invest in IT services to transform existing IT solutions.

Regarding vendors, European software companies and IT service providers will be able to grow their business in this segment today and over the next few years in spite of the strong competitors from the United States. This is because specific know-how about local customers' preferences is very important in this segment and European providers are very good in this respect.

Many software solutions that are used in digital transformation projects are based on open source.

Security



Source: PAC data. Note: Data in this figure does not include games software

Fig. 12: Security market volumes by region, 2015 and 2020

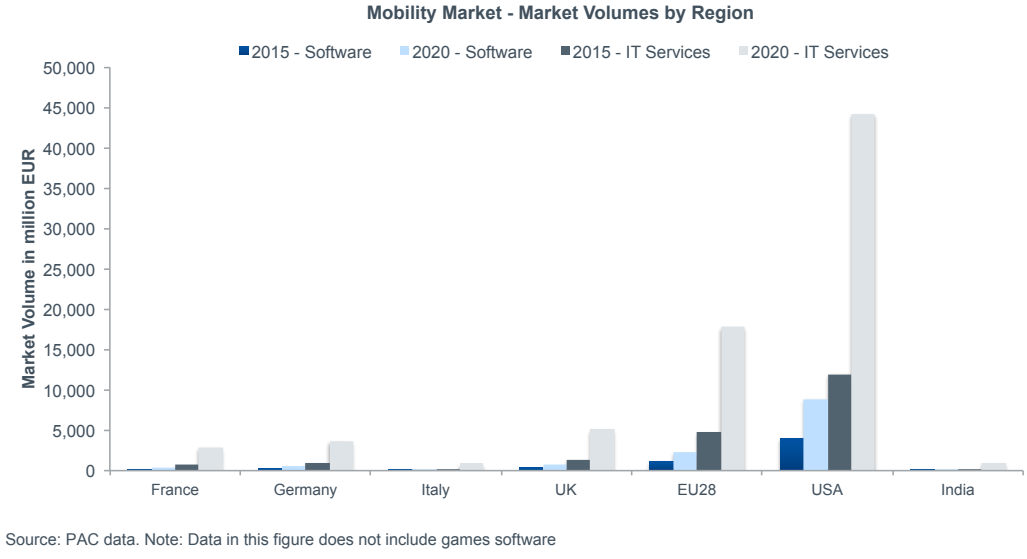
When compared with the digital transformation or big data markets, the security segment is much more mature (although market volumes are smaller). However, this market has different facets: While infrastructure-related security software (such as firewalls and anti-virus solutions) is quite mature and thus shows slower growth rates, demand for identity and access management as well as data and application protection is growing rapidly.

The IT services market for security is growing faster than the solutions market. Services are needed for consulting, implementation and integration as well as for education.

In India, the markets for security software and related services are less mature and growing much faster than in the EU28 or in the US. There is stronger demand for security infrastructure solutions in India as companies first have to create the infrastructure basis for IT security.

There are a vast number of EU28 software vendors that are already successful in this market. Therefore, the ability of the EU28 software industry to compete in the security segment is quite good.

Mobility



Source: PAC data. Note: Data in this figure does not include games software

Fig. 13: Mobility market volumes by region, 2015 and 2020

While most of the innovations in mobile technologies originate from the consumer space, there is a strong spillover effect on the business segment. Many companies are investing heavily into mobile solutions and this trend can be expected to continue over the next five years and beyond. One important driver for the mobility market is the Internet of Things, which makes things, devices, etc. mobile.

The services market is much larger in terms of volume than the solutions market and it is growing faster than the software market. This is because enterprise mobility is very much about developing and deploying mobile applications, the integration of mobile devices into IT environments, as well as the enablement of existing software to support mobile device access. In PAC's market segmentation, all of this is part of services.

3.4. Major IT players

The competitiveness of the European software industry depends on its relative position compared to current competitors, new entrants or potential entrants. Thus, for the analysis of the European software market, the project team takes a closer look at the major players and competitors.

The following paragraphs provide rankings of the top 10 IT players for the software, IT services, and cloud segments. The analysis is divided into three regional parts:

1) The top 10 providers in the EU28 region that generate software, IT services and cloud revenues in the EU28 region;
2) The top 10 US providers in terms of worldwide revenues from software, IT services and cloud; and

3) The top 10 European providers in terms of worldwide revenues from software, IT services and cloud.

Top 10 software providers

The software industry is characterized by a very uneven distribution of company sizes. There are some very big players accounting for a major share of revenues, and a huge number of small and midsize, often highly specialized software providers.

EU28 - Leading Software Providers 2014 (in million EUR)				
Rank	**Company**	**Natio-nality**	**FY End**	**Revenue 2014**
1	Microsoft	US	30-Jun-14	11,675
2	SAP	DE	31-Dec-14	5,715
3	Oracle	US	31-May-14	5,167
4	IBM	US	31-Dec-14	4,682
5	EMC	US	31-Dec-14	2,157
6	Symantec	US	31-Mar-15	1,162
7	HP	US	31-Oct-14	972
8	Dassault Systemes	FR	31-Dec-14	812
9	Sage	UK	30-Sep-14	766
10	SAS	US	31-Dec-14	672
© PAC, February 2016				

Fig. 14: Leading software providers in the EU28 region (based on EU28 revenues)

The European software market is dominated by US providers. Only three companies among the top 10 are European, with German SAP being by far the largest.

- Over the years, SAP has managed to become a global leader in business software applications and has even gained a strong footprint in the highly competitive US market. In recent years, SAP has acquired a number of software vendors in order to complement existing solution areas as well as to become a stronger player in growing areas such as business analytics.
- Microsoft, the largest software vendor worldwide, also leads the European market – mostly due to its enormous market share in operating systems (Windows) and office automation applications (MS Office).
- Oracle is known as a leading database vendor. The company also provides middleware and business applications – which makes it a strong competitor for SAP at global level.
- Sage, like SAP, is a provider of business applications (such as enterprise resource planning, ERP). However, while SAP mostly addresses large enterprises, the main customer segment of Sage is small and medium-sized businesses. Sage is one of the few European providers in this customer segment that managed to become a global player.

- Dassault Systèmes is – among other things – a leading provider of software solutions for product lifecycle management (PLM) used by manufacturing companies to develop and manufacture products.
- HP (which recently split into two different companies) is known for its hardware (computers and printers). However, HP is also a large provider of IT services as well as a maker of software, mainly infrastructure software & platforms.
- IBM and EMC used to be strong players in areas such as hardware, but they are also large software vendors and have grown their business with a number of acquisitions.
- SAS (SAS Institute) is a leading vendor in the business analytics space, which according to the applied segmentation is part of application products.

Worldwide - Leading US-based Software Providers 2014 (in million EUR)				
Rank	**Company**	**Natio-nality**	**FY End**	**Revenue 2014**
1	Microsoft	US	30-Jun-14	45,384
2	Oracle	US	31-May-14	20,411
3	IBM	US	31-Dec-14	17,249
4	EMC	US	31-Dec-14	8,807
5	Symantec	US	31-Mar-15	4,920
6	Cisco Systems	US	31-Jul-14	3,117
7	HP	US	31-Oct-14	3,107
8	CA Technologies	US	31-Mar-15	3,095
9	Apple	US	30-Sep-14	2,631
10	SAS	US	31-Dec-14	1,997
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Fig. 15: Leading US-based software providers (based on worldwide revenues)

- Apple appears on the list of leading US-based software players at global level as it delivers software with its hardware products. In addition, it sells a number of tools and applications.
- Cisco Systems used to be a maker of communications hardware, but has now become a large software player in the field of infrastructure software & platforms as well as application software products.

Worldwide - Leading EU28-based Software Providers 2014 (in million EUR)				
Rank	**Company**	**Natio-nality**	**FY End**	**Revenue 2014**
1	SAP	DE	31-Dec-14	13,731
2	Dassault Systemes	FR	31-Dec-14	2,027
3	Ericsson	SE	31-Dec-14	2,004
4	Sage	UK	30-Sep-14	1,193
5	Siemens PLM Software	DE	30-Sep-14	984
6	Software AG	DE	31-Dec-14	623
7	Wolters Kluwer	NL	31-Dec-14	469
8	QlikTech	SE	31-Dec-14	379
9	Agfa HealthCare	BE	31-Dec-14	344
10	CompuGroup	DE	31-Dec-14	318
© PAC, February 2016				

Fig. 16: Leading EU28-based software providers (based on worldwide revenues)

- Apart from the Swedish company Ericsson, which offers technical software for the telecoms space, and Germany-headquartered Software AG, which provides middleware software, all the leading EU28 software vendors are business application specialists. Clear leader in this market in terms of revenue is SAP.
- Dassault Systèmes (FR) and Siemens PLM (DE) are strong players in the field of product lifecycle management applications, which are popular in the manufacturing industry worldwide.
- Wolters Kluwer, also a well-known publishing house, is a global provider of vertical business application software for tax accountants and lawyers. The company is headquartered in the Netherlands.
- Belgian Agfa HealthCare as well as German CompuGroup provide vertical business application software for healthcare institutions.

Top 10 IT service providers

EU28 - Leading IT Services Providers 2014 (in million EUR)				
Rank	**Company**	**Natio-nality**	**FY End**	**Revenue 2014**
1	IBM	US	31-Dec-14	11,378
2	HP	US	31-Oct-14	7,643
3	Accenture	US	31-Aug-14	6,943
4	Atos	FR	31-Dec-14	6,436
5	Capgemini	FR	31-Dec-14	6,337
6	Capita	UK	31-Dec-14	3,607
7	CGI	CA	30-Sep-14	3,409
8	Fujitsu	JP	31-Mar-15	3,304
9	TCS (Tata Consultancy Services)	IN	31-Mar-15	3,180
10	T-Systems	DE	31-Dec-14	3,059
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Fig. 17: Leading IT service providers in the EU28 region (based on EU28 revenues)

- Regarding IT services in the EU28, the largest players are US-based. However, with Atos, Capgemini, Capita and T-Systems, there are four EU28-based providers in the top 10. They are highly relevant on the global market as well.
- Among other things, IT service providers implement and integrate software and offer operational services for software. In addition, these IT companies are of major importance for the software market, as the success of companies such as SAP relies to a large extent on the partnership with this kind of providers.

Worldwide - Leading US-based IT Services Providers 2014 (in million EUR)				
Rank	**Company**	**Natio-nality**	**FY End**	**Revenue 2014**
1	IBM	US	31-Dec-14	36,493
2	HP	US	31-Oct-14	20,934
3	Accenture	US	31-Aug-14	19,686
4	CSC	US	31-Mar-15	8,581
5	Xerox	US	31-Dec-14	7,621
6	ADP	US	30-Jun-14	7,397
7	Dell	US	31-Jan-15	5,950
8	Deloitte	US	31-May-14	5,579
9	First Data (FDC)	US	31-Dec-14	4,942
10	Oracle	US	31-May-14	4,542
				© PAC, February 2016

Fig. 18: Leading US-based IT service providers (based on worldwide revenues)

Worldwide - Leading EU28-based IT Services Providers 2014 (in million EUR)				
Rank	**Company**	**Natio-nality**	**FY End**	**Revenue 2014**
1	Capgemini	FR	31-Dec-14	9,517
2	Atos	FR	31-Dec-14	7,748
3	Capita	UK	31-Dec-14	3,607
4	T-Systems	DE	31-Dec-14	3,562
5	Amadeus	ES	31-Dec-14	3,013
6	Sopra Steria	FR	31-Dec-14	2,960
7	Ericsson	SE	31-Dec-14	2,672
8	SAP	DE	31-Dec-14	2,624
9	Indra	ES	31-Dec-14	1,907
10	Serco	UK	31-Dec-14	1,895
© PAC, February 2016				

Fig. 19: Leading EU28-based software providers (based on worldwide revenues)

Top 10 cloud providers

Please note that in the presented cloud rankings, the revenues shown are those generated from IaaS, PaaS and SaaS taken together.

EU28 - Leading Cloud Providers 2014 (in million EUR)				
Rank	**Company**	**Natio-nality**	**FY End**	**Revenue 2014**
1	IBM	US	31-Dec-14	1,262
2	HP	US	31-Oct-14	1,006
3	T-Systems	DE	31-Dec-14	836
4	Atos	FR	31-Dec-14	713
5	Salesforce.com	US	31-Jan-15	690
6	Google	US	31-Dec-14	580
7	Amazon Web Services (AWS)	US	31-Dec-14	567
8	Microsoft	US	30-Jun-14	456
9	Capgemini	FR	31-Dec-14	342
10	Adobe Systems	US	30-Nov-14	340
© PAC, February 2016				

Fig. 20: Leading cloud providers in the EU28 region (based on EU28 revenues)

- Among the largest cloud providers in the EU28 region are the leading IT service providers. This is because these IT companies in particular have been transforming their business towards cloud computing (IaaS, SaaS and PaaS). They were forced to do so because of the success of vendors such as Amazon Web Services.
- In addition, IT service providers have become partners of cloud vendors. For example, T-Systems is a partner of Salesforce.com and Microsoft regarding local cloud data centres in Germany.
- Although SAP is a leading cloud provider at worldwide level (see figure 22), it is not among the top 10 of leading providers in the EU28 region (based on

2014 figures). This is because SAP has acquired a number of cloud vendors, such as SuccessFactors, Ariba, Concur and Fieldglass that generate most of their revenues in the US market. However, this is changing right now as SAP has started to offer these solutions in the EU28 countries as well.

Worldwide - Leading US-based Cloud Providers 2014 (in million EUR)				
Rank	**Company**	**Nationality**	**FY End**	**Revenue 2014**
1	IBM	US	31-Dec-14	4,600
2	Salesforce.com	US	31-Jan-15	3,812
3	Amazon Web Services (AWS)	US	31-Dec-14	3,493
4	HP	US	31-Oct-14	2,738
5	Google	US	31-Dec-14	2,417
6	Microsoft	US	30-Jun-14	2,296
7	Intuit	US	31-Jul-14	1,315
8	Adobe Systems	US	30-Nov-14	1,252
9	Oracle	US	31-May-14	1,131
10	Cisco Systems	US	31-Jul-14	677
				© PAC, February 2016

Fig. 21: Leading US-based cloud providers (based on worldwide revenues)

Worldwide - Leading EU28-based Cloud Providers 2014 (in million EUR)				
Rank	**Company**	**Nationality**	**FY End**	**Revenue 2014**
1	SAP	DE	31-Dec-14	1,117
2	T-Systems	DE	31-Dec-14	1,002
3	Atos	FR	31-Dec-14	789
4	Capgemini	FR	31-Dec-14	431
5	BT Global Services	UK	31-Mar-15	281
6	Orange Business Services	FR	31-Dec-14	235
7	Sage	UK	30-Sep-14	159
8	Telecom Italia ICT Services	IT	31-Dec-14	146
9	Sopra Steria	FR	31-Dec-14	121
10	OVH	FR	31-Dec-14	105
				© PAC, February 2016

Fig. 22: Leading EU28-based cloud providers (based on worldwide revenues)

3.5. Further market characteristics

This sub-chapter complements the market analysis for the following market characteristics: number of IT companies, R&D investments, innovation indicators.[3] The figures are largely based on official statistics; the SSBS sector is delineated in the box below.

SSBS in official statistics

Regarding the delineation of the software sector in official statistics, no common, widely accepted approach exists. Common definitions of ICT, e.g. from the OECD, usually include total ICT services, but do not specifically consider the software industry. In this report, the project team delineates SSBS in official statistics wherever possible by including the NACE sectors 58.2 "Software publishing" and 62 "Computer programming, consultancy and related activities". This definition was used in earlier studies[4] and can be regarded as suitable. However, it has to be pointed out that this delineation does not capture telecommunications (NACE 61). While telecommunication firms are increasingly offering services based on software-based systems, an inclusion of this entire segment in the SSBS market would lead to biased results. Moreover, "Data processing, hosting and related activities; web portals" (NACE 63.1) is not included. While this is in line with existing studies and the quantitative importance of this sector has been limited so far, it could be argued that an inclusion would make sense. However, only limited data is available for this sector and additional estimates based on assumptions would be needed to calculate the indicators.

Please note that there are some differences compared to the SMART 2009/0041 study, which limits the comparability between the two studies. While the data sources are identical, differences result mainly from changes in the NACE classification from 1.1. to 2.0. Moreover, the SMART 2009/0041 study does not include software publishing. However, this small sector is of minor importance to the overall results for SSBS. For all similar indicators the project team shows the differences in the results compared to the SMART 2009/0041 study, but they are interpreted carefully given the changes mentioned.

Moreover, in order to be able to point out the development in SSBS over the last five years, the project team uses time series from 2008-2013 for all indicators.

[3] Please note that the employment figures are presented in chapter 4.
[4] See Kimpeler, S., Wydra; S. (2010): Potenzialanalyse Kreativpark Karlsruhe. http://www.isi.fraunhofer.de/isi-de/t/download/publikationen/Report-Potenziale-Kreativwirtschaft-KA.pdf; Leimbach, T., Wydra, S. (2011). Software-Atlas Deutschland 2011. http://www.software-cluster.com/de/ergebnisse/studien/item/fraunhofer-isi-software-atlasdeutschland

Number of software companies

The number of SSBS enterprises is derived from Eurostat Business demography statistics. The number of software companies in Europe was around 632,388 in 2013 (see figure 23).[5] This was about 2.8% of companies in the total business economy[6] or 2.16% of the overall economy.[7] In the US, about 145,000 establishments are active in this sector, accounting for 2.17% of the overall economy.

The number of software enterprises in Europe grew by 31.4% between 2008 and 2013, which is considerably stronger than the economy-wide increase of 5.2%. The number of US software companies grew by about 12.4%, as opposed to a decrease in the total number of companies (-5.4%).[8]

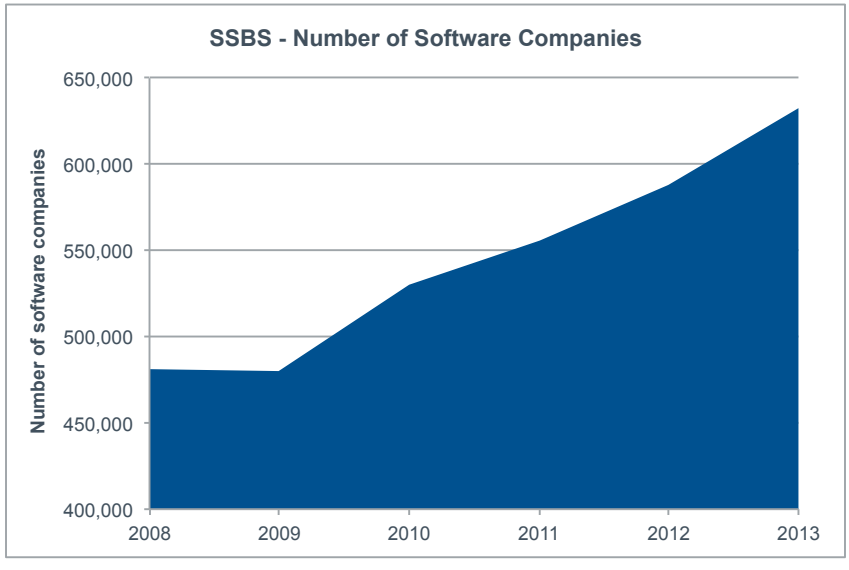


Fig. 23: Number of SSBS enterprises in Europe between 2008 and 2013 (source: Eurostat)

The countries with the largest number of software enterprises are shown in figure 24. The UK is still leading, with about 129,600 software enterprises in 2013. Nevertheless, the share of UK software enterprises in the EU decreased from about 23.4% to 20.5% until 2013 (*figures are not shown*). This is because many other EU countries had higher growth rates regarding the number of software enterprises than the UK.

[5] Ireland was estimated based on its value for 2008.
[6] Total business economy; repair of computers, personal and household goods except for financial and insurance activities, which means: including 'B-J & L-N + S95' and excluding 'A, K, O, P, Q, R, S94, S 96, T & U'.
[7] Including ‚B-S' and excluding 'A, K642, T & U'. It should be noted that the large number of companies within Europe might be the result of including freelancers into the statistics.
[8] All data for US companies as well as for employment and value added in this section is based on the Census Bureau's data.

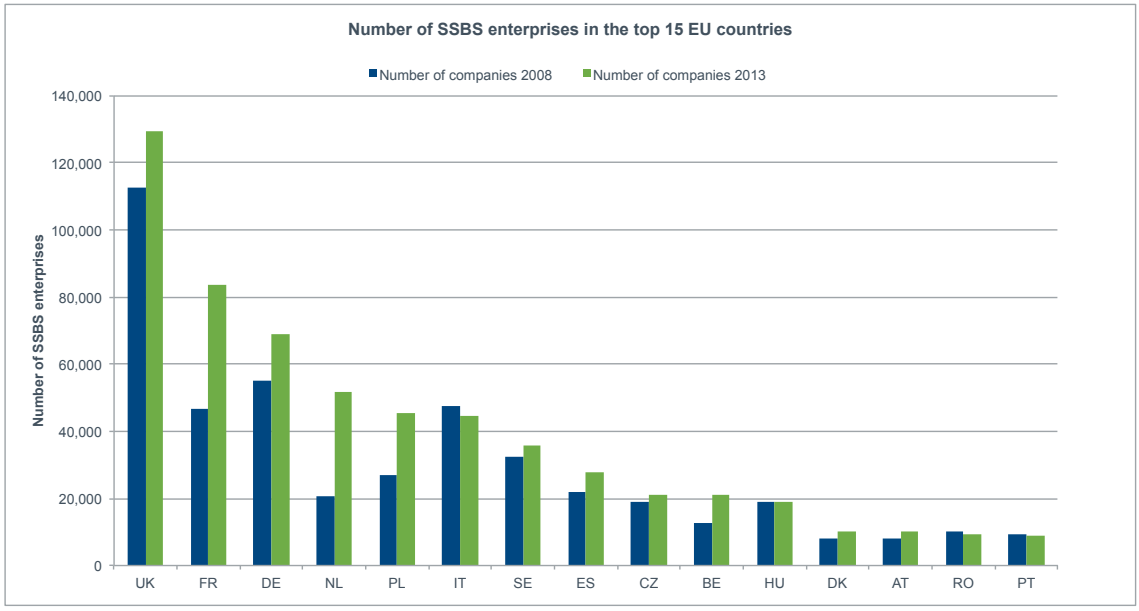


Fig. 24: Number of SSBS enterprises in the top 15 EU countries in 2008 and 2013 (source: Eurostat)

Distribution of SSBS companies by company size

In order to characterize the SSBS regarding company size, figure 25 shows the distribution of enterprises, turnover and employment by different enterprise sizes. Analyses are differentiated between three groups of SMEs (<250 employees): firms with 0-19, 20-49, and 50-250 employees; and one group of large enterprises (>250). E.g. 97% of all firms in SSBS are very small enterprises (0-19 employees). These firms account for 35.9% of employment in SSBS and the share of their turnover is around 25%. Large enterprises (>250 employees) represent only 0.2%[9] of SSBS; their employees make up around 33% of all SSBS employees. However, a comparison with the corresponding shares for the overall economy reveals that the distribution in SSBS almost perfectly reflects the overall economy. The only difference is that turnover seems to be more concentrated in SSBS, with large firms accounting for 51.5%, compared to 44% for the overall economy.

To sum it up, large companies are a minority in the SSBS space, but they are of major importance for total employment and turnover in this sector. However, this finding reflects the structure of the overall economy.

[9] In the US, this share (software enterprises with 500+ employees in relation to all software enterprises) is about 0.9%, which is considerably higher than the mean for the overall economy of about 0.32%.

		Enterprise size (employment)			
		0-19	20-49	50-250	more than 250
Number of firms	*SSBS (2013)*	*97.0%*	*1.9%*	*1.0%*	*0.2%*
	Overall economy[10] (2012)	96.7%	2.1%	1.0%	0.2%
Employment	*SSBS (2013)*	*35.9%*	*11.9%*	*19.2%*	*33.0%*
	Overall economy	38.7%	11.1%	17.2%	33.0%
Turnover	*SSBS*	*20.8%*	*10.2%*	*17.5%*	*51.5%*
	Overall economy	25.1%	10.7%	20.2%	44.0%

Fig. 25: Distribution of key economic indicators by enterprise size in SSBS (source: Eurostat Structural Business Statistics)

Creation and closures of software companies

Behind the overall development of the number of SSBS enterprises, there is a strong dynamic of creation and closures of enterprises. Figure 26 shows the birth rates (share of newly founded enterprises in active enterprises) in the SSBS market for the EU average and for the 15 countries with the largest number of firms. The EU average of 13% means that this proportion of enterprises just entered the market in 2013.[11] There are significant differences between the countries, albeit with no clear geographical pattern or maturity of industries. While Romania shows the strongest dynamic, some Western European countries with a high number of existing SSBS enterprises, such as the UK and France, still show significant birth rates. A comparison between 2008 and 2013 shows a stable development in the EU and in many countries, but in a few countries significant shifts occur, with an increase in Romania and a decrease in the Netherlands.

[10] Total business economy except for financial and insurance activities. 2012 data is used as more recent data is not available yet.

[11] Please note that there is no data available for a comparison with total birth rates for the overall economy in the EU. A comparison for those individual European countries for which data is available shows that for the majority, the SSBS birth rate is above average. This tends to indicate that dynamics in the SSBS sector are above average.

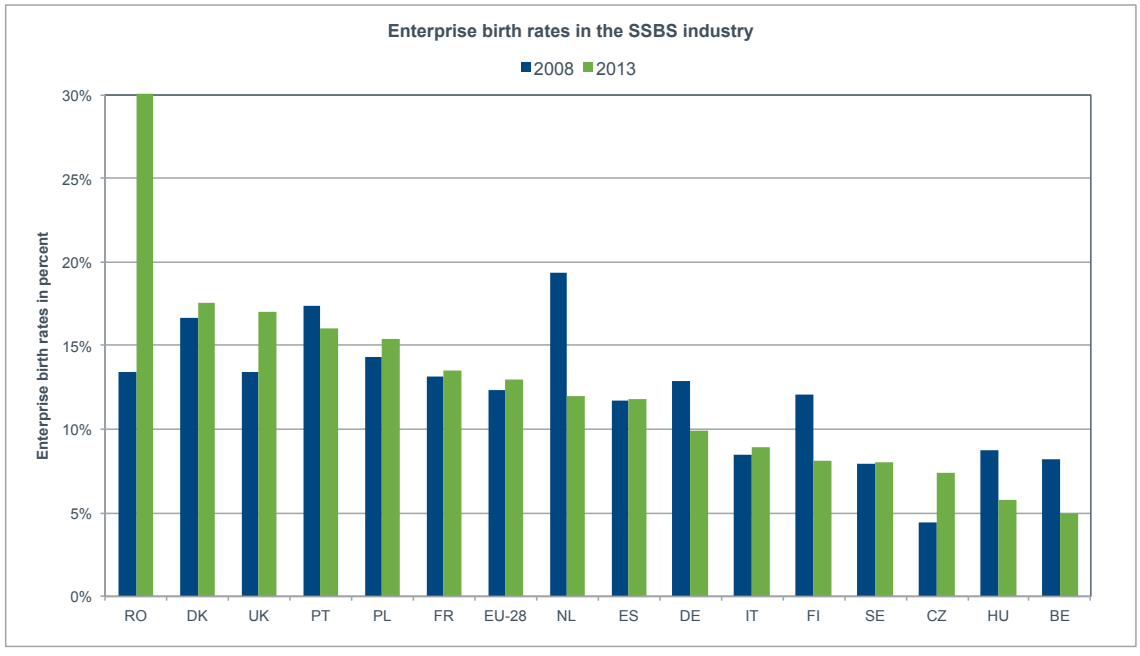


Fig. 26: Enterprise birth rates in SSBS (top 15 EU countries) in 2008 and 2013 (share of enterprise births in active enterprises) (source: Eurostat)

Concerning death rates (share of enterprise deaths in active enterprises), the patterns are quite similar (figure 27). The percentages for death rates are usually lower than for birth rates (e.g. 9% vs. 13% in the EU). Only in three EU countries (IT, CZ, HU), the death rate exceeds the birth rate, which reflects a negative development in the number of SSBS enterprises.

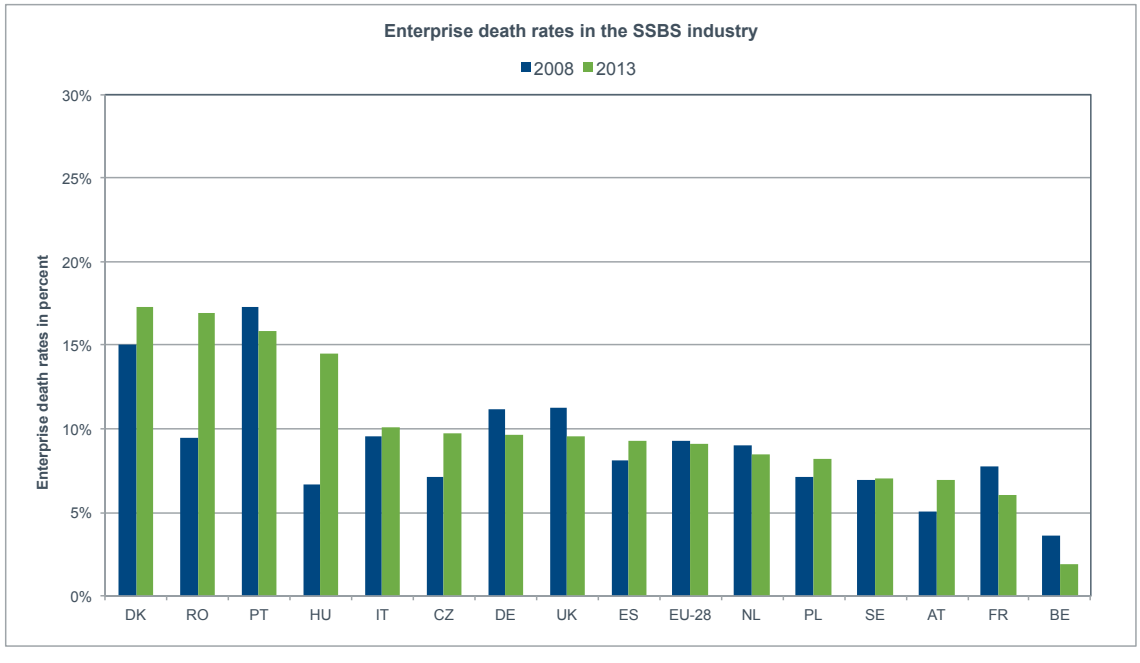


Fig. 27: Enterprise death rates in SSBS (top 15 EU countries) in 2008 and 2013 (share of enterprise deaths in active enterprises) (source: Eurostat)

To sum up, the evolution of enterprises shows that the SSBS industry in the EU is still on a growth path, although there are considerable differences between the countries.

R&D and innovation indicators

Business enterprise expenditure on R&D (BERD) in the SSBS market amounted to EUR 11.4 bn in 2012. R&D personnel numbers 140,000 full-time equivalents and presents almost half of the R&D personnel in the whole ICT sector in Europe (PREDICT 2015). Growth in software R&D investments clearly outpaces ICT manufacturing and the R&D development in the overall European economy. Between 2010 and 2012, R&D investment increased by around 9% p.a. (ICT: 5.5%, overall economy: 4%).[12] R&D personnel also grew significantly during that period, by about 6% p.a. (ICT: 4%).[13]

	BERD	R&D personnel
	(in million, current EUR)	(in thousand, full-time equivalent)
2010	9,535.71	124.91
2011	10,748.02	132.77
2012	11,391.67	141.26

Source: JRC PREDICT reports 2013, 2015

Fig. 28: Development of BERD and R&D personnel in SSBS in Europe between 2010 and 2012

Business enterprise expenditure on R&D (BERD) in the software sector accounted for around 6.7% of total BERD in the overall economy. This share is remarkable given the small size compared to other sectors.

However, the BERD data is not available for the software sector in other major economies for international comparison. For that purpose, the "EU Industrial R&D Investment Scoreboard" from the JRC is used. It has been published annually since 2004, monitoring top EU-based companies investing in R&D and benchmarking them with top investors located in other parts of the world. The 2015 Scoreboard contains 608 companies based in the EU, 829 companies based in the US, 360 in Japan and 703 from the rest of the world. As the Scoreboard only covers the top companies with regard to the overall amount of R&D investment given in published

[12] Data from the PREDICT study for ICT services and ICT manufacturing for 2007-2012 indicates that this trend is valid for a longer time period. While R&D investment in ICT services shows steady growth of at least 2.5% per year, R&D in ICT manufacturing has been decreasing for most of the years.
[13] Figures for the overall economy are not available for 2012.

annual reports and accounts, smaller companies are underrepresented in the figures.

The Scoreboard shows a strong dominance for R&D investments of the US, with EUR 48.5 bn vs. EUR 6.5 bn. in the EU (figure 29).[14] Moreover, the dynamics in the US is significantly higher. Companies based in the US continued to strongly extend their R&D investments, with an increase of 13.1% between 2013 and 2014, well above the growth rate for their competitors based in the EU (4.6%) and Japan (-5.7%). This trend is also reflected in R&D intensity (R&D expenditure/sales). While the US and the EU were on similar levels until 2013 (not shown in the figure), the US outpaced the EU and had a higher R&D intensity of around 2.5 percentage points (13.2% vs. 10.6%) in 2015.[15]

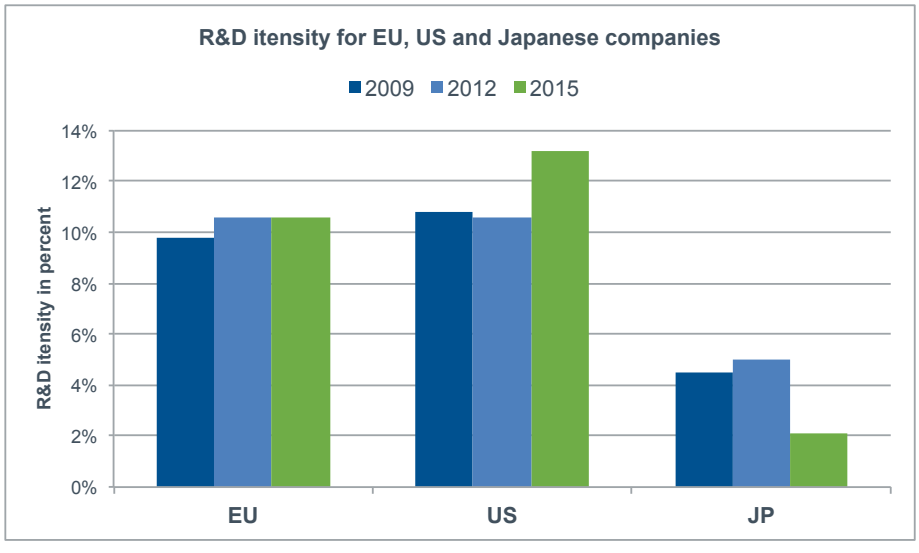


Fig. 29: R&D intensity for EU, US and Japanese companies in the EU Industrial R&D Investment Scoreboard (source: various EU Industrial R&D Investment Scoreboard reports)

R&D investments by the top performing countries in software & services are geographically highly concentrated. Almost 80% of the companies in the 2015 R&D Scoreboard are from the UK, Germany or France.

[14] For these figures the Scoreboard provides more detailed data: R&D investment in software in the US is EUR 28.3 bn vs. EUR 4.9 bn in the EU, while Internet and computer services amount to 20.2 vs. 1.6. The difference against the above-mentioned BERD figures for Europe is most probably due to the fact that the Scoreboard only covers the top R&D spenders.

[15] The SMART 2009/0041 study gives an R&D intensity for SSBS in Europe of around 14.0% for 2006. The difference may be due to classification changes, and not necessarily to a decline in R&D intensity in Europe.

Other innovation indicators

It is widely acknowledged that R&D is just one relevant innovation indicator, but does not capture the full range of innovation activities or their outcomes. The most comprehensive source of innovation indicators on a sector level is the Community Innovation Survey (CIS) coordinated by Eurostat. However, there is no data for software publishing (58.2) available. As this sector only represents a minor share of activities in the SSBS industry as delineated in this study (e.g. share of employment in software is less than 10%), its omission in the following presentation of data should have no significant effect on potential biases of the results.

The results show clearly that the SSBS market is highly innovative (see figure 30). More than 70% of the enterprises in the SSBS industry are innovative, compared to less than 50% in the overall economy. The main type of innovation is product-related, a pattern that is less visible in the overall economy, but other types of innovation also play an important role in the SSBS market. As SSBS is a very important part of total ICT services, the indicators show only limited variety, but for all types of innovation, SSBS outpaces total ICT services.

	Innovative enterprise total (in %)	Product innovative enterprises (in %)	Process innovative enterprises (in %)	Marketing innovative enterprises (in %)	Organization innovative enterprises (in %)
Total (innovation core activities)[16]	48.9	23.7	21.4	24.3	27.5
Total ICT services	68.2	46.3	29.4	38.7	42.2
SSBS (only computer programming, consultancy and related activities)	71.3	55.8	33.6	40.7	47.3

Source: Eurostat Community Innovation Survey data

Fig. 30: Innovative enterprises by type of innovation (in % of all firms in the sector) in 2012

[16] All sectors, but excluding agriculture, fishing, forestry, administrative and support service activities

4. Economic and Social Contribution of the Software Industry

The software industry has a strong economic and social impact throughout the European Union. There is the direct economic contribution from this dynamic industry, its contribution to the wider economy through knowledge spillover and the provision of new technological possibilities, as well as its tremendous effects on society in general. In the following chapter the current contribution of SSBS (see definition of the SSBS industry in official statistics in section 3.5 "Further market characteristics") to the EU economy as well as an assessment of the potential future impact are presented.

4.1. Current contribution to the EU economy and potential future impact

Current contribution

The contribution of the SSBS industry in the EU is measured here in different terms: number of employees, value added and productivity (see section 3.5 "Further market characteristics"). Then the economy-wide impact of software on growth and productivity is discussed through a literature review.

Employment

The workforce in the SSBS industry in the EU was 3,144 million in 2013[17], which is about 2.36% of the total business economy or 2.33% of the overall economy (figure 33). In the US,[18] about 2.02 million employees (2012) work in the software sector, accounting for about 1.74% (overall economy).

Software sector employment in the EU grew by 16.06% between 2008 and 2013, as opposed to a decline in employment in the total business economy of about -3.35%. In the US, the software sector grew about 22.9% between 2007 and 2012. Employment in the overall economy decreased by 3.9% during that period.

[17] In the SMART 2009/0041 study, employment in SSBS amounts to around 2.7 m persons. This figures is equal to the employment for 2008 given in the current study.
[18] Unfortunately no comparable data is available for India.

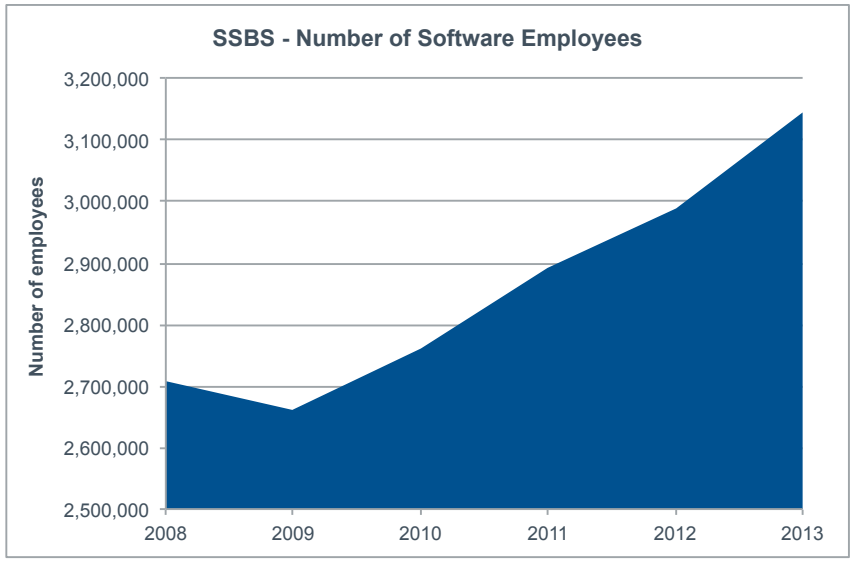


Fig. 31: SSBS employment in Europe between 2008 and 2013 (source: Eurostat)

Almost half of the employment in SSBS is concentrated in three countries, France, Germany and the UK (figure 34). In most countries the number of software employees has increased since 2008. The largest increase was in Germany (+167,900 employees; +36.9% on 2008), which took over the leading position from the UK during that period. The only decrease took place in Greece (-280; -1.4% on 2008).

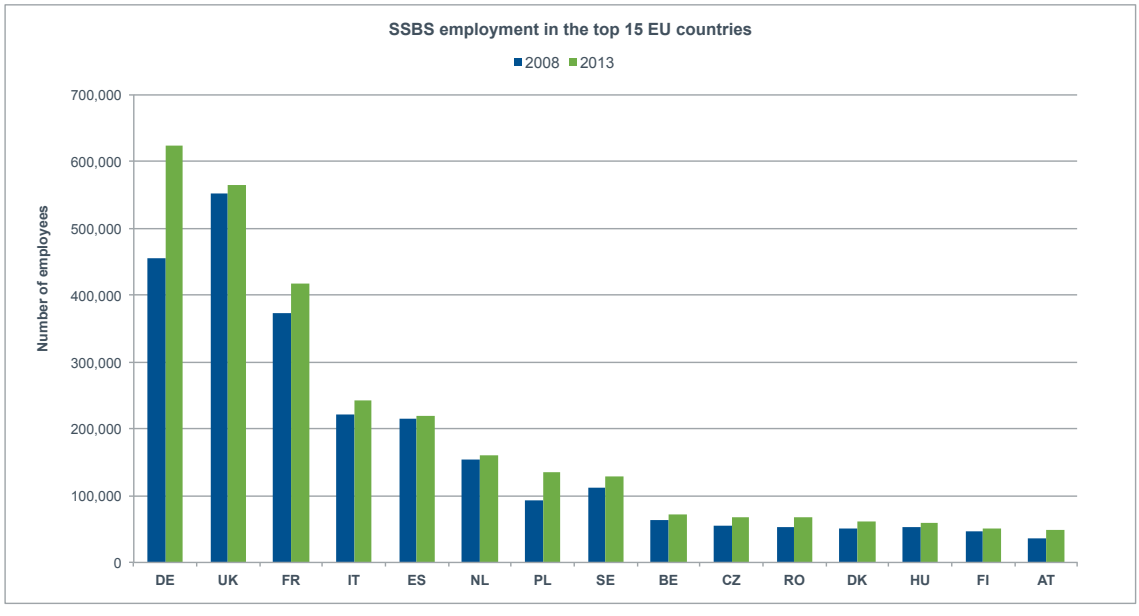


Fig. 32: SSBS employment in the top 15 EU countries between 2008 and 2013 (source: Eurostat)

Value added

The value added of the European SSBS sector amounted to about EUR 220 billion in 2013. This is about 3.56% of the added value of the total business economy[19] (figure 35). The growth of value added in the SSBS sector (20.2%) exceeded the total business economy growth in the EU28 of 3.78% between 2008 and 2013. However, compared to the SMART 2009/0041 study, value added growth is lower than in the 2000-2006 period (~50%). This decline in growth rates in the SSBS sector mainly mirrors the overall decline in value added growth in the economy.

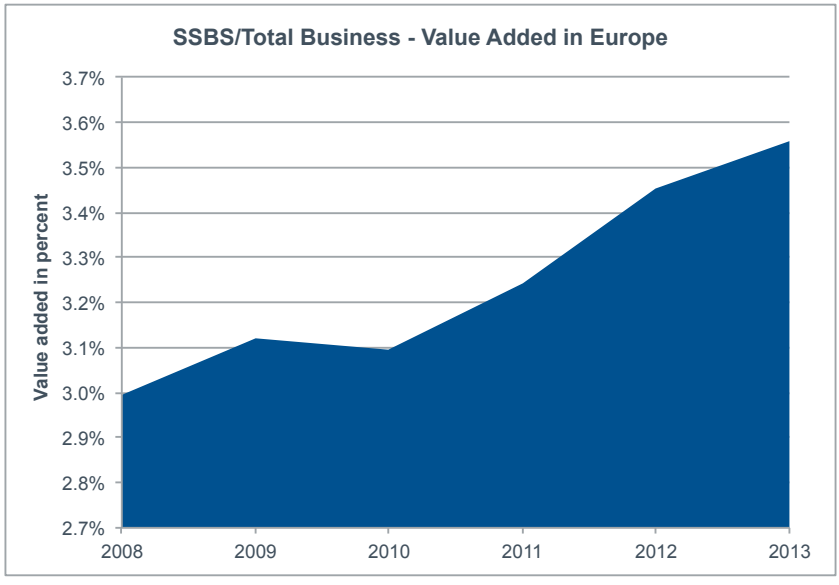


Fig. 33: SSBS value added in Europe between 2008 and 2013 (in % of total value added of the business economy) (source: Eurostat)

When looking at all EU countries (figure 36), the UK has the largest share of SSBS value added in total GDP (4.89%). The smallest share can be found in Greece (1.06%). In most countries the share of the software sector's value added has increased since 2008, with a few exceptions (Denmark, Belgium, Ireland).

[19] Total business economy except for finance and insurance activities.

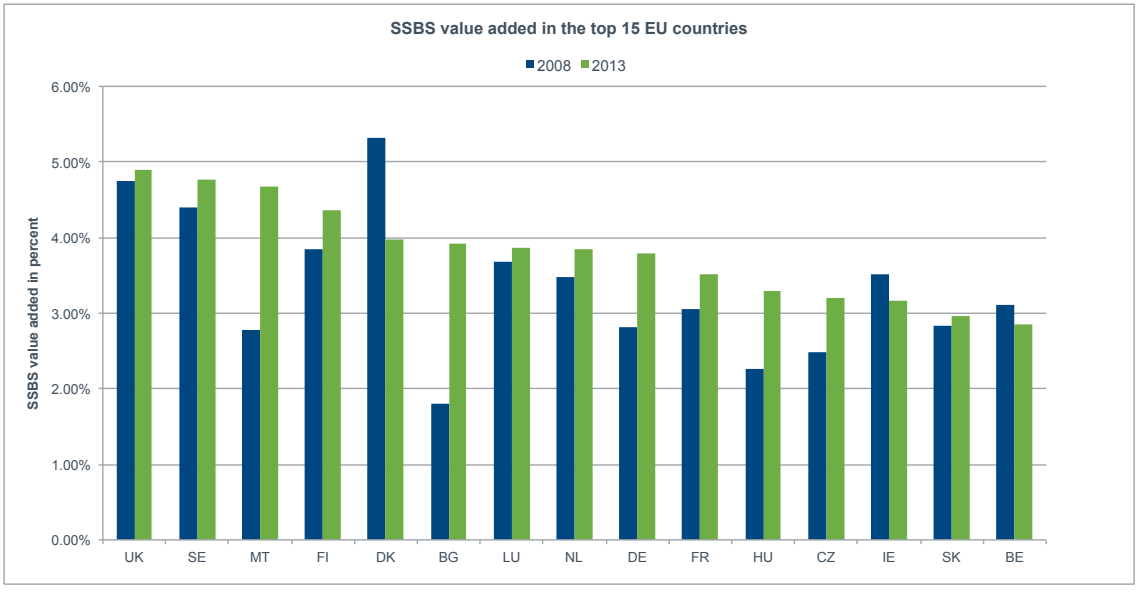


Fig. 34: SSBS value added in the top 15 EU countries in 2008 and 2013 (in % of total value added for total GDP) (source: Eurostat)

Productivity

The productivity (measured in value added per employee) of the SSBS industry averaged about EUR 70,500 per employee in 2013 (figure 37). This is about 50% higher than the productivity for the total business economy of EUR 46,800. However, productivity in SSBS grew by about 3.3%. This is below the total economy productivity growth of 4.4%. This means that while the number of employees and the value added in the SSBS industry has been growing fast, valued added per employee has remained rather flat.

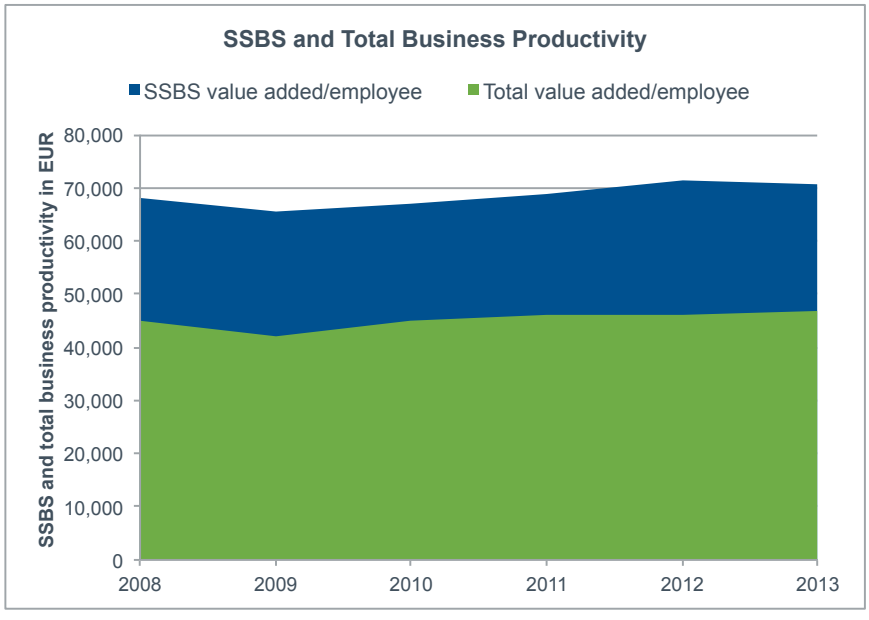


Fig. 35: SSBS and total business productivity in Europe in 2008 and 2013 in Euro, value added per employee (source: Eurostat)

These productivity figures are difficult to compare for different EU countries because of varying purchasing power. Instead, it is more interesting here to compare the differences between the productivity of the software and total business sector and the changes in these two (figure 38). In some countries the difference between software and the total business sector is small, e.g. in Denmark (2.69%), in others it is quite big (e.g. UK, Malta).

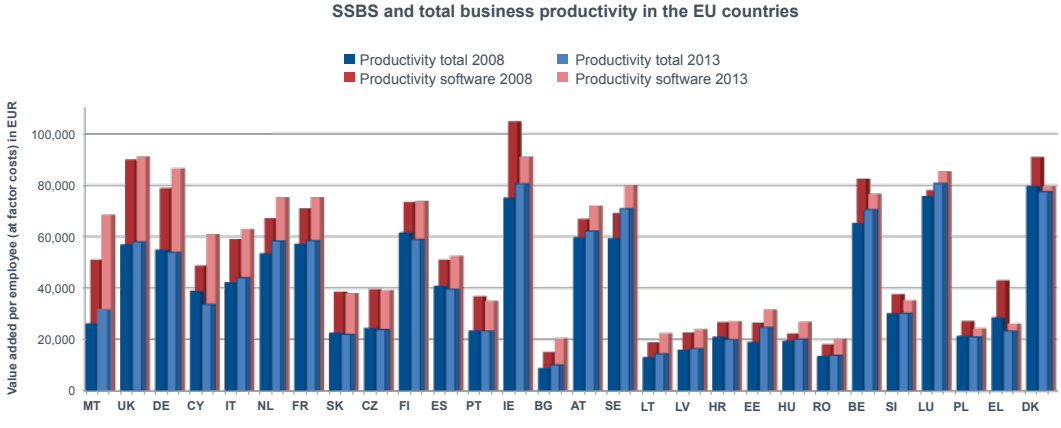


Fig. 36: SSBS and total business productivity in the EU countries in 2008 (left) and 2013 (right) (source: Eurostat)

Impact on growth and productivity in the total economy

As the 2009 study already noted, there is a large amount of literature examining the links between the ICT sector and the overall economy, but only little evidence of the impact of the software industry. This statement also holds true for literature

published in the past 5-7 years. This is why most of the non-exhaustive, updated results below are related to ICT as a whole, but, wherever possible, the specific impact of software is mentioned.[20]

The impact of ICT on economic growth or productivity growth is usually analysed in a growth-accounting model over time and between countries. Economic output, or GDP, is usually determined by the level of inputs (usually capital and labour). Productivity (labour productivity or TFP) is the efficiency with which these inputs are transformed into economic outputs. Usually, analyses distinguish between three different channels through which information and communication technology impacts economic growth and productivity:

- Rapid **technological advances** in ICT producing industries leading to productivity gains: The rapid technological progress in the production of certain ICT goods and services has contributed to a rapid decline in prices and thus to higher productivity and growth in real volumes (Jorgenson, 2001).
- Effect of ICT investment on labour productivity growth through **ICT capital deepening:** ICT plays an important role in increasing investment in overall physical capital due to the steep decline in ICT prices over the past decades, which has encouraged investment in ICT, at times shifting investment away from other assets (Jorgenson, 2001, 2003). Moreover, the continued decline in prices for software and services has led to software and computer hardware replacing other types of capital or labour (Eicher/Strobel, 2007).
- Total factor productivity (TFP) growth, which **increases efficiency through greater ICT use**.

According to various reviews of this literature (Castaldi/Dosi 2008; Gontermann/Grömling 2011; Pilat 2004) as well as recent research (e.g. vanArk 2014a; Byrne et al. 2013; Corrado/ Jäger 2014), some important "stylized facts" can be highlighted:

First of all, ICT has strong and pervasive effects. Especially in the 1995-2000 period, ICT investments and activities pushed productivity growth in ICT, after a long slump in productivity, despite the significant penetration of ICT. After the early 2000s, ICT still made a positive contribution in most major industrialized countries (US, Japan, EU) and time periods. According to van Ark (2014b), for instance, the average overall ICT contribution was about 1 percentage point of EU GDP growth before the crisis, which is substantial given the overall market sector output growth rate of just over 2%. However, since the economic crisis, overall GDP growth and labour productivity growth, as well as the total contribution of ICT have fallen, but remained positive with the exception of the year 2008 (van Ark 2014b).

[20] However, it has to be noted that there are various difficulties in determining software investment in official statistics, over time, in particular when calculating volumes at constant prices, which requires separating price from real effects. This is difficult given the tremendous changes in quality that have to be taken into account here.

Second, the channels of **technological advances in ICT sectors and ICT capital deepening contributed mostly to GDP growth and productivity**. As mentioned, only few studies explicitly present results for software. A recent study by economists from the Federal Reserve Board on the US found that software contributed 0.16% to labour productivity growth through capital deepening and 0.08% through technological advances between 2004 and 2012. This contribution was around one third lower than in the 1995-2004 period, for which the highest growth effects for ICT were recorded. Based on these figures, Shapiro (2014) found that software accounted for 12.1% of all labour productivity growth from 1995 to 2004 and 15.4% of labour productivity gains from 2004 to 2012.

For Europe, Cette et al (2015) found lower effects for software **capital deepening** in the Euro zone than in the US, but positive and stable over time, at around 0.07-0.08% for all periods considered (1974-1995; 1995-2004; 2004-2013). Van Ark (2014) reports a great importance of **technological advances** in software for growth in the EU-8,[21] with a contribution of around 0.1 percentage point in the 2008-2011 period.

In addition, Edquist and Henrekson (2015), who take into account both channels, point out for Sweden that the impact of software has been significantly higher than that of hardware. On average, if the software capital stock increases by 10%, value added in the economy increases by 2.2%. Similarly, in an older study for Germany, Eichner and Strobel (2007) found larger effects for software than for hardware.

This means that software has contributed to labour productivity through both technological advances and capital deepening over the past few decades.

Third, as already mentioned, there are **substantial differences between countries**. In aggregate terms, countries with a strong and dynamic presence in ICT show a better overall performance. The US has outpaced the EU in growth and productivity gains related to ICT over the last two decades. While most of the productivity gap between the United States and Europe at the end of the 1990s can be attributed to the relatively smaller size of total ICT investment and smaller ICT-producing industry (van Ark et al. 2002; van Ark 2014 and see above), the recent gap is due to differences in total factor productivity in non-ICT sectors**,** which includes effects on efficiency from greater ICT use.

However, this contribution to **efficiency from greater ICT use** is most puzzling and unclear. In some countries (notably the US and AU), there is evidence that sectors that have invested the most in ICT, such as wholesale and retail, have experienced an increase in overall efficiency (see 2009 study). However, it is very difficult to assess the impact, as many other factors also affect TFP in these sectors.

[21] EU-8 refers to the weighted average of contributions from eight EU economies, see van Ark 2014b.

ECIPE (2015), for instance, compares software capital investment in sector GDP with TFP growth in various non-ICT sectors. However, TFP is "…only positively related with software investment to some extent across sectors" (ECIPE 2015, p.6). They argue that the partly missing link is caused by the inefficient allocation of resources because of distortions in complementary policies (e.g. changes in labour market regulations, etc.). This is why firms that use software are not able to achieve high growth rates. ECIPE presents a model that estimates the impact of complementary policies in interaction with software capital intensities on TFP in the other sectors. According to van Ark (2014b), the ongoing negative development of TFP as a sign of weaker technological progress and innovation in Europe in combination with various increased rigidities (e.g. products, labour) lead to greater misallocation to less productive firms. Both ECIPE and van Ark regard this development of TFP as most worrying since the capacity of digitalization to accelerate growth will come primarily from the use of these technologies by industries in the non-ICT sector (van Ark 2014b), as the contributions of technological advances and capital deepening from ICT are rather stable and they see no great uptake to boost growth rates. In brief, most of the near future potential of ICT, and in particular software, to contribute to growth and productivity is regarded to be related to its sufficient use in non-ICT sectors and the current framework conditions in Europe are seen as unfavourable.[22]

Potential future impact

Regarding the potential future impact on the development of employment, the current study relies on the Cedefop skills forecast. According to this forecast, the number of jobs in the ICT services sector will grow by 8.6% in total between 2013 and 2025. Based on this, which can be regarded as rather conservative given the fact that the software industry has grown faster than the total ICT services industry in recent years, SSBS employment can be estimated to grow at about 3% annually and will reach a rate of 3.41% in 2025.[23] While a forecast of future employment generally comes with high uncertainties, this estimate appears rather low given the fact that SSBS employment grew by around 400,000 in the past 5 years.

Besides its own contribution to employment, there will be the impact of software on overall employment and on the demand for skilled workers in the economy. As software plays an important role in the digitalization of the economy, it will have deep effects on the labour market. According to an expert survey by the World Economic Forum (2016), mobile Internet and cloud technology as well as advances

[22] Please note that van Ark 2014a and ECIPE 2015 focus on macropolitical and macroeconomic conditions regarding the development of non-ICT sectors, which differs from the scope in section 4. As a consequence, the identified barriers differ from each other.

[23] The 2009 study relied on the EC-commissioned study "Monitoring the e-skills demand and supply in Europe". In the update of this study, Gareis et al (2014) estimate very similar growth rates (difference in growth rates <0.1% p.a.) for ICT jobs to that in the Cedefop study. As the Cedefop study also explicitly covers ICT services and comprises a longer time horizon, this study is used here.

in computing power and big data are the most important technological drivers of change in the labour market.

However, views are divided on the overall impact of digitalization on employment. Some foresee massive job losses, e.g. through the substitution of human services in legal and financial matters by scanning thousands of legal briefs and precedents to assist in pre-trial research; interactive voice response systems to replace personnel in call centres; driverless cars leading to layoffs of taxi and truck drivers, etc. The quite well-known study (e.g. Frey/Osborne 2013) predicts that over the next few decades, 47% of the current number of jobs in the US may be taken over by computers or robots. However, the study has been strongly criticized for methodological shortcomings (e.g. Bonin et al. 2015; Schmoch et al. 2016). Among other things, they do not include the impact of the creation of new jobs and do not take into account the fact that job profiles may change, but not necessarily disappear if some tasks are automated. Nevertheless, others are also sceptical about the net employment effects of digitalization; e.g. the WEF estimates a net global employment loss of more than 5.1 million jobs over the 2015–2020 period.

Other experts are more optimistic. First of all, they estimate the plausible achievable substitution of human workers to be lower. Author (2014, p. 2), for instance, says: "Tasks that have proved most vexing to automate are those that demand flexibility, judgment, and common sense—skills that we understand only tacitly—for example, developing a hypothesis or organizing a closet. In these tasks, computers are often less sophisticated than preschool age children. The interplay between machine and human comparative advantage allows computers to substitute for workers in performing routine, codifiable tasks while amplifying the comparative advantage of workers in supplying problem solving skills, adaptability, and creativity." Furthermore, machines often take over only some tasks of an occupation. This often leads to a change in how specific activities are carried out organizationally, resulting in the specialization of the labour force, but not in the replacement of complete jobs.

Second, some emphasize opportunities in newly emerging job categories, improvements in workers' productivity and less routine work (WEF 2016). New economic sectors may develop that generate new demand for labour. Digital entrepreneurship is a key factor here. For example, big data architects, iOS developers, digital marketing specialists and data scientists are all jobs that barely existed five years ago (OECD 2014; IDEA 2015). This effect is reflected in the expected growth of employment in the SSBS industry (see above). Moreover, productivity gains caused by digitalization result in lower unit costs of production, which increases the competitiveness of the sector and its market share, and may stimulate total demand because of potentially falling prices. In the context of

Industry 4.0, for instance, BCG claims that new investments and increases in the competitiveness of the respective country will lead to demand for labour that outweighs the number of lost jobs (BCG 2015). Wolter et al. (2015) expect net job losses in Germany to be moderate because new jobs will be created (Wolter et al. 2015). Undoubtedly, the necessary skills and tasks of many employees will change profoundly and demand for specific skill groups will rise. The WEF (2016), for instance, expects demand for software and application developers and analysts to rise not only in the ICT sector, but also in other sectors (e.g. professional services).

To sum up, the future impact of software on the labour markets is expected to be tremendous, according to most experts. Still, the overall impact is hard to predict.

4.2. Current contribution to EU society and potential future impact

Regarding the current and potential future (5-10 years) contribution of software to EU society, the project team has identified 10 social domains based on the 2009 study and considered a bunch of literature for updating (e.g. Leimbach/Bachlechner 2014; WEF 2015; WKO 2015; BCS 2013; EC 2014). The results are summarized in the table below:

Social domain	Domain definition	Current contribution	Potential impact
e-access and e-government	Use of information technology by government agencies to transform relations with citizens, businesses, and other arms of government	The Internet it is widely available with access for all and increasingly offered as universal public service (e-access). More and more services offered by public administrations are available over the Internet (e-government).	The Internet is widely available (often for free in public spaces), and in some countries a fundamental right and a universal public service. E-government services make it easier for citizens to use public services because they save time, travel and money and they are more user-friendly. They also make public administrations more efficient, as many administrative processes can be streamlined and data can be connected (reuse of available data). E-government services are the first level of

Social domain	Domain definition	Current contribution	Potential impact
			involving citizens in public decision-making. Higher levels are e-public, e-participation and e-voting, resulting in an e-democracy.
e-inclusion	Use of digital information by all members of society in order to avoid a reduction in opportunities for those who do not have or cannot understand the technology.	Internet services allow disadvantaged people to be involved in working contexts they could not access before.	More economic participation of disadvantaged persons or people living in remote or underdeveloped regions via digital connections (e.g. smartphones). Social software as a tool to alleviate the social exclusion of marginalized groups. Higher employability level of the participants in e-inclusion programs. User friendliness: ICT becomes more accessible (frequent use: remote medicine, virtual leisure). Improved digital literacy through software-based learning tools.
e-work	Impact of digitalization on workflows, work structures and demand for skills.	Reduced importance of distance Mass customization More efficient and environmentally friendly production of goods.	Older employees work longer thanks to the preservation of their productivity through ICT. Less routine tasks for workers. Improved capacity to perform tasks or produce goods and services with visual aids. Flexible and family-friendly working conditions (work-family balance). Advanced manufacturing

Social domain	Domain definition	Current contribution	Potential impact
			makes production sites more efficient by connecting and coordinating data and materials, new ways of producing customized products, users can design their products online.
Benefits for consumers from the optimization of economic processes	Consumers benefit from the optimized use of application software in the production or consumption process.	Collaborative consumption enables better asset utilization. Increased access to tools and other useful physical resources.	Information and communication technologies allow more customer-oriented and customized services. Instead of producing the same product for all, products can be tailored to the needs of special target groups or even individuals. There is huge potential for services regarding many everyday objects (rental, after-sales service, maintenance).
e-education	Learning by using and managing appropriate ICT technologies	Use of ICT technologies as support materials. Access to high-quality teaching courses for everyone connected to the Internet. More efficient university administration and organization of teaching. Reduced	Internet in schools and universities: learning tools, more interaction with teachers, network layout for classrooms, more creativity, including 3-D and audio-visual material, personalized education: real-time measuring of and adaptation to needs, direct access to high-level university teaching through MOOCs (massive open online courses).

Social domain	Domain definition	Current contribution	Potential impact
		importance of distance.	
e-health	Healthcare practice supported by electronic processes and communication	First steps to e-health, e.g. partial remote access to patient data, pilots for integrated e-health services	Remote e-health service procedures facilitating access to healthcare, with better efficiency and cost control. Developed health warning plan (via mobile, Web). Real e-health and mobile e-health services allow personalized intervention (to shorten intervention time), remote monitoring of treatments, remote advice and consultation, virtual consultation with doctors, remote diagnosis and surgery via mobile health. Big data: Identify pathogenic organisms, develop new therapies etc. through the analysis of large amounts of data from different sources. Care: Elderly, disabled or sick persons can longer live in their community (better quality of life; less resources for care). M-health: More self-sufficiency, self-managed healthcare, better decision-making.
Smart energy	Intelligent integration of energy sources and power consumption to form the future	Advanced smart grid services first for companies, then for private households	Smart grids: Usage-centred distribution of renewable energy; control and monitoring of consumption. Real-time monitoring of

Social domain	Domain definition	Current contribution	Potential impact
	energy ecosystem		energy prices, selection of energy sources according to availability, ensuring energy continuity, automatic management of energy depending on the environment (weather, temperature, light, time, number of people, etc.).
e-security	Process of ensuring the confidentiality, integrity and availability of electronic information	Digital signatures and digital security technologies	Reliable electronic identity management: positive effects on e-commerce and e-administration. Private and business data as well as critical infrastructures are protected, avoiding serious incidents. Industrial risk prevention (traceability, infrastructures, disasters, etc.). Defence and homeland security: pattern recognition and data processing, securing of networks.
Sustainable development	Contribution of software to sustainability	Using the Internet for environmental needs	Optimized measurement/ metrics of carbon footprint: management software including carbon accounting (and associated costs), environmental audit (modelling of eco-balance, etc.), embedded software calculating and communicating the eco-balance of things/products. GIS more efficient:

Social domain	Domain definition	Current contribution	Potential impact
			optimization of city planning, land settlement. Reduced or eliminated materials as well as reduced travel/shipment thanks to electronic delivery (e.g. e-books) or on-demand production. Advances in climate change research (e.g. improved forecasts) because of new possibilities to analyse large amounts of data from different sources.
Transport and mobility	Direct and indirect changes in the transportation sector due to software applications	Some pilots for connected mobility, public transport automation (tramway, subway) and traffic management. Supply chain: tracking, yield management. Digital assistance systems to enhance driver security.	Increased public transport automation (one ticket for tramway, subway, railway, etc.); interoperability of mobility solutions (e.g. ticketing). Modes of transport are more integrated: intermodality (via smart geo-localization, including information on passengers). Virtual mobility increasingly replaces physical mobility (remote services, remote working etc.). Travel optimization: improved energy efficiency of vehicles, information about travel time, adaptation to weather conditions (advice, automatic assistance, mobility optimization).

Social domain	Domain definition	Current contribution	Potential impact
			Private vehicle automation (incl. anti-collision systems, adaptation to road signage, etc.), leading to more efficient and less risky traffic. Enhanced driver security through digital assistance systems (distance regulation, emergency break, e-call). Intelligent infrastructure: adjustment to the traffic.

5. Identification of Key Drivers and Opportunities for the Software Industry

5.1. Key technological trends and their impact on software value chain and ecosystems

Numerous technology trends may have a major impact on the development of the SSBS market in the coming years. Depending on their benefits, their cost and their level and pace of adoption by end users (niche or mass market), they may more or less help to accelerate the growth of the overall SSBS market.

These key trend topics, which represent drivers and opportunities for the European software industry, are the main reason why Europe should invest in software technology. At the same time they are the main areas the European Commission should focus its research investments, regulations and political actions on. Thus, the identification and evaluation of key topics – now and in the future – is critical for this mission.

The following paragraphs describe the most relevant trends and their impact on the size and growth of the European software market, the value chain and ecosystems. The project team particularly considers the impact on the three aspects of 1) software development, 2) software distribution, and 3) provider landscape. Potential changes in the topics' relevance for the European software industry compared with the 2010 study are discussed shortly. In the table displayed at the end of this chapter the project team assesses the maturity of each topic in Europe and the competitiveness of European IT providers for each topic compared with the global competition. In addition, comparisons with other countries are drawn.

Something that is very similar for all the topics analysed is the fact that they often represent highly dynamic market segments with many new, innovative players entering and with traditional players having to drastically modify their traditional software and market approaches. In addition, these topics often require an additional set of skills – often resulting in a topic-specific skill shortage.[24] Furthermore, as is the case for all innovative software areas, IT service providers need to be able to help companies identify topic-specific business cases.

For each topic the project team provides the following details:

- Description of developments;
- Impact on software value chain and ecosystems;
- Impact on European software vendors, software-related service providers and games developers.

For the evaluation of the maturity of each topic as well as the competitiveness of the software market in the EU28 region, the following evaluation schema is used:

[24] For barriers see also chapter 7.

Maturity	Competitiveness
Definition: Adoption of topic within companies as well as in the local software industry. Presence of local vendors.	**Definition:** Ability of software vendors headquartered in the EU28 to compete with global players in EU28 markets.
Emerging	low
Growing	medium
Mature	high
Declining	very high

Digital transformation

Description of developments[25]

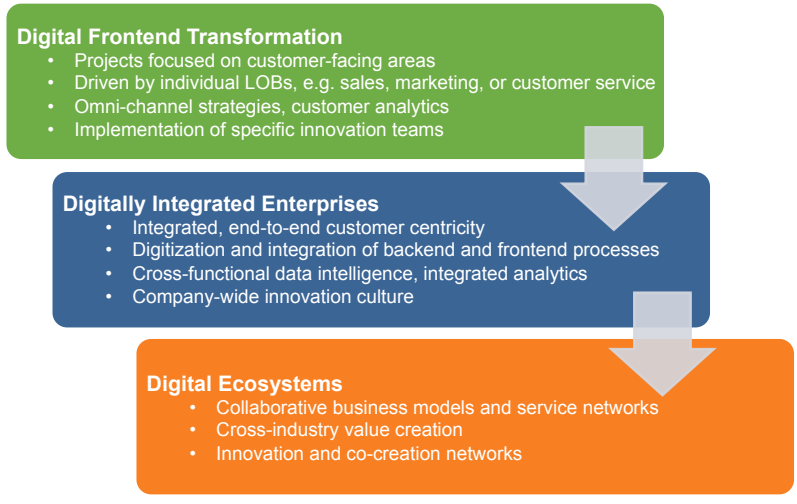
Software providers in Europe and worldwide are currently faced with highly dynamic market conditions and have to find appropriate ways to address these. This is due to the fact that digital transformation has become a primary strategic focus of companies in all industries over the past months. On the one hand, companies need to continue their business efforts to become more efficient and innovative with the help of software. On the other hand, they want to support their digital initiatives with software.

Back-office processes (e.g. financial accounting, inventory management, etc.) have been digitized with the help of business applications for many years now. Today, the majority of digitization activities centre on front-end transformation (e.g. sales, marketing) and are primarily driven by the need to improve the customer experience across all digital and non-digital interaction channels. For software providers with a related portfolio this currently creates above-average revenue growth in customer-facing market segments.

However, companies are increasingly looking for solutions and providers that can accompany them during their entire digital transformation journey, including sales/marketing, customer service, supply chain management, procurement, and logistics. Thus, they are broadening their view from customer-facing areas to becoming digitally integrated enterprises. Cross-functional and front-end/back-end integration will make the difference in the business strategies of the future. The project team therefore expects that for both software buyers and software vendors,

[25] Many insights are taken from PAC's SITSI Market InSight "Digital Transformation: How Should Software Providers Move Forward?", 2016.

the need to define and execute holistic digital strategies and concepts will rise significantly over the coming months.



European software and SaaS providers need to be able to best address the broad range of requirements in order to gain a strong position in this rapidly changing market. They need to adapt their product and market strategy to the digital transformation business. This implies transforming themselves in order to support their digitally transforming customers.

	Maturity	Competitiveness
Digital transformation	Emerging	Medium
	Today, the majority of digitization activities center on front-end transformation, but companies are moving on to become digitally integrated enterprises. Highly dynamic market as many European companies start new digital initiatives. Many European software vendors are currently defining their solution strategies for digital transformation.	The European software industry is able to grow this business in spite of the competition from US-based vendors. Local know-how about consumers' preferences and behavior is very important when discussing digital front-end transformation. The EU digital single market may support EU-wide business expansion for software vendors, because common standards will facilitate cross-border business. Many SMAC technologies (SMAC=Social, Mobile, Analytics & Cloud) are based on OSS: This could provide an alternative to middleware platforms from US-based vendors.

Impact on the software value chain and ecosystems

Software development: Digital transformation leads to a significant transformation of software development. As companies define digital agendas and launch initiatives for digital transformation, they evaluate if and how their existing software fits into this. The various trends of digitization, such as mobile technologies, cloud computing, big data, social network technologies and, increasingly, the Internet of Things (IoT), encourage companies to radically revise their IT approaches. Thus, software product developers have to incorporate or enhance their software capabilities around these various innovative technologies in order to create real business value. Moreover, a holistic customer experience requires close collaboration between various business areas and stakeholders. If a business application does not support the digital integration of external business

partners very well, it may be necessary for a company to modernize this software or even migrate to another software product or cloud service.

This means that software vendors will either develop new functionalities themselves or integrate third-party products and solutions (through partnerships or acquisitions). Niche digital transformation software players, for example, have to ensure that their applications can easily be integrated with third-party solutions and platforms.

Many of the digital technology concepts summarized by the SMAC acronym have strong links with open source solutions:

- Social (Facebook is based on those technologies);
- Mobility (Android);
- Analytics & big data (Hadoop);
- Cloud (OpenStack).

OSS is also widely used in the development of digital software.

Distribution: Platforms are of rapidly increasing relevance. They enable cross-functional and even cross-organizational analytics and collaboration, and allow the creation of networks. Thus, software vendors that support digital transformation and SaaS providers have to promote the **platform business** as strongly as possible – either by establishing platforms themselves or by joining respective ecosystems. Cloud platforms in particular will serve as an important pillar in facilitating business model transformation. Consequently, the providers' future business should focus on integration (and development) platforms as a service rather than stand-alone software packages. In order to be of high relevance in the digital ecosystems of the future, providers have to enable their platforms for third-party connectivity, most often with APIs. Openness will be key.

In order to ensure a seamless interaction of applications across companies' entire business, the software selection process more and more becomes a **joint strategic decision** by various LoBs – rather than being decided on by a single department. As a result, marketing software providers that used to mainly work with marketing heads in the past have to significantly refocus. The same holds true for enterprise software providers that predominantly worked with IT heads in the past. A different set of skills is therefore required in the sales and marketing approach of software and SaaS providers. For system integrators, for example, this results in a slight shift from technology-oriented and implementation-oriented, software-related services towards more business- and consulting-oriented services.

PAC divides the **digital front-end transformation software market** into the following sub-segments:

Fig. 37: Sub-segments of the digital front-end transformation software market (PAC definition)

Provider landscape: The provider and solution landscape in the digital front-end transformation core segments is highly fragmented, with, for example, many traditional software players adding new or enhanced digital functionalities to their products as well as hundreds of specialized vendors within each digital transformation sub-segment. Consequently, competition is strong, but so is the potential for collaboration with partners.

The substantial growth rates in digital transformation software segments have led to the market entry of many new players – mostly cloud start-ups – while established players have been able to further extend their business. Key growth topics today are, not surprisingly, cloud, analytics and mobile.

However, the market is very dynamic and likely to enter a consolidation phase as digitally integrated enterprises and digital ecosystems are evolving.

Providers of software platforms that support the digital business will play a major role in this area. Among many others, examples are US-based vendors such as Salesforce.com, IBM, Oracle, Adobe, and Microsoft, as well as European players such as Sage, Dassault Systèmes, Software AG and SAP. The gaming industry is at the forefront of digital transformation, with the newest software models already in production for several years now: cloud, freemium, artificial intelligence, big data, global hosting, but also collaborative platforms for massive Multiplayer online games. Many of these concepts may be used in the business world as well. European players such as Ubisoft (France), Rovio Entertainment (Finland) or King (Sweden) are worldwide leaders.

The Indian software market is moving into this direction, too, in order to compete with US-based players that have a strong presence there.

For European software vendors, digital transformation is an opportunity and a challenge at the same time. The opportunity is to position as a more strategic vendor for European companies by helping them to digitize their business. The challenge is that the vendors have to transform their business and that they more

and more compete with new entrants in the market – including SaaS players – that address digital transformation topics as their core competency.

Digital transformation: Impact on European software vendors, software-related service providers and games developers

Impact on European application software vendors: *In the business software segment, digital transformation means that the software has to support different channels to interact with customers, allow social collaboration and provide the integration of external business partners that are part of the digital ecosystem. Moreover, the flexibility and adaptability of the software is key as companies want to be able to modify existing business processes seamlessly or create new business processes. Integrated BI & analytics, big data and mobility are other topics to be considered. The diversity of the digital paradigm means that its effects on software companies are very deep and broad.*

Impact on European infrastructure software & platform vendors: *Digital transformation creates demand for the integration of different software technologies, for example on-premise software with cloud-based services, as well as the integration of frontend and backend systems. This also drives the need for data integration. As software platforms become strategic, software vendors either need to build such platforms or support one or more of the leading software platforms. OSS is the de facto platform for most of the digital software.*

Impact on European providers of software-related services: *Regarding business opportunities, digital transformation means big business for service providers in Europe, as it is complex, diverse and very close to business needs. However, in this segment, IT service providers compete with digital agencies and management consulting firms. European IT service providers have started to restructure their organizations and to set up digital business units as demand for services is shifting from IT-focused technology services to business strategy support and implementation.*

Impact on European games software vendors: *As a consumer segment, the games business is at the forefront of digital transformation. Games are marketed, sold and consumed via different channels such as PCs, mobile devices, games consoles and the web. Also, the user experience in games is influencing the development of user interfaces in business application software.*

Comparison with 2010 study

Although software-supported digitization was already taking place in 2009/10, digital transformation was not as much of a key trend as it is today. One of the

main differences is that in the past, digitization largely was an IT strategy task. Today, the digital transformation journey has become much more of a structural and organizational – rather than a technological – topic. Becoming a digitally integrated company requires a paradigm change in the way enterprise processes are organized. It necessitates a move from an IT-centric approach to a strategy where technology is a truly integral part of the business.

Analytics & BI

Description of developments[26]

Business analytics has been of high relevance for European companies for over a decade now – be it business intelligence (BI), big data or any type of analytical applications. This is because companies see great benefits from these solutions as they help them to improve their decision-making.

Business intelligence refers to presenting data to decision makers in reports and dashboards. Analytics goes beyond this, providing more value to the business as it creates new information from the data. Also, analytics provides more freedom and flexibility for end users.

Technologies that have been around for years are becoming mainstream within the analytics & BI space, for example columnar databases, in-memory databases and Hadoop file systems. These technologies allow new approaches to tasks like predictive analytics, and are mostly based on OSS. In addition, visual analysis has grown very popular with tools like QlikView and Tableau.

As companies increasingly become data-driven, analytics will remain a key topic on their IT agendas. Companies particularly invest into real-time analytics (based on in-memory technologies) in order to speed up data analysis and reporting. In addition, companies invest in solutions to provide BI to a larger community of business users and enable them to use BI software in a self-service fashion.

The different segments of the analytics software market will grow at different speeds. While segments such as traditional data warehouses and reporting are maturing, analytical databases, data management and advanced analytics (which includes predictive analytics, for instance) are much more dynamic segments regarding growth. A key aspect of the future of analytics is artificial intelligence, which allows to identify the meaning of information that is hidden in huge volumes of data, detect weak signals and emulate human behaviour. Coming from some very high-performance environments such as finance brokering or military systems, artificial intelligence is poised to be the new paradigm of BI especially for solutions such as security, social networks, simulation, IoT or robotics.

As analytics is going to become a ubiquitous topic that will be incorporated in almost every area of the software business, much more profound knowledge is required at the user, software vendor and the IT service provider level.

[26] Many insights are taken from the SITSI Market InSight "Business Intelligence and Data Management Worldwide", 2015.

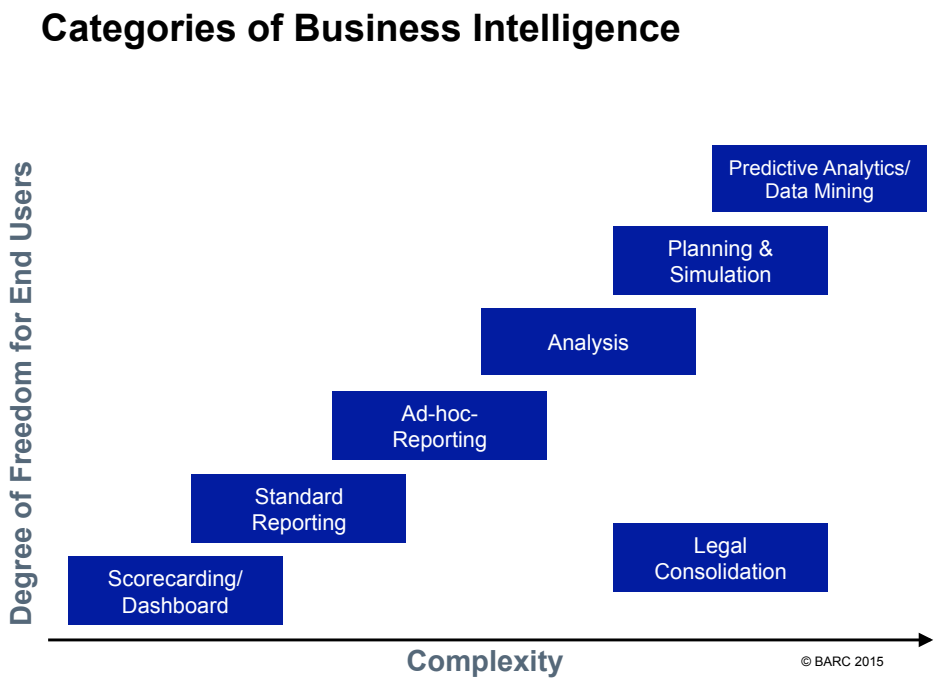


Fig. 38: Categories of business intelligence

While most of the largest business analytics players are US-based, there is a number of European players. Many of these vendors are specialists for a certain market segment and they can all benefit from the growth of the market, be it large enterprises or medium-sized businesses. Especially the latter are willing to buy from local players that address their specific requirements. This is also true for the various providers of business application software that add business analytics features to their products – sometimes by partnering with BI software specialists.

Analytics & BI versus big data

Opinions are divided as to where analytics & BI ends and big data begins. Big data implies large volumes, but when does a large data set become "big data"? Most people instinctively "know it when they see it", but a clear definition is something that the industry has been arguing about for some time. So most people settle for some variant of the "three Vs" definition originally suggested about a decade ago in a somewhat different context: big data is a data set with volume, variety and velocity. Others add a fourth 'V', even a fifth, with a number of suggestions as to what those should be. PAC believes the best definition uses four 'V's, with the fourth characteristic being "value."

Big data is all about providing cost-effective solutions to big data problems using tools and techniques different from those that have been developed over the last 20-30 years for analysing the highly structured, aggregated and generally numeric data relating to business operations. Also, big data capacities are an outcome of the usage of cloud computing. The next step in big data is the usage of AI to go even further in analytics.

To be more precise, the big data market is seen as comprising "solutions for problems where the volume of data and its variety OR volume means that it cannot be cost-effectively managed and analysed with traditional database tools and techniques."

	Maturity	Competitiveness
Analytics	Growing	Medium
	Large installed base of software products that allow new approaches, such as real time or predictive analytics. Modern solutions come with in-memory technologies, visualization and self-service BI. Different maturity levels in the EU28: much more mature in the UK than in other countries.	With German SAP, one large European vendor is among the top ten BI software vendors worldwide. There are many more, often specialized players in Europe that are able to compete with global rivals to a certain extent. Especially midsize companies are willing to buy from local players that address their specific requirements.Good capacities in artificial intelligence with expert systems for the military, utilities and finance. HPC capacities from Atos. Talend is one of the emerging leaders.

Impact on the software value chain and ecosystems

***Software development**:* Real-time analytics and self-service BI are drivers for investment in the enhancement of existing BI software and platforms (performance improvements, scalability) as well as new investments, e.g. into analytical databases.

Other developments concern the user experience of BI software, including mobile features.

More and more software developments of cutting-edge solutions for finance or high-tech are based on AI algorithms, coupled with big data infrastructures.

Distribution: A number of BI software vendors offer SaaS editions of their products and the project team expects more to follow. In addition, SaaS players such as Salesforce.com have expanded into the BI and analytics space. One main driver for SaaS-based analytics is that companies need tools that analyse data from the cloud, for example business data from a cloud-based customer relationship management software.

As lines of business become users of analytics, software vendors as well as their ecosystem partners will have to change their sales approach from technology-focused to more business-focused. Moreover, system integrators build their own solutions on the basis of BI platforms and offer them as a bundle of software and services.

Provider landscape: While the majority of the large global vendors of analytics software as well as the leading providers of analytics software platforms are US-based (except for SAP), there is a number of small to medium-sized businesses in Europe. Due to the importance of the topic, these European vendors have growth potential.

SAP, for example, endorsed the business analytics topic when it bought Business Objects, a company that has done more than most to propel BI into the mainstream and take it forward over the last two decades. Furthermore, much of SAP's product innovation efforts today are in the business analytics space, notably its SAP HANA in-memory database, the major revision of Business Objects, and the stream of new products and acquisitions targeted at data visualization and more agile, self-service BI.

Another example is Software AG from Germany. Through various acquisitions (including the in-memory data management platform Terracotta), the middleware specialist has become a provider of analytics and big data software, too.

Talend is a recognized specialist in the field of data integration in the BI and big data business that was founded in France and has now US-based headquarters. Talend also provides an open source edition of its software.

Qlikview, a well-known contender in the area of data visualization, was founded in Sweden and belongs to the top players in Europe. Like Talend, the vendor has its headquarters in the US.

Many start-ups are springing up in Europe around AI-backed technologies. They are an asset for Europe, but also a target for buyers outside Europe.

Analytics & BI: Impact on European software vendors, software-related service providers and games developers

Impact on European application software vendors: *For application software, BI is a must-have, a differentiator and an ideal tool for cross- and upselling. Applications more and more combine transactional processing with tightly integrated BI functions. BI & analytics as a service is a growing segment as well, fuelled by the increasing adoption of applications that are provided as software as a service. Providing artificial intelligence will become a competitive advantage for software vendors.*

Impact on European infrastructure software & platform vendors: *Due to the technology shift towards analytical databases and in-memory computing, vendors need to further develop their software. As topics such as the traditional data warehouse are maturing, they have to consider the above-mentioned technologies.*

Impact on European providers of software-related services: *For consulting firms and system integrators, BI & analytics remains a hot topic. However, demand for services has started to shift from pure technology-related towards more business-related services. Therefore, service providers have to react accordingly.*

Impact on European games software vendors: *Game software vendors use analytics to evaluate usage statistics of gamers and how their games are used. Especially in the area of online gaming, real-time analytics is used to detect possible problems (performance, outages, etc.) gamers may have.*

Comparison with 2010 study

In the 2010 SMART report, analytics was part of the much broader information management topic. However, for the EU28 region, the strategic importance and relevance of this topic has increased rapidly. Thus it has been given a more prominent place in the current study.

Compared to 2010, new technologies such as in-memory computing for analytics have emerged and are becoming part of various analytics solutions and platforms.

US-based vendors still dominate the software market for BI and analytics. However, EU28-based IT service providers have become much more present in the analytics space as they have increased their capabilities and competencies here.

Big data

Description of developments

Digital transformation trends imply both an increase in data volume creation and the ability to process this information at the pace users are used to with their most common mobile and web services.

There is a lot of confusion around the term "big data". Which is normal, since it encompasses a huge number of needs and technologies.

While segments of the traditional BI business are becoming mature, big data analytics is on the rise. Big data comprises data that goes beyond structured, internal data (from business applications and databases), such as poly-structured data (text documents, data from the Web, from devices and sensors as well as social media content). Such innovative solutions are increasingly required in order to meet new challenges such as big data and fast data, social networking analysis, and unstructured and textual data processing, which are becoming highly interesting for businesses looking to improve their operational performance, customer relationship management and corporate performance management. The possibilities are manifold – and so are the decisions to be made, the needs for strategic guidance and implementations.

Many companies have started big data projects, e.g. in the area of sales and marketing. For these undertakings, companies invest into innovative software solutions for data management and data analysis as not all of the existing business intelligence software is suitable for big data analysis, too.

In terms of market growth, big data is among the stars in the software market. However, these topics are difficult to be sold as such. Major opportunities come from more business-oriented topics, usually linked to one aspect of the digital transformation that is taking place in the industry. Companies may want to:

- be able to react more quickly to new competition;
- be proactive with regard to customer needs and behaviour;
- transform and monetize data they already own;
- act proactively before problems occur;
- sell recurrent services instead of simply products;
- analyse data in the field etc.

With the rise of big data, demand for predictive analytics increases from companies that want to invest in topics such as big data-driven forecasting. Also, the project team believes that the growth of data from devices and sensors in the manufacturing sector ('Internet of Things') will result in even more use cases for predictive analytics.

Artificial intelligence belongs to the hot topics within big data. This is a combination of the processing of large data sets and a number of technologies

including machine learning and natural language processing. This market segment has large potential for various industries in terms of improving existing business processes as well as creating new services that have not been possible before. A potential use case for such technologies is to provide recommendations for doctors based on large amounts of scientific literature as well as (anonymous and aggregated) data from laboratory experiments. Artificial intelligence is key to other areas such as self-driving vehicles and intelligent personal assistants.

The principles of artificial intelligence are not brand-new. However, the availability of computing power, cloud computing and the management of large data volumes, as well as the decreasing costs for such technologies are some aspects supporting the increasing use of artificial intelligence. The project team believes that artificial intelligence is not a market on its own. Rather, it will enrich and influence various existing IT technologies. For example, artificial intelligence will be combined with software business applications to better support the automation of tasks and planning routines such as for demand and supply.

	Maturity	Competitiveness
Big data	Growing	Low
	Very fast growing topic. Major opportunities come from more business-oriented topics, usually linked to one aspect of the digital transformation that is taking place in the industry (e.g. improved customer experience, responsiveness, etc.). Many custom developments, proliferation of standard software is yet to come. Maturity levels vary significantly between EU28 countries (UK and Nordics). Vendor landscape is dynamic, with many new players on the rise looking for European customers.	Existing analytics vendors add big data competencies, e.g., SAP and Software AG (Germany). Rising number of specialists at European level, e.g. Blue Yonder (Germany). However, US-based vendors are much stronger. Growing usage mixed with AI in several hi-tech verticals: robotics, defense, aerospace, finance and CPG, but also more and more in automotive. OSS projects are important in Europe for this topic.

Impact on the software value chain and ecosystems

Software development: Big data is too often associated with Hadoop, as if this was the only technology to be considered. It is true, though, that Hadoop and MapReduce are at the forefront of the big data hype. These open source technologies were developed by big Web pure plays that were not satisfied – in terms of price and performance – with traditional analytical database technologies. In essence, Hadoop and MapReduce split a workload into multiple chunks of information, process them on a distributed commodity hardware infrastructure, and then reassemble these pieces into valuable information. Huge amounts of data can be processed this way.

Distribution: As many investments in the big data area are related to totally new initiatives, there are only few replacements of existing software for big data analysis and for big data management. Such software is provided via cloud computing (big data as a service) or as a managed service.

Provider landscape: The market around big data software is evolving rapidly, with many new vendors and technologies offering a lot of new competencies. Existing vendors of analytics software as well as IT services companies that provide consulting and system integration for analytics are adding big data competencies.

In addition, there is a rising number of specialists that offer big data infrastructure software or big data analytics & applications.

For European software vendors, big data provides a number of opportunities in the field of applications for specific business processes, such as demand forecasting in the retail sector. These applications may leverage existing big data technologies as underlying platform. The software maker focuses on the domain expertise it can provide for a certain industry.

Even though PAC's latest vendor rankings may suggest that the major software and IT service players (IBM, Oracle, SAP, Accenture, Capgemini, etc.) dominate the big data area as they do the other technology areas, this is not the entire truth: They are not that far ahead of the others, and many players are catching up quickly, with growth rates in the big data area of far over 70%, such as Blue Yonder in Germany, or Octo Technology or Jems Groupe in France. The project team believes that, in order to reinforce their capacities regarding big data, leading consulting firms and system integrators will try to snatch these specialists – as Ernst & Young recently did in France by acquiring Bluestone.

Big Data: Impact on European software vendors, software-related service providers and games developers

Impact on European application software vendors: *A link between big data and business applications offers new ways to manage and optimize business processes. Therefore, application vendors should tap into this market.*

Impact on European infrastructure software & platform vendors: *Big data requires new types of data storage and data integration given the volume and velocity of the data, which leads to growing demand for new data storage, database technology and integration tools. Software vendors in this segment have to add these competencies in order to benefit from growing market demand.*

Impact on European providers of software-related services: *As the big data market grows much faster than the traditional BI market, service providers have to position in this segment with consulting, system integration and the hosting of big data infrastructure.*

Impact on European games software vendors: *Games software vendors use big data for a more comprehensive market and trend analysis as well as to predict what types of games will resonate with what audiences. Moreover, a lot of games software relies on artificial intelligence to provide a live game experience. This is a key aspect for deeply immersive games, and one of the key competitive advantages of most of the market blockbusters.*

Comparison with 2010 study

In the earlier report, the big data topic was part of the much broader information management topic. However, due to its strongly increased relevance, big data has now become a separate market segment.

Big data software is still strongly dominated by US-based vendors. However, EU28-based IT service providers have strongly extended their analytics capabilities to include big data. The topic will become even more important with the proliferation of IoT in the EU28 region, because big data analytics as well as artificial intelligence are, among other things, important technologies in that field.

The 2010 study already mentioned artificial intelligence (AI) as the next frontier for IT. The project team now see development efforts from various IT vendors that incorporate such techniques in their offerings. Examples of commercial platforms that include artificial intelligence are IBM Watson and Microsoft Cortana Analytics. Other relevant players are Google, IPSoft and Wipro. These non-European providers are rapidly winning new clients in the EU28 market.

Mobility

Description of developments

We have seen an unprecedented pace of innovation in mobile technologies over the past five years, involving devices, networks, development platforms, and applications.

Mobile devices have become a part of the everyday life of many consumers, and so has the use of mobile apps. For an increasing number of consumers, the mobile phone is the device of choice for the management of various aspects of their private and professional lives. For example, an increasing number of people use messenger tools like “WhatsApp”, “Telegram” or “Threema” or other social media services for daily personal communications and information.

While most of the innovations in mobile technologies originated from and were aimed at consumer markets, strong spillover effects into business segments can currently be observed, driving a new enterprise mobility wave. Mobile technologies have become a fixed part of everyday business life. Their influence on the way we work, the way we interact with customers and on business processes is tremendous and will grow even further in the years to come.

In companies, the proliferation of mobile devices is driving demand for software to develop, deploy, and distribute mobile apps, manage mobile devices and integrate them into the corporate IT environment. In addition, mobility is linked to initiatives around the digital enterprise as well as to cloud computing, because virtually every app has a cloud service it connects to. However, the increasing parallel usage of mobile devices for private and business purposes generates significant security risks and administrative challenges for companies.

As a result, European companies are investing heavily in mobile solutions and services supporting their integration and secure usage.

Mobility is a great example of an opportunity for the European software industry. In the previous study, the project team already underlined the fact that mobility had become one of the most important software opportunities, e.g., with the transformation of phones into portable computers or even retail terminals (mobile payment), but also stressed the relevance of mobility within the Internet of Things (IoT). This pervasive connectivity opens huge new opportunities for the software industry, as well as for the automotive, electronics, aerospace and agricultural industries, to name but a few.

	Maturity	Competitiveness
Mobility	Growing	Medium
	While most of the innovations in mobile technologies originated from and were aimed at consumer markets, there are strong spillover effects into business segments, driving a new enterprise mobility wave. European companies are investing heavily in mobile solutions and services supporting their integration and secure usage. Rapidly growing relevance of mobility within the Internet of Things (IoT).	The market comprises a number of mobile specialists as well as large software vendors that provide mobile capabilities. However, the infrastructure and middleware market is dominated by US-based vendors with a strong international presence. Leading mobile platforms are US-based. European mobile middleware vendors include SAP and Software AG, for instance. Business opportunities for the European software industry rather lie in the design and development of mobile applications. The ability of European providers to support broader, more holistic concepts than just mobility management will be a decisive factor in an increasingly intense global competition. *Ericsson or Nokia, and also all OSS projects that provide non-US-based middleware platforms. European telecoms operators have a global scope, with several being in the top10 WW.*

Impact on the software value chain and ecosystems

Software development: Due to the proliferation of smartphones and tablets, users have high expectations regarding the mobile experience of software. In addition, customers expect that mobile features in software solutions are offered as a default feature that is included in the software license or subscription fee. So in this case, the options for additional revenue that software makers can generate with mobile features may be limited.

The development and provision of mobile apps for workplace and process software solutions is becoming a commodity. At the same time, a rising number of SaaS applications are based on HTML5 and responsive Web design, which allows the use of applications on any device and makes native mobile business apps more and more obsolete.

A new generation of workplace and process solutions arises from the interplay of mobile with cloud, big data and social technologies. The project team expects an increasing need for solutions that help streamline (and secure) the development, testing, deployment and management of mobile and cloud applications. The security of mobile data is one of the major topics on companies' mobility agendas. Thus, basic mobility (management) services may serve as a teaser for the acquisition of long-term strategic consulting and integration projects. From the perspective of IT service providers, the project team moreover sees an increasing need for mobile application lifecycle management, testing and security services.

For European software vendors, mobility is a key topic and many have started to embrace it by adding mobile or any-device features to their products. They have the opportunity to grow their business by reaching out to mobile users as a new customer segment.

Distribution: The increasing need within companies for external support with the development of a security concept or the deployment of a mobile device management (MDM) solution not only opens additional revenue streams for IT (service) providers in the short run. Even more importantly, it opens the door for more strategic consulting and system integration projects with a focus on defining a long-term strategic vision for integrating mobile technologies into the overall IT strategy. This includes, for instance, how to integrate mobility management with overall IT services management, how to integrate mobility into holistic future workplace concepts, or how to optimize business processes involving mobile business applications.

At the same time, the users of mobile devices are becoming a direct new revenue source for software vendors. For example, a software vendor can offer a commercial mobile app via an app store. This way the vendor may generate revenue with customers it has not been able to reach before.

Provider landscape: One main trend that significantly impacts the software value chain as well as the partner ecosystems of software vendors is "mobile first", which means that the mobile device is more and more becoming users' preferred access method. Thus, software vendors tend to no longer consider mobility as an isolated discipline and are increasingly eager to support mobile devices. What's more, many of them follow an "any-device" strategy that is about supporting any kind of end-user device, be it a desktop/notebook, tablet or smartphone.

Leading mobile infrastructure software such as Apple iOS and Microsoft Windows were developed by US-based companies and the largest device manufacturers are located in the US or Asia. Moreover, a number of providers of mobile middleware (for the integration of mobile devices into software, the management of devices and for the security of mobile devices) are based in the US. Therefore, business opportunities for the European software industry lie more in the design and development of mobile applications.

Android, initiated by Google but based on OSS, provides a platform that is much more open and standardized. It also provides a much better level of cyber security as the code is open. Since the source code is open, this mobile operating system can potentially be secured and hardened to reduce vulnerabilities.

Despite tremendous demand, the mobility management software landscape is close to consolidation accompanied by fierce price competition due to the large number of suppliers and low entry barriers in a rapidly maturing market. The ability of European providers to support broader, more holistic concepts than just mobility management will be a decisive factor in an increasingly intense global competition.

A number of companies provide mobile apps for customer engagement in order to increase customer intimacy and customer loyalty and gather information about

their customers' behaviour. In addition, such mobile software is used to conduct business via mobile devices (e.g. ticket sales in public transportation systems).

Mobile devices have an impact on software-related services, too. Mobile devices are platforms for the delivery of (paid) content, games or services such as payment services. There are European examples such as the French company Deezer or its Swedish competitor Spotify. Both offer a subscription-based service for digital music and audiobook streaming over the Internet that is accessible via mobile devices.

Mobility: Impact on European software vendors, software-related service providers and games developers

Impact on European application software vendors: *As companies ask for mobile features, software vendors need to support mobile access to their applications. Moreover, new generations of application software come with embedded support for different devices, including smartphones, tablets and PCs.*

Impact on European infrastructure software & platform vendors: *Mobility drives demand for integration software that integrates mobile devices into existing IT landscapes, provides tools to develop and deploy mobile apps, and manages and secures mobile devices*.

Impact on European providers of software-related services: *More and more, mobility is part of software implementation projects. Also, system integrators help companies to "mobilize" existing IT systems, implement mobile middleware and write mobile applications. Consulting firms support companies in the definition of a mobile strategy. Providers offer mobile middleware and mobile device management as a managed service.*

Impact on European games software vendors: *Games software is provided as mobile apps and the mobile device is used as a game console. This market segment has been the booster of very successful European games start-ups such as Rovio or King.*

Comparison with 2010 study

In the 2010 SMART study report, the project team expected mobile applications to provide immense growth opportunities. This is still valid. However, it is also true that mobile features of software are often delivered as a default so that it does not generate additional revenue for the vendor.

In addition, the 2010 report mentioned the commoditization of mobile infrastructure software. Apple's iOS and the open source platform Android are the leading platforms and there is hardly any chance for a European provider to create

its own platform. Also, large software players such as Microsoft, IBM and Oracle have expanded their portfolios with mobile middleware.

A widespread use of mobile devices in enterprises can now be seen, for example for sales and field service. Mobility is more and more becoming the default user experience for software.

Social collaboration

Description of developments

Globalization and business acceleration permanently push demand for social collaboration. Time to market and short innovation cycles are key competitive factors in all industries today. In addition, in light of the increasing relevance of knowledge work in developed economies, social collaboration is becoming a key productivity driver. As a consequence, businesses collaborate in virtual value networks rather than in traditional value chains. Employees spend more and more time collaborating in frequently changing and globally distributed virtual teams. Traditional collaboration concepts and technologies are not sufficient for an efficient management of the arising network economy.

This is why social collaboration (SC) is more and more becoming an integral part of business processes. Firstly, companies are increasingly using social media tools to interact with their customers, for example via Facebook, Twitter, chats etc. The goal is to analyse customer behaviour, opinions and attitudes about topics, brands, products and services. In fact, a first-class customer service or new digital service offerings require an efficient collaboration across and beyond enterprise boundaries. From this perspective, social collaboration supports the interplay of all divisions involved in customer relationships, including marketing, sales, contact centre, customer service etc., with the goal to accelerate the information flow and to shorten reaction times. This calls for software and SaaS solutions that, on the one hand, facilitate this kind of close interaction and, on the other hand, enable the analysis of immense volumes of (mostly unstructured) social media data.

Secondly, companies implement social media technology for a more efficient and direct collaboration with employees, customers and suppliers. Social collaboration is part of the transformation of the digital workplace. While today, workplaces still are rather optimized for industrial workers, they are now being transformed to better support the knowledge-driven economy that calls for a more collaborative style of work. The modernization of workplace infrastructure has therefore become a key topic on the IT agenda and the key to raising the productivity of knowledge work(ers) as well as staying competitive in the increasingly fierce "war for talents". Of course, social collaboration facilities are an integral part of future workplace environments. Related issues addressed by SC software solutions include, for example, knowledge management, information retrieval, employee productivity, talent management, process efficiency.

Social collaboration features are provided via specific software or SaaS solutions. But in addition, SC capabilities are now included in enterprise software, e.g.

customer relationship management software, forming the basis for a new kind of workflow between people, and between people and program events.

It is important to understand that SC goes beyond technology. Without reshaping organization and leadership concepts, the mere implementation of these tools will not deliver the expected results. It is also important not to perceive SC as a stand-alone area with silo applications. It has to become an integral part, complementing traditional ways of collaboration and process optimization in all software application areas.

There are various starting points for social collaboration projects, initiated by different stakeholders within the company. The graph below summarizes the main entry points to start a social collaboration project[27]:

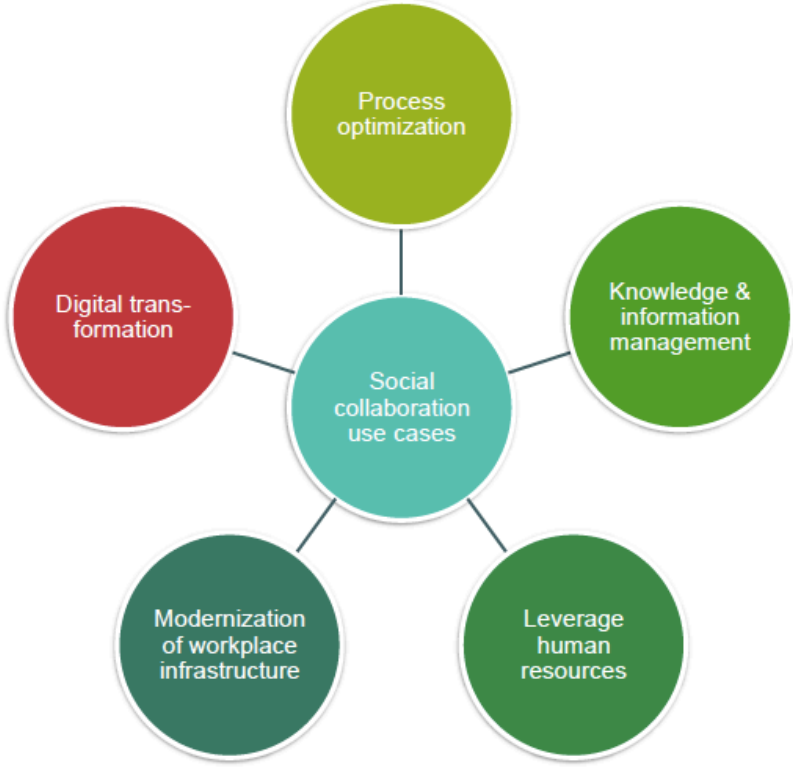


Fig. 39: Main entry points to start a social collaboration project

[27] Taken from "Call for action: Social collaboration goes business!", PAC Market InSight Worldwide, 2013.

	Maturity	Competitiveness
Social collaboration	Growing	Low
	Traditional collaboration concepts and technologies are not sufficient for an efficient management of the emerging network economy. Thus, social collaboration is more and more becoming an integral part of business processes. The related software market is very dynamic as the number and variety of requirements are rapidly growing. Relevant software features are sold as stand-alone tools or as part of application software.	The market is dominated by US-based social media networks. Some European software vendors such as Dassault provide social collaboration and social media analytics. Larger European vendors that provide social collaboration are SAP and Unify (now part of Atos). European social collaboration software suppliers will have to adjust their strategies in light of a significant consolidation process. Integration issues and usability will become key competitive factors.

Impact on the software value chain and ecosystems

Software development: Software vendors add social collaboration features to their application software products or offer add-on functions. For these vendors, social media features can provide an additional revenue stream. In addition, software vendors build interfaces to public social media networks such as Facebook, LinkedIn and Twitter. These connections to social media networks are used to further engage with customers.

We expect the next generation of SC projects to focus much more on integration issues in order to build future-ready digital workplaces and complete process optimization solutions. Fast technical progress, in particular in cloud and mobility, are important enablers of social collaboration. Social networks are naturally best established and enhanced in the cloud. Even more important: Widespread mobile access to networks is key for the effectiveness of social collaboration. Software providers need to adjust their solution portfolios to these changing requirements.

Distribution: Many of the social collaboration solutions (either as a stand-alone solution or a module within a business application or enterprise content management software) are provided as a service from the cloud.

Provider landscape: There is an increasing number of software vendors from related areas, but most customers will not accept multiple social collaboration platforms in the medium run. Therefore, a fierce battle for being the preferred SC solution can be expected.

The keener competition will be accompanied by growing price pressure, leading to lower growth rates in the medium run. Large software players in particular, which consider SC as an add-on for pushing the sale of their core products, will intensify price competition – and thus put pressure on independent SC specialists, of whom only very few will succeed.

European social collaboration software suppliers will have to adjust their strategies in light of a significant consolidation process, which PAC expects in the short to medium run. PAC believes that by 2020, only a few specialized SC suppliers will survive, while large players from related segments (CRM, ERP/HCM, ECM) will gain in importance. Social collaboration is also likely to change the balance of power in the ECM/intranet and UCC markets. In an increasingly fierce market environment, integration issues and usability will become key competitive factors. Analytics, gamification and mobility are likely to become growth drivers.

The European software vendors that provide social collaboration features include SAP ("JAM", a tool that was developed by SuccessFactors, which was acquired by SAP) and Unify (former Siemens Enterprise Communications), which now belongs to Atos, as well as Bluekiwi from France, which was bought by Atos, too.

Social collaboration: Impact on European software vendors, software-related service providers and games developers

Impact on European application software vendors: *Business application as well as enterprise content management software vendors (on-premise or SaaS) have embedded social collaboration into their products or provide such features as an add-on.*

Impact on European infrastructure software & platform vendors: *As social collaboration requires integration into business processes, integration software can provide the integration into existing applications that run the respective business processes*.

Impact on European providers of software-related services: *System integration services are needed to implement social collaboration tools and integrate them into applications. Companies need consulting and training in order to successfully deploy social collaboration and gain value from it.*

Impact on European games software vendors: *Some level of social collaboration is used within gaming communities. Also, gamers connect with each other via social collaboration features. But a network like Facebook is the springboard for many start-ups, such as King, which has now an extended games portfolio. The viral aspect of Facebook has been a critical accelerator for some of these companies. A large games software ecosystem is based on these platforms.*

Comparison with 2010 study

In the 2010 SMART report the project team described social media in the context of Web 2.0. Nowadays, the Web 2.0 topic has vanished; the principles behind it have become state-of-the-art in Web-based services.

The projections from 2010 concerning the market share of social media in the total market for software and software-related services are still valid. The revenue generated comes from advertising on consumer-facing social media networks and to a small extent from fees for premium services. The revenues generated in the enterprise space come from subscription fees for social collaboration and social media analytics solutions.

Since 2010, there has not been a big uptake in the social collaboration area within the European software industry. A number of players have added such features to business applications. Unify (now Atos) is among the larger specialists.

DevOps

Description of developments[28]

DevOps has been growing as a topic on the back of the need for more agility from the IT department in digitally transforming companies, and because companies recognized the lack of interaction between siloed IT operations and application development in complex IT organizations. Teams have been working in an isolated way, often pulled in different directions, with conflicting goals, which leads to painful release cycles that translate into slow and troublesome product/service launches.

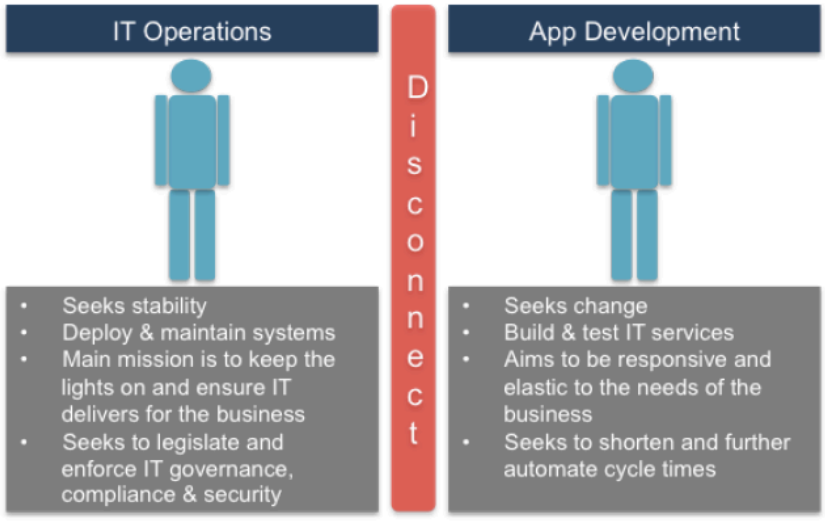


Fig. 40: The DevOps challenge

There are various definitions of DevOps, but the generally accepted understanding of the topic is that "DevOps is a cultural change inside the IT organization where new practices, frameworks and methodologies are implemented in order to accelerate software development and release cycles".[29]

DevOps emerged as a concept that requires tight collaboration between the software development and the IT operations of a company, especially regarding the development of company-specific applications as well as Web applications. The concept addresses challenges coming from ever shorter innovation cycles and frequent changes in the functionality of software. The benefits of DevOps are better time to release, improved cost of application delivery, increased quality and security assurance, and the IT department becoming more responsive to the business.

While previously a heavily technical topic that had the greatest uptake among the open source developer communities, DevOps has rapidly caught up in the corporate IT department over the past 18 months. For the UK, PAC estimates that more than 50% of the FTSE 100 companies have already engaged in some form of DevOps.

[28] Many insights are taken from the UK SITSI Market InSight "DevOps – A Reality Check", 2015.
[29] "DevOps – A Reality Check", PAC Market InSight UK, 2015.

	Maturity	Competitiveness
DevOps	Emerging	Medium
	The DevOps software market is shaping up. Vendors of development tools and cloud platform providers address this market. In the future, cloud-based platforms (platform as a service) will play a major role for DevOps as the development of modern software more and more takes place in the cloud.	The European software industry has the opportunity to adopt the DevOps concept. However, leading development platforms and technologies are US-based. DevOps has deep roots in OSS that can be used. Many OSS projects have European roots, such as Symfony (SensioLabs).

Impact on the software value chain and ecosystems

Software development: In order to adopt DevOps, companies need – among other things – new software tools for development, testing and project management. In the future, cloud-based platforms (platform as a service) will play a major role for DevOps as the development of modern software more and more takes place in the cloud.

Distribution: For IT suppliers in general, DevOps is a double-edged sword. It may open new project opportunities, but may also cannibalize existing outsourcing and offshore revenue streams. Given the massive penetration of outsourcing and offshore for example in the UK, there are questions about the viability of DevOps as an operating model for end users, and as a revenue source for IT suppliers.

There are cases in the UK market where, on the back of DevOps, end-user organizations have reverted to some level of in-sourcing, or at least to a more rigorous control of SLAs from their suppliers, based on increased internal accountability.

For system integrators, DevOps provides some interesting opportunities to reposition around deeper automation and orchestration, IT consulting and provisioning. However, at the same time, DevOps can negatively impact the current revenue streams of IT service providers ranging from infrastructure management to testing and application development.

Provider landscape: There are various ways to classify the vendors competing in the DevOps space: by type of product and technology, by functional area covered, by level of product/service integration, etc. From a vendor size and revenue maturity perspective, there are three classes of providers that are currently active: emerging specialists; legacy system administrators and middleware generalists seeking to refresh their portfolios to remain relevant; and integrated development platform vendors offering PaaS runtime/instances. Many software development environments have strong OSS roots, especially around new Internet-focused languages, such as Symfony, and are at the core of DevOps.

DevOps: Impact on European software vendors, software-related service providers and games developers

Impact on European application software vendors: *For application vendors, DevOps is only relevant if they offer a software platform for development.*

Impact on European infrastructure software & platform vendors: *For vendors of development environments, testing tools and related components, DevOps provides new business opportunities. Also, platform as a service (PaaS) provides DevOps features as an alternative to on-premise tools.*

Impact on European providers of software-related services: *Service providers can provide consulting and training for European companies that want to adopt DevOps for their internal software development. In addition, system integrators can implement and integrate the respective DevOps tools.*

Impact on European games software vendors: *DevOps was born in business IT. Of course, games software makers rely on agile software development methods, as they have to keep up with the highly dynamic market.*

Comparison with 2010 study

DevOps just started to become a topic in 2009/10 and therefore had no relevance to the former study. However, this has changed over the last few years and DevOps gets much more attention today.

Cloud computing

Description of developments[30]

It is obvious that digital technologies entail a deep transformation of the business models for a lot of end-user companies, but also in IT providers' organizations. The main catalyst for this evolution is cloud computing.

Cloud computing is, however, not only a trend topic; it is closely linked to another investment area: there is no cloud computing without IT security considerations. The other way around, the emergence of big data and IoT use cases is hardly conceivable without cloud infrastructures.

There is no doubt about the fact that cloud computing, with all its facets, is relevant for companies throughout the world. However, there are a number of differences concerning usage, investments and sourcing strategies. In 2015, PAC conducted the "SITSI® CxO Investment Priorities Survey", interviewing around 3,000 decision makers in user companies all over the world to get their views on current IT trends, key requirements and investment plans. Some key findings on the topic of cloud computing are:

[30] Many insights are taken from the SITSI Market InSight "CXO 3000 – Investment Priorities: Cloud Computing", 2015.

- Western Europe is a growing market for cloud computing according to PAC's market estimates for this region, although the project team does not see the market shift from on-premise to the cloud at the same pace as in the United States. The lack of trust in cloud computing due to security and compliance issues is one reason why the cloud turns out to be a very important topic for only one in five Western European companies.
- In Europe as a whole, the UK (followed by a few other countries that have already been particularly mature in terms of traditional IT services/outsourcing, such as the Netherlands or some Nordic countries) is the clear forerunner in the cloud space.
- Countries in Central Europe used to be much more conservative regarding cloud computing due to security, legal and data privacy concerns. However, the more local data centres are set up and the more local IT providers offer cloud-based services, the lower this barrier is for companies to use cloud computing.
- Especially in the US, where the majority of cloud providers are headquartered, using cloud computing has become common. Cloud computing is already widespread and its use will continue to rise.
- The APAC region seems to be a promising market for cloud computing. China and India are quite enthusiastic about the cloud. For companies in China and India, cloud computing can be the right strategy to rapidly deploy new infrastructure and solutions in order to cope with the fast growth of the economy in various segments. Also, companies in these two countries typically do not have as much legacy IT to consider as their European counterparts. However, APAC is anything but a homogeneous region and it has to be kept in mind that within China and India, for example, the cloud business is mostly limited to certain well-developed areas.
- Today, companies of all sizes have recognized the relevance of cloud computing for their future business. Concrete investment plans, however, including the willingness to spend more on the cloud concept, are more pronounced at larger companies. Smaller companies still rather show a wait-and-see attitude.
- There are industry sectors, such as media or services, that are by far more mature and more open towards cloud usage than more conservative sectors such as insurance, utilities or the public sector.
- Storage and server capacity as well as web hosting have been the playground for most of the early cloud adopters. And server and storage are not only the most important areas in the public cloud space, but they are also at the heart of any private cloud transformation, be it internally or with the help of a hosting provider.
- Regarding infrastructure as a service, all the three different deployment options – public cloud, in-house private cloud, and hosted private cloud –

are relevant today and will remain relevant in the future. Companies use a mix of these options.

- For companies in all regions, public cloud IaaS is a reality today, even in Western Europe, where companies tend to be restrictive regarding public clouds due to security issues. The Americas region is the one with the largest share of companies that are willing to expand their public cloud activities even more.

In general, larger enterprises can benefit more from cloud computing than smaller organizations thanks to economies of scale. These organizations typically have larger and more complex IT environments. They invest into cloud computing to deploy new solutions or to extend existing environments. Moreover, the migration of existing IT systems to the cloud is on their IT agenda.

Smaller companies (up to 500 employees) typically do not have a large IT staff and therefore have a less well-defined IT strategy. If they invest, they think about cloud computing in a tactical rather than strategic way.

Increasingly, consumers are becoming addressees of cloud services, too. One driver for this are mobile devices, as many mobile apps are linked to cloud services. However, consumers often do not even know that they are using the cloud.

	Maturity	Competitiveness
Cloud computing	Growing	High
	Dynamic market as more and more software vendors start cloud business activities. Western Europe is a growing market for cloud computing, although the market is not shifting from on premise to the cloud at the same pace as in the United States.	Many European software vendors already have a cloud solution in place or are about to roll out such a solution in the near future. Strong European brands are e.g. SAP, T-Systems (Germany), Capgemini, Smart Focus, Cegid, Visma (France), Sage, Fidessa, Northgate IS (UK). There are a number of European providers of cloud computing infrastructure (Orange and OVH in France, Deutsche Telekom and United Internet in Germany and British Telecom in the UK) that compete with global players such as Amazon Web Services and Microsoft (Azure). European vendors with data centers within the EU can better address the data security and data privacy concerns of European customers. However, currently there is a strong tendency of US-based cloud solution vendors to open local data centers, too. The biggest IaaS platform project, the OSS-based Open Stack, has strong European participants. OSS is largely used for cloud infrastructure and software development.

Impact on the software value chain and ecosystems

Software development: In the traditional software business, a software producer maintains different releases or product generations of the products that are used by its customers, while the developer of a cloud solution manages only the current release or product generation.

For European software providers, cloud computing holds a number of opportunities. For example, as there is only one version or code base to be managed, the cloud service is available from everywhere. With a cloud solution it can therefore be much easier for software vendors to establish a Europe-wide business than with traditional on-premise software.

The cloud allows start-ups to start quickly and grow their business much faster than in the traditional software business.

Distribution: The delivery models of application software products are dramatically changing with the advent of the cloud computing and SaaS models. More and more customers want to buy everything "as a service". Cloud subscriptions replace software license fees and maintenance fees. Software can be sold much more easily as a digital product. This is a huge challenge for companies that are used to selling products or services on a fixed-price basis. They need to rethink their business models in order to be able to provide full service on top of a product or variable fees for their services.

For the software industry, cloud computing has a huge impact. Vendors feel the pressure to offer cloud-based solutions or at least provide software that can be deployed in the cloud. In some segments of the software market, the shift from on-premise software to cloud computing is already under way at a fast pace. Many European software vendors already have a cloud solution in place or are about to roll out such a solution in the near future.

Although cloud computing is an evolution of the software industry that has been taking place for quite some time, on-premise software will not be replaced completely. Companies will maintain parts of their existing software landscapes, not every piece of software will be moved to the cloud. What's more, a large number of software vendors have started to offer different deployment options for their solutions (cloud and on premise), while a large number of vendors will offer cloud-only solutions.

Many cloud vendors have established so-called "cloud marketplaces" where, in addition to the vendor's proprietary solutions, clients can purchase and access third-party cloud solutions as well – often from ISVs, system integrators or third-party cloud vendors.

However, a lack of standards and interoperability of today's cloud solutions hampers even faster adoption.

Provider landscape: The emergence of the cloud concept has more than ever shaken up the positioning of traditional IT vendors within the IT value chain. Traditional revenue models have been changing from selling software licenses and maintenance contracts to subscription-based revenue streams. The cloud phenomenon impacts all vendors on the IT market – product vendors as well as IT service providers, telecoms, value-added resellers, etc.

Over the last few years, the emerging cloud offerings have enabled the establishment of a huge number of new, "cloud-born" businesses, often in areas using the Internet, such as entertainment or e-commerce, but the digitalization of traditional businesses and processes has increased the impact on the "old economy" as well.

In addition, cloud computing reinforces the trend towards subcontracting and/or sourcing, and thus further accelerates the transfer from internal IT to external service providers. The CIOs of the future are expected to position themselves as

aggregators rather than managing large internal teams of developers, operators, etc.

European vendors with data centres within the EU can better address the data security and data privacy concerns of European customers. However, currently there is a strong tendency among US-based cloud solution vendors to open local data centres, too. In general, competition from US-based cloud providers will become much more intense as they regard regions such as Western Europe as growth markets.

There are a number of European providers of cloud computing infrastructure that compete with global players such as Amazon Web Services and Microsoft (Azure). Among others, these are Orange and OVH in France, Deutsche Telekom and United Internet in Germany, and British Telecom in the UK. As European telecom operators provide the infrastructure for the Internet that is used by the various Internet companies, they want to have a share of the revenues generated. One way of doing this is to increase their activities as cloud providers.

Cloud computing is mostly based on OSS infrastructure software stacks that are managed by open consortiums such as Apache.OpenStack is slowly replacing VMware for the new architectures and for more and more legacy cloud architectures. New cutting-edge cloud technologies such as Dockers were originally developed as an OSS project, even if it was mostly done by one company (Google). The availability of these cloud platforms is an opportunity for the European IT market, but also for the various European industries, as they can avoid being locked in by US-based vendors. Several large middleware players, such as IBM or HP, now base their cloud solutions on the leading cloud platform, OpenStack. This makes it a de facto standard and facilitates the use of cloud computing by lowering integration cost.

Cloud computing: Impact on European software vendors, software-related service providers and games developers

Impact on European application software vendors: *For application vendors, a cloud strategy will soon be a must-have. At least a cloud-ready software is mandatory.*

Impact on European infrastructure software & platform vendors: Software vendors need to become cloud providers. And the integration of cloud services into existing IT landscapes as well as the integration of different cloud services is a promising field to generate new revenue.

Impact on European providers of software-related services: *System integrators need to add competencies for SaaS-based solutions as demand is shifting from on-premise software to the cloud in some segments. This includes the integration of cloud services (processes and data) into IT systems. Hosting and outsourcing providers have to find ways to better compete with cloud infrastructure providers, e.g. by offering their own cloud services. Open source cloud stacks are gaining traction, even if the existing pool of competencies and the marketing pressure from US middleware companies may still prevent large-scale partnerships.*

Impact on European games software vendors: *Cloud computing is common in the games business as mobile gaming apps as well as PC games connect to cloud services. Also, browser games that run in the cloud are a growing segment. Open sourced cloud stacks, for obvious reasons, are the best choice for both classic and mobile deployments.*

Comparison with 2010 study

Cloud computing is an example of an emerging software technology that was already mentioned in the 2010 study as a key driver. The cloud computing architecture has made the proliferation of mobility and IoT possible.

In the 2010 report, the project team stressed the investments of companies into private clouds, and this is still the case. The study distinguishes between the hosted private cloud (dedicated cloud infrastructure for one customer that resides in an external data centre) and the managed private cloud (cloud infrastructure resides within the company and is managed by an external provider). Both types will remain relevant in the future.

Compared to 2010, the project team now sees a fast growth of the public cloud (resources based on a cloud architecture residing in an external data centre and made available to several customers) in the European countries. In some countries, such as France, the UK, Germany and the Netherlands, it will leapfrog the hosted private cloud in terms of market volume in the near future.

This means that the European software industry has to make the transition towards the cloud (private and/or public). More and more European companies want to understand if and how a software vendor supports cloud deployments. The mix of cloud computing and open source is an opportunity for European companies.

Cyber security

Description of developments

We live in an increasingly digital world, in an environment that is globally interconnected. This IT-intensive economic model is based on the Internet and on connected and collaborative business models with open processes, systems and data. This creates numerous business opportunities.

However, the more digital information becomes an asset in the economy, the higher the risk involved if this information gets lost, stolen, corrupted or deformed. Demand for cyber security increases due to the proliferation of Web-based digital services and the use of mobile devices. At the same time, cyber criminals have started to realize that applications are a profitable target for their attacks.

According to PAC's research, cyber security is among the major concerns of companies in the EU. In order to protect their IT assets, companies need both strategies and solutions. On the one hand, companies seek to protect their assets, on the other hand, they need to comply with regulations and need to meet security standards. Because of this complex environment, many businesses – particularly SMBs – are looking to outsource security either in part or in total.

So security is a high investment priority among European companies. Enterprises today face the challenge of implementing new SMAC technologies to support the business as part of their digital transformation programs, while keeping them highly secure.

However, due to the fact that cyber security has many roots in IT infrastructure, it often protects the infrastructure, but fails to protect its very reason of being, and that of IT infrastructure, namely applications and content.

Additionally, local, regional and industry regulations have been tightened across the continent since the Snowden revelations. According to a recent PAC survey, regulations and compliance are a top trigger for cyber security investments; even the most important one in France. As they more and more become mandatory, their impact will grow. Governments and some businesses have started to push a preference for national cyber security providers, or at least for European ones.

The project team considers four segments in the security software space:

- Infrastructure: Antivirus, firewalls, intrusion detection, etc.
- Identity & access management: Electronic access control (identification and authentication), single- sign on
- Data & application: Encryption, digital rights management, content filtering as well as application security, development and testing

- Governance, risk, compliance: Information security management systems, security information and event management

The infrastructure part is maturing and shows slow growth. Governance, risk and compliance is an area with a lot of investments. The management of information security is becoming an ever bigger challenge for companies. The software market for such tools shows double-digit growth.

As applications are a profitable target for attacks, the market for security software is growing. This, as well as the fact that companies have to collaborate with external partners, means that demand for identity & access management is constantly rising.

Solutions around the Internet of Things and big data will drive demand for security software on different levels, such as applications, systems, data and networks.

Cloud computing has two effects on the value chain and the ecosystems of the security software market. Companies invest in security solutions that allow the secure usage of cloud computing. And security solutions are offered as a cloud service.

Artificial intelligence and big data are the next paradigm in cyber security, as they permit the creation of contextual and behavioural systems, which are the most efficient way to manage the complexity of today's digital world. In this area, European companies also have a window of opportunity, as it lowers entry barriers to this mature market. Artificial intelligence is quite well developed in certain countries, such as France, and in some industries, such as defence, aerospace or finance.

	Maturity	Competitiveness
Security	Mature	High
	The cyber security market has two faces: Infrastructure software is higly mature regarding perimeter protection. Market dynamic comes from cyber security requirements. But the other part of the cyber security market, such as identity & access management, GRC (governance, risk & compliacne), data and application protection, is growing fast.	As an infrastructure market, it is poised to be a global market, like all middleware. However, its data and application aspect creates domestic specificities and preferences, as does tightening continental, national and industry-wide legislation. Thus, the competitiveness of European players is high. There are many security competencies in Europe, and software vendors come from various countries, e.g. Eset (Slovakia), F-Secure (Finland), Sophos (UK), AVG (Czech Republic), Panda Security (Spain) and Stormshield/Airbus (France). European companies are well positioned in behavioral and contextual analytics (artificial intelligence + big data), the next cyber security paradigm.

Impact on the software value chain and ecosystems

Software development: Security impacts the software business in two ways. Firstly, applications (mobile apps, on-premise software, e-commerce software or cloud-based/hosted applications) need to be protected. This calls for the implementation of security software for existing applications. In addition, security is integrated into the product in the development phase ("security by design").

Secondly, cyber security solutions are based on software. Therefore the increasing demand for protection drives software investments. A large number of software

vendors offer either single-point solutions or complete cyber security software stacks.

Distribution: Like other software market segments, the security software business is transitioning towards the cloud. Users of security software subscribe to a service that provides the software features and the necessary updates. Security software becomes part of software platforms ("Platform as a Service").

Provider landscape: Content and application security players are divided into infrastructure-centric and application-centric specialists. The most efficient in this market will be those that cover both, especially if they have a strong business background. As for most of cyber security, with the exception of commoditized tools like anti-virus or anti-spam, the market has both a strong local flavour and a global reach, being a perfect example of a "glocal" market sub-segment. As an infrastructure market, it is poised to be a global market, like all middleware. However, its data and application aspect creates domestic specificities and preferences, as does tightening continental, national and industry-wide legislation. European players are relatively numerous, and many new companies are created across the continent, especially for contextual and behavioural technologies.

Overall, in the security segment, the market for IT services (project services and outsourcing) is growing even faster than the solutions market. This is because companies need a lot of support from external providers in the form of consulting, implementation and integration, as well as education. The IT services market for cyber security remains a very fragmented service market.

Service providers can benefit from the fact that many companies want to work with local or European suppliers.

Cyber security: Impact on European software vendors, software-related service providers and games developers

Impact on European application software vendors: *As applications have become a profitable target, application security is gaining in importance – be it embedded into solutions or as add-ons. Also, as applications are offered in the SaaS model, vendors have to consider security here as well.*

Impact on European infrastructure software & platform vendors: *As security infrastructure software is maturing, vendors will add competencies in other areas such as IAM (identity and access management) and GRC (governance, risk, compliance). Growing business will come from securing the cloud as well as providing security as a cloud service. Cyber security is also a very dynamic segment for many continental software companies. Due to their competencies, they are takeover targets for foreign vendors.*

Impact on European providers of software-related services: *Cyber security holds many opportunities for consultants to help identify business cases. System integrators are required to orchestrate solutions, integrate various devices and data sources, as well as transform existing IT landscapes.*

Impact on European games software vendors: *As games software (including multiplayer online games and online services for games consoles or mobile gaming apps) stores gamers' personal data, manages payment processes and connects to social media networks, data privacy and access security is mandatory.*

Comparison with 2010 study: In the 2010 SMART study projections, the project team of course predicted growth in security software. However, the impact of cyber security was not as strong as it is today, which means that the importance of security has even increased.

Security will remain an extremely important market for the software industry and IT service providers in the EU28 region as local competencies and client sensitivities will remain decisive competitive factors in the future.

Internet of Things (IoT)

Description of developments[31]

The Internet of Things is becoming an increasingly important investment area for companies in various industries.

The IoT provides enormous business potential for companies. The technological possibilities seem so comprehensive that business opportunities appear to be overwhelming. Companies from various industries want to discover how they can exploit this potential by using IoT technology and how to implement the respective solutions.

One central component of many Internet of Things projects is a software development platform that provides infrastructure, tools, libraries and analytical services in order to create a customer-specific application for a dedicated use case. Furthermore, software is needed to integrate data from various devices, including SCADA-based systems (SCADA = Supervisory Control and Data Acquisition), into business applications (e.g. ERP/CRM/PLM), analytical systems, etc.

Besides the creation of new software, major investments are expected from companies to enhance existing software or even re-architect it so that it better supports the IoT in terms of user interfaces and the processing of device data.

The IoT will be a major driver for cloud computing, such as cloud-based platforms to process and analyse machine data. Big data and artificial intelligence are cornerstone technologies here.

Examples of IoT use cases are predictive maintenance (scheduling of maintenance services on the basis of predictive analytics) and connected car (connection of vehicles to various services including driver assistance and after-sales).

IoT projects require software investments in the different technological domains of IoT:

- Local intelligence: Sensors, chips, artificial intelligence, embedded systems;
- Vertical integration: IoT data has to be integrated into ERP/CRM/PLM, MES, SCADA and data analytics;
- Horizontal integration: Machine-to-machine connectivity (M2M), machine cloud data platforms, mobile devices, SCM, service integration;
- Human-machine interaction: New interfaces and new I/O concepts, development and adjustment of business processes & roles;
- Security: Applications, data and networks;
- Networks.

[31] Many insights are taken from the worldwide SITSI Market InSight "Internet of Things – Positioning strategies of technology, software and service vendors", 2015.

	Maturity	Competitiveness
IoT	Emerging	High
	The new market is in its early stages as new business models evolve. Established software vendors add IoT capabilities. This segment is strongly integrated into vertical business processes such as utilities, aerospace, defense and automotive.	Vendors can leverage competencies in manufacturing, car manufacturing, energy and healthcare. Vendors create IoT platforms and form ecosystems with companies. Also, companies will become IoT software vendors. Germany is a forerunner for Industry 4.0. Moreover, there are various initiatives in different EU countries, such as self-driving cars, trucks and shuttle buses. Network technologies from telco providers and operators provide a strong foundation. Smart cities and smart utilities are developing in many European countries. SigFox, a wireless communication specialist based in France, has the largest IoT network worldwide.

Impact on the software value chain and ecosystems

Software development: Software platforms act as integration hubs for the integration of data from cyber-physical systems, for instance.

Start-ups in the area of smart home automation (services, flexible tariffs), smart health (data from fitness trackers and special tariffs for healthcare).

Continental and other firms buy software companies to develop industry automation (for internal production as well as a service for third parties).

Software is used to manage car traffic in cities.

Makers of industry products become software providers, for example lighting system makers, car industry.

One trend here is the integration of and analysis of data from sensors, devices, machines, cars, etc.

Software providers offer business applications with integrated analytics for certain processes, such as predictive maintenance of industrial plants. Cloud computing is a key enabler for IoT-related software developments.

Distribution: IoT platforms are offered as a cloud service, be it private or public cloud. As IoT is relevant for the IT organization as well as for various lines of business within a company, software vendors must be able to sell their solutions to these departments. IoT is all about business cases and use cases, so the sales strategy has to focus on the identification and implementation of business cases rather than on features and functions. This may be a challenge for various software vendors that are used to selling technology to technology-focused buyers. Network operators are critical for managing and distributing IoT-related data.

Software vendors enter co-developments with European companies from various industries to create IoT solutions. This strategy may be a challenge for software vendors as it goes beyond the typical supplier-customer relationship.

Customers will use software platforms that provide solution components to create their IoT applications. They pay for the platform and for the services as well as the IT resources they use. The orchestration of preconfigured software offered as a service as part of a platform will be one approach to this. Software vendors have to be able to provide such platforms/ preconfigured services, while IT service providers are needed to support this orchestration to allow the creation of IoT

solutions. Besides, there will be ready-to-use IoT applications offered by software vendors as well as IT service providers.

Provider landscape: Regarding the ecosystem, IoT requires a closer collaboration between companies and IT vendors. Connected car, for example, is one of the most important topics for the automotive industry in Europe and an opportunity to establish a sustainable positioning on the global market. To achieve this, even closer collaboration between manufacturers and suppliers, but also between automotive and IT companies, will be necessary.

Many major software vendors have become active in the IoT business, including IBM, Microsoft and SAP as European player. Vendors of product lifecycle management solutions such as PTC (US) and Dassault (France) have entered this segment, too. US-based chip manufacturer Intel also positions itself in the IoT market. Telecom operators such as Orange or Telefónica are important providers of enabling technologies for the IoT, and so are some start-ups such as SigFox (France). European industrial companies such as Siemens, Schneider Electric and Bosch provide IoT software and/or services, so does US-based General Electric. Examples of IoT specialists are Tado (Germany) and Jasper (USA).

Internet of Things: Impact on European software vendors, software-related service providers and games developers

Impact on European application software vendors: *Business applications will be built to realize the IoT, existing applications will become IoT-ready, e.g. by adding IoT-enabled middleware. IoT also is a perfect launch pad for industries to become part of the IT market.*

Impact on European infrastructure software & platform vendors: *As software platforms for the IoT are key to this segment, software vendors should position in this area and look for partnerships with companies from the IoT-savvy industries.*

Impact on European providers of software-related services: *IoT holds many opportunities for consultants to help identify business cases. System integrators are required to orchestrate solutions, integrate various devices and data sources, as well as transform existing IT landscapes.*

Impact on European games software vendors: *Games software is connected to motion sensors, for instance. And as virtual reality (VR) becomes popular, the software is linked to VR glasses.*

Comparison with 2010 study: The 2010 report focused on RFID as an enabler for the IoT. Nowadays, RFID is still relevant for the IoT and it is used in the field of industrial manufacturing, retail and logistics, but it is one technology among many.

For some companies, the Internet of Things is a logical extension of the RFID tagging projects they adopted over the past decade to track high-value assets throughout the supply chain. Recent technological advances such as smaller and cheaper tags and sensors, wireless networks that are available practically everywhere and at any time, reduced storage costs, increased computing power and machine learning capabilities are driving the adoption of IoT technologies and processes in European companies.

The software industry in the EU28 region stands a good chance of participating in this fast-growing market. Those IT providers that are able to enhance the emerging IoT technologies, create a relevant partner ecosystem and meet the potential challenges of connecting devices, goods, facilities, processes and people will be well positioned over the next five years to differentiate themselves from competitors and create new revenue streams and value-add. In addition, with IoT software and solutions being developed in-house by European companies from the manufacturing or the utilities sector, these companies are currently strengthening their market position against their competitors.

Open source software

Description of developments

Open source software (OSS) has become a relevant part of the software industry. For example, Firefox is one of the most popular web browsers, Linux is a major operating system platform, the Apache HTTP Server is a leading platform for websites, Hadoop is a widespread software for the distributed processing of large data sets and forms the foundation of many big data projects, Android is the leading mobile operating system for mobile devices, and WordPress is a common tool for the management of Web blogs. In the field of software development, the Eclipse framework plays a major role.

Open source software is widely used in the middleware space, a market segment where US companies reign, and were Europeans are rather weak. OSS is also a firm promoter of standards and interoperability. This openness lowers the risk of a vendor lock-in. OSS is based on communities that develop software in a collaborative way. Many enabling technologies for SMAC have strong OSS roots.

It is fair to say that open source software is an enabling technology for cloud computing since many cloud services are based on this type of software. OpenStack Cloud Software, for example, is a collection of software components that can be used to create cloud services. One user of OpenStack is the European nuclear research centre CERN, but also the European Commission, which just selected it as its public cloud platform of choice.

Software vendors that build new products can save costs if they reuse existing open source software components instead of developing software on their own or buying software components. As a result, open source software can foster the development of new software products as well as the creation of new software vendors. OSS allows companies to incorporate IT in their value chain in an easy

way. Instead of buying commercial software that may involve the risk of a vendor lock-in, they just have to share value with the OSS community.

Open source can also be a key success factor for co-innovation as none of the participants will have the upper hand. OSS can create standards that are very important for the development of emerging technologies and that help lower the total cost of ownership.

Open source technology is also relevant for the Internet of Things. A machine manufacturer can save costs if the software that is embedded into its products or devices is free of charge. The Android software platform for mobile devices is a good example of how open source can help to grow a device business.

There are a number of examples of open source software developed in Europe. The EU and countries such as India or Brazil have defined their own open source strategies. Open source software can potentially provide a higher level of interoperability than commercial software solutions. This is an important aspect for public authorities within one country or one region.

On the consumer side, open source has become popular as well. Examples are the Firefox web browser, the image editor tool GIMP (GNU Image Manipulation Program), as well as a number of games that are based on open source software.

	Maturity	Competitiveness
Open source	Growing	High
	There are many open source projects initiated by vendors or organizations based in Europe. Moreover, European software developers are members of various open source projects. Companies, local governments and the EU adopt open source software. SMAC-based software and services rely heavily on OSS due to its openness and flexibility, but also because a whole generation of developers have been trained on OSS.	The European software industry can adopt the open source model to create interoperable software platforms by leveraging existing open source software. In fact OSS is a key lever of EU competitiveness on the key IT topics of the digital age, especially if European industries do not want to depend too much on third-party platforms for some of their core business activities.

Impact on the software value chain and ecosystems

Software development: The basic principle of open source software development is that a community of software experts contributes time and effort for coding, reviewing and testing to publicly available source code. Large open source communities such as the Apache Software Foundation are funded organizations.

Many open source technologies are used to develop software. One example is the Eclipse Framework. The software technology that is the basis for cloud computing also includes open source software.

For the proliferation of software platforms as a service, openness and interoperability are key. Therefore, open source software is likely to play a major role here as well. The open source software stack Cloud Foundry forms the basis of PaaS offerings from various IT vendors.

Aspects that need to be considered are the availability of support for open source software as well as the development roadmap of the respective software.

Distribution: Open source software is accessible via free download. Some commercial vendors offer open source software in order to create a large user community. They generate revenues from subscriptions to support and updates and/or professional services as well as from selling extensions or professional editions that are based on the open source software. Examples are the providers of the Linux distributions RedHat and Suse.

Provider landscape: Open source software has also become an important part of a number of software ecosystems. It has become an alternative to commercial software in various areas and is included in many commercial software products. For example, the so-called LAMP stack is a common framework for websites (LAMP = Linux, Apache HTTP Server, MySQL database and PHP programming language) that competes with commercial software components.

Major commercial software vendors such as IBM and HP have made open source technology a part of their business by integrating it into their own products and by providing professional services for open source software.

Some software makers have transferred part of their own assets to an open source foundation. For example, CloudStack, a development from Citrix, is now part of the Apache Software Foundation. Such open source software foundations represent a software ecosystem in their own right.

On the other hand, commercial software vendors buy open source software providers. For example, the open source business intelligence software company Actuate was bought by the enterprise content management vendor OpenText.

Examples of European open source projects are LibreOffice from The Document Office Foundation and Jedox from Germany. The vendor provides a community edition of its BI solution.

Open source software: Impact on European software vendors, software-related service providers and games developers

Impact on European application software vendors: *Many business applications already include open source software and this is going to increase. Some vendors may donate part of their products to an open source foundation in order to create a larger user community that will potentially become buyers of commercial add-ons or services. On the other hand, open source software that is free of charge can be an alternative to commercial application software.*

Impact on European infrastructure software & platform vendors: *Due to the large amount of infrastructure software based on open source, including software to build cloud environments, business has becomes difficult for commercial infrastructure software & platform vendors. They need compelling arguments in favour of their proprietary software. One option will be to embrace open source software as a common standard and to build proprietary solutions on top.*

Impact on European providers of software-related services: *Service providers already use open source software in IT projects. However, for them, it is less relevant whether software is open source or commercial as long as it helps them drive their business. Providers of cloud computing will use open source software in their data centres. System integrators will use open source tools in custom software development projects for cost-efficiency reasons.*

Impact on European games software vendors: *Games developers use open source software for development as well as for deployment (online games). In addition, some games software is available as open source.*

Comparison with 2010 study

The 2010 SMART report described the importance of open source for the software market. The relevance has become even higher due to the growth of Linux, Apache and open source middleware, as well as the use of open source software for the creation of cloud computing environments (private and public cloud), big data usage (Hadoop) and the proliferation of mobile devices (Android).

5.2. Maturity of key topics – EU28 compared with the US and India

For the evaluation of the maturity of each topic as well as the competitiveness of the software market in the EU28 region compared with the US and Indian markets, the following evaluation schema is used:

Maturity
Definition: Adoption of topic within companies as well as in the local software industry. Presence of local vendors.
Emerging
Growing
Mature
Declining

USA

Topic	Maturity EU28	Maturity USA
Digital transformation	Emerging	Growing
Analytics	Growing	Mature
Big data	Growing	Growing
Mobility	Growing	Growing
Social media	Growing	Growing
DevOps	Emerging	Emerging
Cloud computing	Growing	Growing
Security	Mature	Mature
IoT	Emerging	Emerging
Open source	Growing	Growing

The US is both the largest single market for software investment and home to three quarters of the world's 50 largest software vendors.

The country sets the pace at global level for the adoption of new technologies (social, mobile, analytics) and delivery models (cloud). And these topics are increasingly moving from tactical projects happening around the edge of US businesses into the heart of the transformation that is under way across all industry sectors. US-based SMBs in particular are adopting software and SaaS faster than in any other country.

Cloud computing has been changing the market dramatically. Providers of software as a service (SaaS) are now part of the top 10 US software providers.

The proximity to Hollywood with its immense number of highly innovative and experienced media companies, entertainment providers and graphic design companies is pushing the gaming software market.

Comments on the key topics in the US market:

- US companies as well as the US software industry were the first to start **digital transformation**, including the adoption of new business models.
- The leading **BI/analytics** platforms are US-based and the solution market is mature. In addition, US companies have a higher maturity level as regards BI/analytics technologies. It is a highly innovative market.
- **Big data** is a growing topic and is already more mature than in the EU28.
- **"Mobile first!"** has become the mantra for many software companies.
- Leading **social media** networks are US-based. Companies use social media to engage with customers. Social media is part of marketing strategies, which drives software investments. Many companies have also adopted social collaboration internally to improve business processes.
- Software vendors, IT service providers and companies adopt **DevOps** at an increasing pace.
- Regarding **cloud computing**, the US is a growing and maturing market as its software industry started the transition towards the cloud very early on. Leading cloud providers are US-based.
- Due to the strong demand for **cyber security** solutions, this topic is a growth driver for the software business, too. Leading security software vendors are US-based.
- **The IoT** is still an emerging topic. The US vendor landscape has been fragmented so far. However, IoT platforms are emerging.
- **Open source** leads to commoditization and price pressure on the software market.

India

Topic	Maturity EU28	Maturity India
Digital transformation	Emerging	Emerging
Analytics	Growing	Growing
Big data	Growing	Emerging
Mobility	Growing	Emerging
Social media	Growing	Emerging
DevOps	Emerging	Emerging
Cloud computing	Growing	Growing
Security	Mature	Growing
IoT	Emerging	Emerging
Open source	Growing	Growing

The Indian market is characterized by a huge number of human resources available at low (although increasing) cost and with a high level of qualifications. However, Indian and international players are often challenged by a complex bureaucracy and weak road, power and telecom network infrastructures in this country.

The Indian market is dominated by US-based software providers that together account for half of the market. International software players have long dominated the market because local Indian IT majors have focused much less on software than on IT outsourcing services. However, the Indian IT industry is increasingly creating a balance between software products and service sector growth. Key to this current trend is the rise of software product start-ups in India, which are rapidly growing in number (more than 3,000 start-ups to date, and increasing every month), developing industry-specific solutions and targeting specific niches.

The industry hopes to gain momentum in the coming years and to win a greater share of the global market. Policy initiatives play a significant role in fostering the national software sector. Owing to a positive sentiment in the market due to the newly formed government's technology-centric initiatives, the IT industry sees happier years ahead. Despite challenges in the global market, the Indian software industry has seen steady growth recently.

The immense popularity of Bollywood and the ever increasing number and specialization of providers around movie productions are a clear driver for the Indian games software market. A rising popularity of mobile and online games can

be observed. Sony is the largest player in the Indian video games software market thanks to the success of its PlayStation.

As Indian IT service companies enter the European markets, they will bring Indian software products to this market, too. Thus, a significant rise in competition can already be observed in the European SSBS market beyond the UK, for example in Germany or the Netherlands.

Comments on the key topics in the Indian market:

- **Digital transformation** is an emerging topic for Indian companies and the Indian software industry. Many software start-ups enter the market. The Digital India government program may lead to software investments.
- Companies are more and more building **BI** infrastructures. The market shows less maturity, but higher growth. There is a growing number of local software vendors. A transition from a service-led IT provider landscape to a mixture of products and services is taking place.
- **Big data** is an emerging topic. Indian start-ups as well as existing vendors enter this segment.
- Many local vendors provide **mobile** platforms. Strong adoption of mobile technologies within companies and in the consumer sector.
- There is growing adoption of **social media networks**. Companies use social media to connect with customers. The usage of social collaboration within enterprises is becoming more and more relevant.
- Software vendors, IT service providers and companies adopt **DevOps**. However, this segment is rather in its early stages.
- There is an increasing number of local **SaaS** offerings. Local cloud & SaaS vendors become competitors for the global players.
- Growing software business due to **cyber security** demand. However, leading security software vendors are US-based.
- **The IoT** is an emerging topic everywhere. There are government/NASSCOM initiatives to push IoT-related technologies in the Indian market.
- Government and companies strongly push **open source** for software development. In addition, open source is used in emerging areas such as cloud computing and big data.

6. Understanding the Role of In-house Software Development

Assessing the importance and growth trends of current in-house software development activities in European companies from different industries is another important step when analysing the trends in the growth and competitiveness of the European software industry. In order to understand the impact of in-house development trends on the software industry, to assess the change in the industry's structure and to deduce potential policy measures, it is mandatory to understand the influencing factors of make-or-buy decisions that are currently at work. For the assessment the project team conducted qualitative and quantitative analyses as described in detail below. This kind of analysis was not part of the 2010 study, thus had to be developed from scratch.

Definition of in-house software development activities

For this study's analysis, the project team defined in-house software development as the development of software within a company, performed by employees and resulting in products that are not distributed externally as software products. This also applies to those companies from the manufacturing sector, for example, that develop software embedded in machines, vehicles, devices, etc.

External developers, outsourced development activities or development services provided by systems integrators are not considered here.

According to PAC's segmentation, in-house development of software can be performed:

- from scratch with any kind of third-party development tool (open source tools, commercial development software tools or cloud-based development environments);
- on the basis of a third-party software platform (e.g. ERP software); this can comprise the development of new code (add-on features) or the customization of the business logic.

Basically, with in-house software development, the entire lifecycle of software is considered – from design requirements analysis through design and code development to testing and deployment as well as maintenance.

Methodology

To estimate the volume and growth of current **in-house software development activities** in different industries, the project team first did a **qualitative analysis** based on PAC's own sector-specific knowledge and on the results from semi-standardized expert interviews conducted with 25 companies from different sectors and countries (see the interview guide at the end of this report). The project team also discussed potential drivers and barriers for in-house development with them.

In a second – **quantitative** – analysis, the project team estimated the market size and growth rates of in-house software development in nine industries[32], based on PAC's sector-specific market models. These models are based on a combination of PAC's comprehensive country-level and vertical-specific IT market figures and the qualitative analyses done for this and related projects, including a series of expert interviews with relevant market players.

The quantitative basis for the analysis is the model of total IT expenditure. PAC distinguishes between:

Fig. 41: Total IT expenditure (PAC model)

In order to estimate the volume of in-house software development, the project team considers in-house software development expenditure as part of personnel expenditure, that is the cost for internal IT staff involved in the design, development, customizing, operation and maintenance of software used within a company. Thus, according to PAC's segmentation, in-house software development is not part of SITS expenditure (SITS = software and IT services), but is added to it when considering IT expenditure in general.

This study's analysis is additionally based on the following assumptions:

1. Personnel expenditure is divided into costs for application-related and infrastructure-related tasks. On a cross-industry average, the share of application-related costs in personnel expenditure was slightly more than 60% in 2015, with a tendency to grow slowly until 2020. The remaining share of nearly 40% is infrastructure-related (e.g. implementation and maintenance of IT network, internal service desk) and will not be further considered in the analysis.
2. Within application-related personnel costs, the project team estimates an average share of slightly more than 30% to be related to the implementation of standard software bought externally. The project team does not consider this as in-house software development expenditure. The remaining nearly 70% are the basis for the volume and growth analysis on in-house software development in this study.

Several factors impact the industry-specific shares mentioned in the assumptions 1) and 2), thus affecting companies' tendency to do in-house software

[32] These nine industries are part of PAC's comprehensive SITSI database. For a definition and detailed description of the methodology and market segmentation see chapter 5 and www.pac-online.com/sitsi. Please note that the vertical segmentation used slightly differs between the qualitative and the quantitative analysis. The project team's qualitative analysis additionally considered the healthcare segment in more detail. However, in PAC's SITSI database and the quantitative analysis, healthcare is not considered separately, but included in the public sector. The quantitative analysis additionally covers the telecommunications sector and the services & consumers sector.

development. Some of the most important factors are described in the following chapter.

6.1. Identification of factors influencing make-or-buy decisions in different industries

Recently, software-related make-or-buy decisions have shown a stronger tendency towards the 'make' side, especially when it comes to product development. For many companies, software has become a critical success factor for products and services and is regarded as an innovation enabler.[33] In the automotive sector, for instance, innovations mostly originate from the area of electronics and over 50% of electronics development costs are related to software (based on PAC research in the area of manufacturing). And this figure is expected to increase. The same trend can be observed in other industries.[34] In some cases, companies have transformed their traditional products into digital entities and started selling services instead of just products. Software is going to be at the core of such business models.

Therefore, the question of whether to buy or make software is becoming increasingly strategic and is currently being discussed at board level in many companies. In the market, several different trends can be observed, including companies acquiring software houses in order to build internal resources, the extensive hiring of software-focused resources, and the extended cooperation between corporate clients and IT service companies. One example of a company that bought a software vendor is the automotive supplier Bosch from Germany, which acquired Inubit, a German specialist for business process management software. Continental, another German automotive supplier, acquired Elektrobit, a German vendor for embedded software solutions. French-based Schneider Electric acquired Invensys, which among other activities makes software for industry automation. And in 2015, the Dutch sustainable energy provider Eneco acquired Quby, developer of the Toon intelligent thermostat with which customers can make their homes smarter. The software will also be made available to other developers as open source.

In order to understand the impact of these trends on the software industry and to assess the change in the industry's structure, it is mandatory to understand the influencing factors of make-or-buy decisions that are currently at work. In the following chapter, the identification of the factors impacting the propensity for in-house software development in different sectors is based on 1) the project team's own sector-specific know-how based on qualitative and quantitative research, and 2) expert interviews conducted as part of this project by PAC and CXP. The consortium conducted expert interviews with 25 companies from different sectors

[33] More and more products and services of global engineering player Bosch Group, for example, are based on software – often self-developed. The company's subsidiary Bosch Software Innovations, focused on developing software solutions for the connected world, developed a software platform for the Internet of Things, the IOT Suite.

[34] For example, German mail-order retailer Otto Group has transformed itself into a multi-channel player with a strong e-commerce presence over the past few years. After using standard software for its online shop for about 13 years, Otto started developing its own e-commerce software in 2011.

and countries. In the interviews respondents were asked, for example, whether they did in-house software development and, if so, in what areas. The project team also discussed with them the potential drivers and challenges of in-house development.[35] Some of the statements heard in the interviews are provided in the sections below.

The consortium's research shows that the general propensity of companies to do in-house software development is influenced by the following factors, which may vary between industries:

- General software maturity level (as regards standardized solutions)

The higher the level of maturity as regards the use of standardized, off-the-shelf software solutions, the lower the propensity of companies to internally develop their own applications because it can be cost-effective for companies to not have to manage the lifecycle of a software by themselves. This is particularly the case if IT systems become more complex and have to fulfil an increasing range of requirements. For example, retailers' check-out systems have to support omni-channel functionalities and advanced payment systems and are thus becoming more and more complex. That's why it may be an advantage for retailers not to develop everything on their own.

Cloud may play an important role here as well. One of the expert interviewees stated that "cloud usage has an impact, as it makes software use more easy and in-house development becomes less likely". Thus digital pioneers that are counting on the cloud are expected to rather prevent in-house development.

- Availability/quality of external software solutions/competitive structure

The more external software solutions are available on the market and the higher their quality, the lower companies' need to develop their own solutions. The availability of software is strongly influenced by the competitive structure of an industry: a higher number of competing companies within a specific market segment makes it more attractive for software providers to develop high-quality, of-the-shelf solutions and related services for this particular market segment. Software providers are looking for segments that promise a large and growing addressable market. Especially in the manufacturing industry, one can observe a fast increasing complexity and individualization of production processes, systems and products due to the rising share of software, sensors and connected devices. As a result, the level of software reuse is declining and many software developments need to be done from scratch – a strong barrier for the availability of external solutions. However, pressure from customers and the competition between software vendors will lead to the emergence of more and more mature software (or even packages).

- Status of digital transformation/risks through disruptive technologies

The industry-specific status of digital transformation has a strong influence on companies' tendency to develop internal software solutions. Increasing pressure on

[35] An overview of the questions discussed in the semi-standardized interviews is provided in the appendix to this report.

business models (real time!) due to the emergence of disruptive technologies forces companies to adjust their software landscape in order to quickly address new requirements from customers and partners. Pioneers of digitization may currently be struggling to find a suitable solution on the market, as their requirements may be too specific. Even if a provider were able to develop it, it may be too expensive because an existing solution needs to be comprehensively adapted to the specific company requirements. And companies may not trust providers to fully understand their specific requirements, which often involve highly specialized process know-how and product innovation ("Our requirements are too specific. This cannot be done by external providers or would be far too expensive", a manufacturer said). Thus, companies tend to build their own specific software know-how in order to respond adequately to their specific innovation and digitization requirements ("New requirements come from the production sites with regard to new analytics and management functionalities. The IT needs to understand the resulting specific needs and how to translate them into concrete processes", said a European manufacturer).

- Business pressure to develop in-house, e.g. due to competitive aspects, need for speed, security issues, etc.

Business pressure and changing market environments force companies to consider in-house software development options as a competitive advantage. Added value created through bespoke software becomes highly important.

As the expert interviews show, speed has become a decisive factor for many companies – the speed of product development, time-to-market, customer interaction, etc. Companies tend to develop and adjust software on their own if they want to react quickly to changing customer preferences and market demands, but think that the communications and development processes with external partners may take too much time and effort. Many of the interview partners assumed that "it is easier and less time-consuming to "quickly" do the development and related adjustments internally". A large manufacturer said: "We have more flexibility if we do it in-house; if we need something new we can start quickly without first inviting tenders and selecting proposals".

In addition, security issues are intensifying business pressure and pushing in-house development activities as companies, for example, do not want to give sensitive internal process know-how to external software partners. In-house development allows the complete control and ownership of the intellectual property.

- Need to differentiate through innovativeness

The increased business pressure coming from rapidly changing customer demands, time-to-market pressure, increasing competition from new, innovative and global competitors has moreover become a strong driver for innovation. The need to differentiate themselves from competitors is even becoming a matter of survival for many companies. Against this background, in-house software development is becoming part of companies' research & development strategy and is therefore strongly pushed. As a large manufacturer put it: "We want to keep internal software development know-how in order to ensure internal innovative impetus".

- R&D investment patterns

A pronounced R&D intensity is often related to a higher propensity to develop software internally. This is due to the factors mentioned above, such as the difficulty of finding suitable solutions or making sure that important and innovative internal know-how does not find its way to competitors. Moreover, engineering-driven companies that see product development as their core competency have a tendency to disapprove of solutions from external providers ("not invented here").

- Externalization rate of business processes

This factor comprises, for example, the intensity of networking, process integration with suppliers, customers and partners, or co-innovation activities. The more complex the supplier and partner network and the more collaboration and cooperation takes place, the more useful standardized applications become as they can provide a common standard, e.g. for data exchange and interaction on the basis of business processes. In this case internal development is not so relevant. Companies no longer want to have isolated solutions (the "silo" approach), but solutions allowing them to easily interconnect and exchange.

- Company-specific factors

The factors described above of course vary from company to company, but for most of them one can observe industry-specific trends. These are, however, complemented by further aspects that the project team considers to be rather company-specific factors with no clear industry tendency.

One argument that the project team heard very often in its interviews was that there was no suitable external software solution available today as the company's **business model** is **unique and highly innovative**. This means the company has highly specialized processes and needs specialized software with customized features, which are better developed in-house. On the other hand, customization and specialization always increases the complexity of solutions. For some of the interviewed companies **complexity** is the very factor that forces them to look for standardized external solutions, as in the long run they expect these solutions to be less costly and time-consuming and more easy to maintain. More and more companies are particularly seeking for solutions with a wider scope to reduce the number of solutions and the overall complexity.

However, in many cases standard solutions are adjusted internally to a significant degree – which diminishes the advantages of such a standard solution.[36] According to one of the project team's interviewees (wholesaler): "**Standard solutions have their limitations**. Thus we will always need a certain portion of customization and specific solutions". This person estimated the share of in-house software in his company at 60% and expects it to remain about the same in the future. A manufacturer confirmed this and even expects more in-house activities in the future: "We expect an increase in in-house software development, although we try to focus on standard solutions." And a respondent from a large logistics company

[36] A standard solution is a commercial of the shelf software that is being used as it is, without significant customization of the business logic.

said: "In the future we will use more standard solutions, but at the same time we will make more individual adjustments". However, customizing the software through additional, specific development is expensive: companies have to pay for development, integration, regression testing, upgrade, etc. For each upgrade it is extremely difficult to carry out the corresponding specific follow-up developments. The problem is even more significant in industry-specific software areas.

The decision to develop internally also depends on the **urgency** of implementation. If extensive integration is needed and the implementation timeline is quite flexible, companies tend to do the development internally. This, however, requires companies to deploy enough internal resources to do it. Against this background, some interviewees said that "**size matters**", meaning "in-house software development is more likely if you are a larger company with a large IT landscape and a large number of internal IT staff already available."

However, even large companies decide against in-house development, as the statement of a person working in a large German public transport company shows: "There are too many ups and downs in the demand for software development, making it hard and expensive to keep the internal resources all the time and keep their **know-how up to date**". This company uses external software only. IT skills shortages may also increasingly prevent European companies from doing software development on their own. A large manufacturer sums up the hampering factors for in-house development as follows: "Developing software internally is of high complexity, takes a lot of time and requires comprehensive skills – be it for programming, organizational issues, or processes". Quite similar is the view expressed by a large European wholesaler: "The **complexity** of the solution, the need for speed, and the availability of internal resources might hamper internal development".

Some of the companies the project team talked to said that they had "strong internal software development know-how for **historic reasons"**. If this is the case, the propensity to develop software internally is much higher. Companies simply use their internal resources, based on the strong company-specific process know-how and rapid responsiveness they already use.

To sum up, companies have a stronger tendency to conduct in-house software development if

- They are active in a sector where the level of maturity with regard to the use of standardized, off-the-shelf software solutions is generally low.
- The general quality and availability of a specific external solution is rather low (e.g. because they operate in a small market segment).
- Their software requirements are too specific (e.g. because they are highly innovative and/or pioneers of digital transformation, or because they work in a highly specialized market segment).
- They do not want to give sensitive internal process know-how to external software partners.

- They have their doubts about a quick and efficient communication with external software providers around software development and adjustment.
- They have a pronounced R&D strategy and see in-house software development as a relevant part of it.
- Their supplier and partner network is not very complex.
- They have a certain size and have enough internal IT resources and competencies.
- They used to do it in the past and they do not see any reasons why they should not continue to do so in the future.

6.2. Estimating the amount and growth of in-house development in different industries

Qualitative insights by verticals

The tables and the spider graph below summarize the results of the project team's qualitative analysis focusing on the following industry-specific aspects:

- Software maturity level in the industry (as regards usage of off-the-shelf software).
- Availability of external software solutions/competitive structure in the industry.
- Status of digital transformation.
- Business pressure to develop in-house, e.g. due to security issues, competitive aspects or specification of needs, etc.
- Need to differentiate through innovativeness.
- R&D investment patterns.
- Externalization rate for business processes.

On a scale from 1 to 5 the project team roughly evaluates the sector-specific impact of these specific factors on the **propensity to do in-house software development**. A higher score means that this factor results in a higher tendency to conduct in-house software development. The average values of these estimations show a general tendency of how likely in-house development is in the different industries.

Overview: key insights into in-house software development by industry

Key (tendency to conduct in-house software development):	1 - very low	2 - low	3 - medium	4 - high	5 - very high

Criteria	Manufacturing		Banking		Insurance		Public Sector (Government)	
Software maturity level of the industry (as regards usage of off-the-shelf software)	**2**	Quite high software maturity level	**5**	Very low off-the-shelf software maturity level, software is traditionally highly bespoke & created in-house	**3**	Medium software maturity level	**5**	Very low software maturity level
Availability of external software solutions (also related to competitive market structure)	**4**	Many standard SW solutions available in the market, but many process requirements cannot be covered by commercial, off-the-shelf applications	**4**	Typically best-of-breed solutions; a lot of customization of standard products or internal developments needed	**4**	Typically best-of-breed solutions; a lot of customization of standard products or internal developments needed	**4**	Standard/off-the-shelf software available for specific processes; often best-of-breed solutions
Status of digital transformation (initiatives started, strategies defined)	**3**	Few large pioneers, but especially the large number of European SMEs are rather lagging behind; differences exist between sub-segments within manufacturing; high relevance of emerging concepts based on intelligent use of product data (IoT, industrial IoT/Industry 4.0)	**3**	Banks are in the middle of dig. transformation as regards client relations, but have often failed so far to digitize internal processes; innovative fintech start-ups threaten core business	**2**	Only few digital transformation initiatives started; insurers need to expand beyond offering a few basic mobile or social functionalities	**2**	Growing interest, but public sector authorities are naturally cautious about disruptive technologies (such as digital and connected citizen service platforms); strong differences between countries
Business pressure to develop in-house	**5**	Highly individualized and specialized processes require in-house development; high competitive pressure	**3**	Strong solutions developed in-house & a lot of internal development staff, but efficiency goals require standardization & harmonization; in addition, compliance & risk mgmt. are of great importance and ask for standard solutions	**3**	Strong solutions developed in-house; need to comply with heavy regulations; risk management is important	**5**	Core processes are highly individualized, lack of existing off-the-shelf solutions; complex procurement procedures, slow internal decision processes

Criteria	Manufacturing		Banking		Insurance		Public Sector (Government)	
Need to differentiate through innovation	**5**	Rapidly changing customer demands, time to market, increasing competition from new & innovative (Tesla) and global (Chinese) competitors	**4**	Competition from direct/online banks, need for digital/mobile customer service, innovative fintech start-ups threaten core business	**4**	High transparency of offerings (Internet portals)	**1**	Rather weak interest or need to differentiate through innovation
Externalization rate for business processes (networking, process integration of suppliers, customers, partners; co-innovation)	**2**	Highly complex supply networks, highly complex products	**4**	Less complex supply chains, partner networks and products	**2**	Rather complex network of brokers, agents etc.	**3**	Defence/central intelligence rather complex, other areas less so
R&D investment patterns (often strong need for solutions developed in-house)	**5**	Product development is part of core business	**4**	Core business is strongly linked to SW development; currently a lot of R&D around mobile solutions, payment solutions, security functionalities	**4**	Currently a lot of R&D around mobile solutions, multi-channel customer service solutions, security functionalities	**1**	Very limited
Average	**3.7**		**2.9**		**2.7**		**3.0**	

Fig. 42: Overview: key insights into in-house software development by industry – Manufacturing, Banking, Insurance, Public Sector

Criteria		Healthcare		Utilities		Retail/ Wholesale		Transport/ Logistics
Software maturity level of the industry (as regards usage of off-the-shelf software)	**4**	Rather low software maturity level	**3**	Medium software maturity level	**2**	High software maturity level	**2**	High software maturity level
Availability of external software solutions (also related to competitive market structure)	**2**	Mostly standard solutions for ERP and patient records; much fewer standard solutions for staff management	**2**	Many standard SW solutions available; in most areas (business management and operations)	**2**	ERP systems and check-out systems highly standardized; increasingly merchandizing solutions etc. as well	**3**	Many standard software solutions available; companies often use old-fashioned software --> increases tendency to migrate to off-the-shelf software rather than develop in-house solutions; however, competition is becoming more intense as players leave the market and the market (and solution availability) is thus rapidly shrinking
Status of digital transformation (initiatives started, strategies defined)	**2**	Initiatives are mainly seen around open data (use of aggregated patient data for research activities) or e-health (remote communication with patients); hospitals start digital initiatives to improve internal processes	**2**	Utility companies are looking to leverage new digital technologies in order to drive efficiency, differentiate from the competition, and provide a more compelling experience to customers. Mobility and IoT (smart meters, thermostats, smart asset management) are at the heart of this trend. However, many EU countries are on a rather low level.	**2**	The digitization of consumers forces retailers to restructure customer interaction, service and sales channels, marketing activities; however, dedicated digital strategies are rather rare.	**4**	Digital transformation already shows a high level of maturity in terms of digitization at European level, despite some remaining disparities among individual transport companies and various transport sub-segments.
Business pressure to develop in-house	**2**	Highly regulated market	**3**	Changing business models, from resource provider to customer-focused business; requirements regarding smart energy, increasing market	**3**	High competitive pressure, speed matters, solutions often do not exist yet, high customer expectations	**3**	Logistics: Challenges are to enable processes for online commerce, improve customer service with digital services. Transport: Digital customer

				transparency				services and customer loyalty are challenges.
Need to differentiate through innovation	**2**	Highly regulated market limits options	**2**	Limited options for differentiation	**5**	Pressure is extremely high, customer centricity, strong competition	**3**	Transport: Airlines are struggling to differentiate. Logistics: Customer service is a differentiator, as is the pressure to provide fulfilment services for online retailers
Externalization rate for business processes (networking, process integration of suppliers, customers, partners; co-innovation)	**2**	Complex network of doctors, clinics, health insurers, accident insurers, social courts, etc.	**2**	Network of energy distributors, brokers, customers, wholesalers, etc.	**2**	Highly complex network of suppliers, retail channels and customers; integration of payment providers	**2**	Logistics providers need to integrate with retailers' systems, provide online portals; transportation firms need to provide mobile apps and portals for B2B & B2C customers
R&D investment patterns (often strong need for solutions developed in-house)	**2**	Rather limited	**4**	E.g. smart energy, smart meters, electric car charging stations, energy management	**2**	Only few "classic" R&D activities	**2**	Limited need for in-house dev.; often maintenance and extension of existing home-grown software; tendency to replace home-grown solutions with off-the-shelf software where possible
Average	**2.0**		**2.6**		**2.6**		**2.7**	

Fig. 43: Overview: key insights into in-house software development by industry – Healthcare, Utilities, Retail/Wholesale, Transport/Logistics

The following spider graph summarizes the vertical estimations:

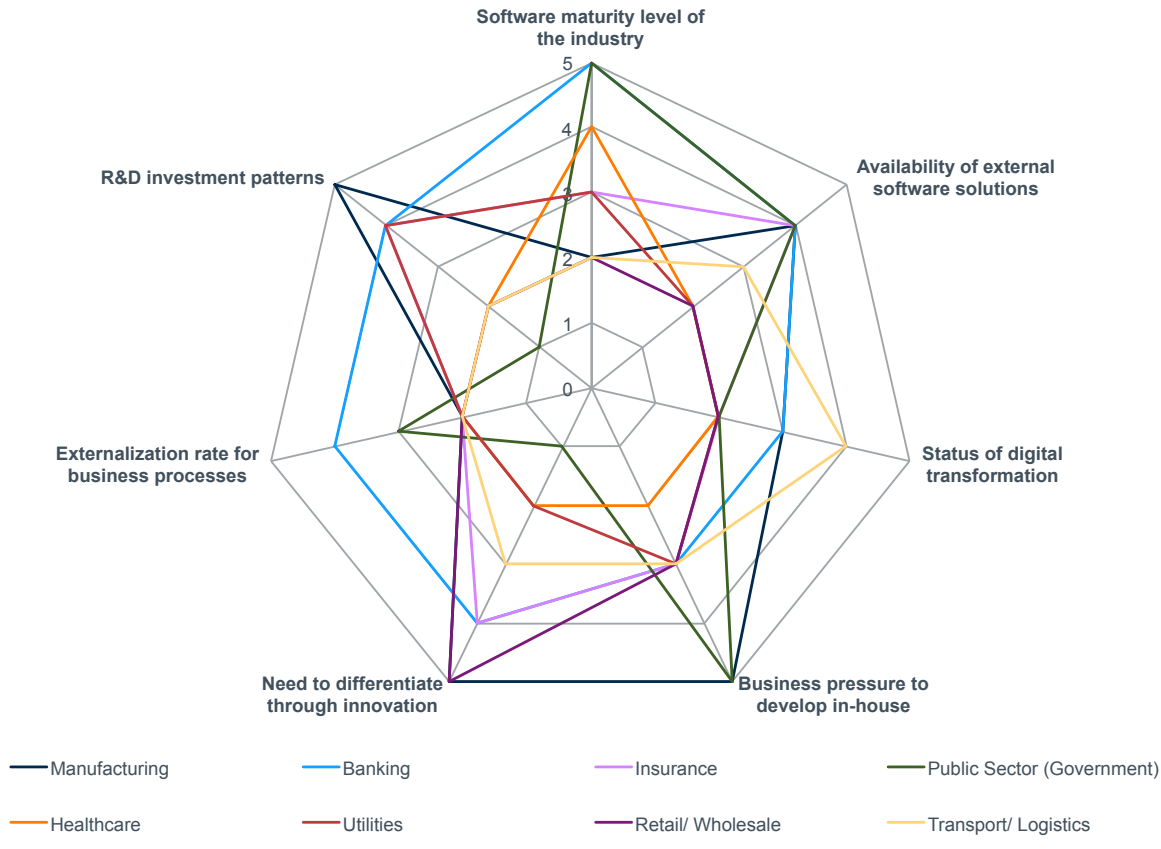


Fig. 44: Key insights into in-house software development by industry

The following two examples – for the manufacturing and the banking sectors – give some more detailed insights into the considerations made for each of the vertical segments. These qualitative analyses are taken into account in the quantitative market estimations provided below.

Example 1: IT expenditure in the manufacturing sector – focus: Industry 4.0/industrial IoT

Growing requirements and challenges for European manufacturers, such as global competitive pressure, lead to price pressure, which in turn requires ongoing efficiency improvements in manufacturing. The optimization of production processes and supply chains is therefore mandatory for manufacturers. And the need for shorter product development cycles and a quicker time to market has become even more pressing.

Generally, the manufacturing industry is strongly affected by the development of new technologies (e.g. cyber-physical systems, embedded software systems, mobility, big data, the cloud, etc.), which has an impact on both processes (e.g.

product development, production, logistics) and products (e.g. intelligent/ smart products). The tendency to develop software internally is pronounced in the manufacturing sector, as innovative solutions are often highly company-specific and the fear of losing internal know-how is great. However, the importance of in-house software development varies quite a lot depending on each manufacturer's individual situation and on the sub-segment (e.g. automotive industry vs. chemical industry or automotive OEMs vs. small automotive suppliers).

The considerable business challenges manufacturers are facing today and the new technological/IT developments drive investments in Industry 4.0/industrial IoT initiatives or the Internet of Things (IoT). In the long term, the optimization of the entire shop floor through industrial IoT will be inevitable in order for European manufacturers to stay globally competitive. However, in the short to medium term, PAC does not expect any revolutionary industrial IoT projects to be launched on the shop floor. Instead, ongoing IT projects are expected that manufacturers will implement to optimize their shop-floor processes, for example, by developing shop-floor processes towards a true lean manufacturing concept, or by setting up consistent master data management, or by implementing efficient warehouse management processes.

Based on the applied segmentation, market data and estimations, the project team came to the following conclusions:

- A very large share of overall IT expenditure on Industry 4.0/industrial IoT is internal spending. Especially in terms of vertical integration and local intelligence, companies are currently building internal resources. This trend is expected to intensify over the next few years, albeit at a slower pace than external IT spending.
- External IT spending on Industry 4.0/industrial IoT is strongly focused on IT services. These basically include integration services related to analytics (vertical integration) and the cloud (horizontal integration), as well as embedded software development services (local intelligence).

As the topic of industrial IoT and related software applications and IT services will become more mature over the coming years, resulting in a larger number of high-quality solutions available in the market, the consortium expects spending to shift towards more external solutions in the medium run. Internal spending will grow as well, but at a lower pace.

Example 2: In-house software development trends in European banks

Rapidly changing customer demands, shrinking profits, increased competition from highly innovative fintech companies, and not least the increasing level and complexity of regulations are currently shaping the business environment of European financial services institutions. Companies in the banking sector used to have a lot of in-house software development and some of them still use home-grown solutions to manage their core processes. As the companies have a high number of internal IT staff, they can easily handle internal software development projects. However, over the years, this legacy software has increasingly become less flexible, less adaptive to new market developments (e.g. multi-channel

offerings) and less efficient. In addition, on a global level they often use different systems in different countries. But cost and competitive pressure is currently forcing financial services institutions to standardize and harmonize their IT infrastructure and application landscapes. These developments are driving more and more banks to replace home-grown software with off-the-shelf alternatives.

On the other hand, in some areas, in-house development may even increase. Banks are particularly forced to improve and innovate their products and customer service. Therefore, their R&D is currently focused on topics such as mobility, mobile payment solutions, multi-channel service provision, security and compliance, with the aim to develop individualized in-house solutions.

Quantitative analyses by verticals

Market volume and growth of in-house software development in the EU28

Similar market considerations are used for all nine analysed industries in order to 1) estimate for the EU28 the amount and growth of in-house development by industry and 2) compare the volume of in-house software development expenditure with that of total SITS spending by industry.

The total **market volume** of internal software development expenditure is estimated at €52.3 billion in 2015, according to PAC data (not shown). With an **average yearly growth** of 1.8%, this figure is expected to increase to €57.2 billion in 2020.

As regards the different industries within the EU28, the project team sees the following developments:

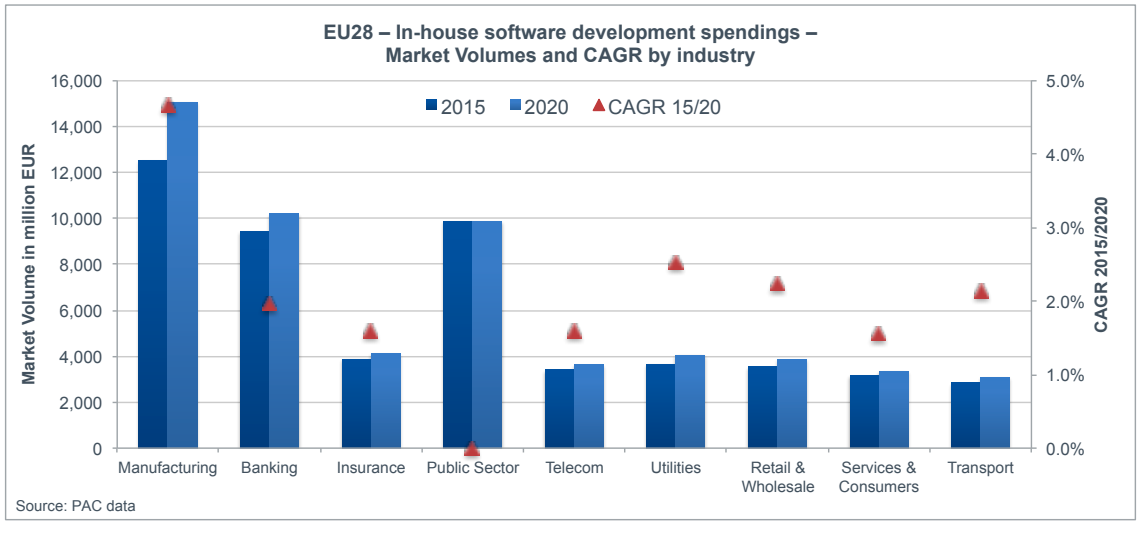


Fig. 45: EU28 – In-house software development spending – market volumes and CAGR by industry

Except for the public sector, where the figure remains more or less the same, market volumes will increase in all sectors within the EU28 between 2015 and

2020, according to the project team's estimates. The largest increase is forecast for the manufacturing industry. In this sector, product development as well as the development of software that is embedded in the products is part of the core business. In addition, topics such as (industrial) IoT are currently heavily driving manufacturers' propensity to develop software internally. Relevant solutions are often not yet externally available in the market or companies just want to prevent internal know-how from leaving the company when external software partners get involved. The project team expects manufacturing growth rates to increase until 2017 and slightly slow down afterwards (not shown).

Market shares of in-house software development in the EU28

While the volume of investments in in-house development will continue to grow (although at a slower pace, as seen above), a comparison between total and sector-specific in-house development expenditure on the one hand and total SITS expenditure on the other will show shrinking percentages for in-house development between 2015 and 2020, according to PAC estimates (see figure 6). Compared with total software and IT services (SITS) spending, in-house software development expenditure amounted to around 20.3% in 2015. This figure will slightly decline to 19.5% by 2020 (not shown).

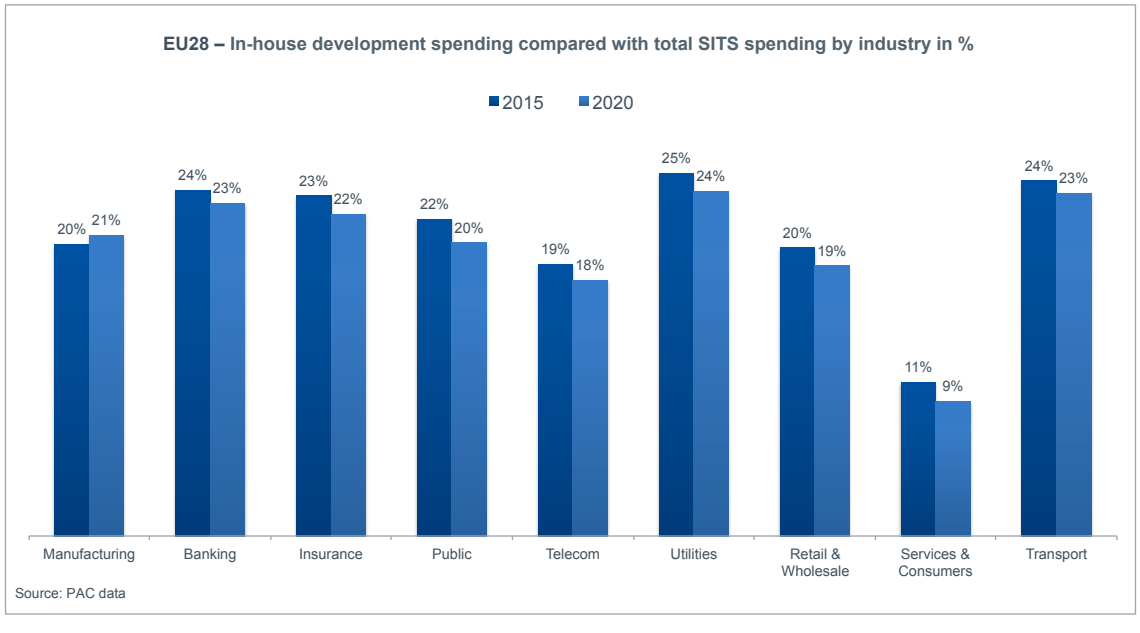


Fig. 46: EU28 – In-house development spending compared with total SITS spending by industry in %

The falling percentages will not be due to a decline in in-house software development expenditure (see figure 5 above), but to the strong increase forecast for total SITS expenditure, which will grow at faster rates than in-house software development spending. Again, the only exception is the manufacturing sector, where the growth of in-house software development will further increase and outpace external IT spending.

However, internal software development will definitely remain highly relevant in all analysed industries.

6.3. Impact of software development business models

When companies want to develop software, they can either use their internal resources (developers within a company, which is considered as in-house development in this report) or they can use external services provided by systems integrators, service providers or freelancers.

In the following chapter, the implications of the various software development business models are discussed.

Software development by a subsidiary

Some companies, especially large organizations, use nearshore or offshore development facilities in other countries (including non-EU countries) for their in-house software development activities. These subsidiaries can be more cost-effective thanks to lower wages.

This is neither a driver nor an obstacle for in-house development because companies only establish such facilities if there already is demand for in-house software development, not vice versa.

Outsourcing

As demand for individual software development increases, companies evaluate ways to outsource such activities due to internal skill shortages and cost considerations. Companies outsource activities that are less critical. For example, a car manufacturer will hardly outsource the in-house software development for its autonomous driving technology, as this is highly confidential and highly relevant for its competitiveness.

Outsourcing can be an alternative to in-house software development and more and more companies take advantage of this. This fact is taken into account in the qualitative market analysis for in-house software development in this report.

Two areas of potential outsourcing in the area of in-house software development are testing and maintenance. In terms of testing, companies develop the software in-house, but hire a service provider to do the software testing.

When it comes to maintenance, the software is developed and deployed by the company. Maintenance tasks such as bug fixes and upgrades are performed by an external service provider.

Open source software development

Open source software can help reduce the cost of software development and deployment, and make software more interoperable. PAC does not consider open source as a driver or obstacle for in-house development. If companies decide to develop in-house, they look for appropriate tools to do so, be it open source or commercial software.

Co-development

Co-development by several companies is becoming popular as demand for specific software features is increasing and because companies are looking for ways to share investment efforts and skills and to shorten development cycles. For example, software vendors co-develop applications together with their customers. Another example are the joint development efforts by companies that belong to the same vertical industry in order to create a standard solution that can be used by a number of organizations. PAC expects in-house development based on co-development to proliferate, especially in areas such as the Internet of Things. Manufacturing companies will co-develop software with systems integrators or software vendors.

Co-development is an alternative to the in-house development of software. Companies opt for it if it is of mutual interest and if it does not have a negative impact on their competitiveness. Co-development may drive in-house development, as the development efforts can be shared with one or more other companies.

6.4. Further interesting insights gained from the expert interviews

The conducted expert interviews not only focused on analysing whether or not companies conduct internal software development. From those companies that do, the project team additionally wanted to know whether they use open source software for their in-house development and whether they carry out the development activities within the EU or abroad. This provides further insights into the topic.

Open source

The project team has not found any concrete evidence suggesting that open source software is either a clear driver or an inhibitor for in-house development. The willingness to use open source software (OSS) for in-house software development activities strongly varies between companies even within the same industry. It is often strongly related to a specific person – most often the head of IT – who either favours open source software or not. While some of the interviewees value the speed of development and the reduced number of errors due to the collaboration with a large community of software developers, others are less convinced of the advantages of open source software for their own development activities as they are afraid that "important internal know-how might become publicly available" or they "have doubts about the functionality and stability of open source software solutions". Another respondent mentioned two more challenges: "There is a risk that support from the community may diminish if the market loses in importance (but this could also be the case with standard software)" and "the community might be rather small in a specialized market", which may reduce the quality of community support. Companies using open source software often said they mostly used it for smaller, highly specific or less important application areas.

The answers given by the interviewees regarding the intensity of OSS usage range from "we have not dealt much with this topic " or "open source has never been a

big topic for us" to "yes, we do use OSS in several areas" or "we are open to open source software use, but we only use it in very small and specific areas today, especially due to our strategic tendency to use Microsoft solutions. However, we expect to be using small open source software solutions in the future as well".

How much of the in-house development is done within the EU?

Nearly all of the companies interviewed that declared they were developing software internally, do so 100% within the EU, although most of them are global players. There was only one company respondent (large logistics provider) who stated that the largest part of the development (80%) was done by employees in India, the remaining 20% within the EU.

How could your company benefit if the European Commission were to support the development of the software market within the EU?

The project team unfortunately did not receive many answers to this question. However, the support for open source software and the related community was particularly emphasized:

- A global player active in manufacturing and logistics said: "I would like to see more support for the OSS community. Government and EU institutions should use OSS much more themselves! This would provide great use cases, ensure long-term support, secure solutions and a high level of quality control. And it would also help other users."
- A large wholesaler told us: "We appreciate what is done by the OSS community. That should receive support in the future."
- A large manufacturer said: "We would appreciate receiving support for innovative internal software development projects (also as joint projects together with other companies) as this is very cost-intensive. We started a project once but had to stop it due to exploding costs." In addition, he would like to see more "support for EU companies with IT projects for manufacturing, where the IoT topic is highly challenging."
- With regard to cloud computing, a bank told us: "Technology is advancing at a faster pace than legal decision-making."

7. Identification of Key Barriers to the Competitiveness of the Software Industry

7.1. Introduction and methodology

What are currently the most important barriers to the development of a strong European software industry? What are the obstacles to the development of a genuinely European software sector? What needs to be done – irrespective of specific groups of players like politicians, enterprises or consumers – to build a strong and competitive software and Internet industry in Europe?

These are the questions addressed in this section. The starting point for identifying current key barriers was the thoroughly created list from the 2010 study. This list consists of the top 10 barriers as seen in 2009/10, with the top 3 barriers being "interoperability and standardization", "market fragmentation", and "lack of support for high-risk, R&D intensive start-ups". The list itself was the result of a prioritization process in which many experts were involved and which was based on a systematic review of factors which, in turn, were derived from the innovation system approach.[37]

In order to update the top 10 list from the 2010 study, the project team cross-checked the findings with findings from current studies and position papers. In an internal expert workshop carried out in February 2016 in Karlsruhe, the project team synthesized the different findings and created a new top 10 list of key barriers. The top 3 barriers on this updated list are "market fragmentation", "status-quo orientation of European enterprises", and "existing rules and governance structures within IT-using sectors".

In a next step the project team presented these findings to a group of external experts at a workshop that took place in Brussels in April 2016. The aim of this workshop was to generate a consolidated list of current barriers. The different updated barriers can then be compared with current policy measures in order to derive specific policy recommendations.

In the following chapter, the different steps and preliminary results of identifying key barriers are described. Afterwards the preliminary list of updated barriers is presented.

7.2. Updating the list of key barriers

Using the systems of innovation approach, the SMART 2009/0041 study grouped the 29 identified barriers into nine categories. This list, which can be found on pages 142ff in the 2010 final report, does not imply any prioritization. Instead, it presents a spectrum of possible barriers to the development of the software industry in Europe and elsewhere:

[37] For the list of the 29 systematically derived barriers see the table on pages 142 ff in the 2010 final study report.

1. Knowledge Base

1- Lack of R&D funding
2- Lack of horizontal cooperation

2. Knowledge Diffusion and Networking

3- Lack of vertical diffusion and cooperation
4- Problems with cross-border operations
5- Lack of internationalization
6- Access to finance/credit solutions

3. Entrepreneurial Activities

7- Lack of support of innovative SBIS (software-based Internet services) SME
8- Lack of potential use of public data

4. Financial Capital Development

9- Lack of strategic procurement
10- Lack of support for high-risk, R&D intensive start-ups

5. Regulatory Environment

11- Lack of standardization
12- Lack of interoperability
13- Misuse of IPR
14- Inflexible IPR
15- Low use of digital dividend

6. Market Creation

16- Market fragmentation
17- Lack of legal harmonization
18- Cross-border operations
19- Lack of public procurement
20- Inequalities in public procurement
21- Lack of SBIS adoption
22- Lack of awareness/trust

7. Creation of Legitimacy

23- Privacy concerns
24- Lack of trust
25- Security

8. Human Capital Development

26- Lack of skills

9. Strategic Intelligence

27- Lack of market data
28- Lack of data for policy analysis and assessment
29- Lack of coordination

In order to understand the relevance and scope of the 29 barriers the project team particularly studied the analysis of the 2010 final report in chapters 4 (pages 119-144) and 5 (pages 145-282). Additional information on the barriers is provided in the 2010 report "Baseline Scenario for 2020 (D3)" in chapter 6 under the heading

"Outline to barriers and policies for the development of the SSBS industry" (pages 262-309).

Initially, it was intended to check each and every one of the 29 barriers for current relevance and edit the list in line with recent developments, especially in the light of current studies and position papers. However, the project team found that the recent studies and position papers did not address the whole range of possible barriers, but only a fraction of it. Since time and budget restrictions had to be considered, the project team was unable to extend the number of studies and position papers included in the update. Moreover, it is quite reasonable to expect that in the period between the 2010 study and 2016, there are no more recent studies and insights available for each of the 29 barriers. Thus the project team decided to adapt the research strategy and start with the top 10 list, while later proceeding to analysing details of the individual barriers as given by the 2010 study and by the more recent studies.

The 2010 study includes a ranking of the obstacles on the basis of more than 60 different studies and 50 expert interviews. In the final report, the top 10 obstacles are analysed on pages 134-139. Summarizing these descriptions, the following top 10 obstacle list emerges:

1. Interoperability and standardization
2. Market fragmentation
3. Lack of support for high-risk, R&D intensive start-ups
4. Lack of skills (media competency of end users as well as change management skills of managers)
5. Lack of legal harmonization, lengthy regulatory processes
6. Cross-border operations
7. Lack of trust and security (ranked higher in the context of SBIS)
8. Lack of SBIS adoption, including lack of a cloud computing infrastructure
9. IPR regulation
10. Broadband infrastructures

In a second step, the project team identified and analysed six current studies on the development of software and software-based services in Europe, using the same analytical approach that was followed in the 2010 study. This means the project team looked at the ranking of obstacles first and then analysed the scope and reasoning for individual barriers. The following studies and position papers were included in the update process:

- DigitalEurope (2010): Vision 2020: A Transformational Agenda for the Digital Age. Brussels, www.digitaleurope.org/DesktopModules/Bring2mind/DMX/Download.aspx?Command=Core_Download&entryID=157&PortalId=0&TabId=353.
- Strategic Policy Forum on Digital Entrepreneurship (ed.) (2015): Digital Transformation of European Industry and Enterprises. A report of the Strategic Policy Forum on Digital Entrepreneurship. The forum was established by DG Internal Market, Industry, Entrepreneurship and SMEs of the European Commission and is managed by DigitalEurope, the European Association for the IT sector. March 2015, http://ec.europa.eu/growth/sectors/digital-economy/entrepreneurship/strategic-policy-forum/index_en.htm.
- RAND Europe; WIK Consult; IDC; IC Focus; ISMB, Fi3P (2012): Towards a competitive European Internet industry. A socio-economic analysis of the European Internet industry and the Future Internet Public-Private Partnership. Final Study Report. May 2012, authors: Stijn Hoorens, Dieter Elixmann, Jonathan Cave, Man Sze Li, Gabriella Cattaneo. http://fi3p.eu/assets/pdf/final/FI3P Final Study Report v1 0.pdf. Also: Appendix A: Barriers to competitiveness of the European internet industry, http://fi3p.eu/assets/pdf/final/FI3P%20 Appendix%20A%20v1.0.pdf.
- IDC (2012): Quantitative Estimates of the Demand for Cloud Computing in Europe and the Likely Barriers to Up-take. Final report of the project SMART 2011/0045. July 13, 2012, authors: David Bradshaw, Giuliana Folco, Gabriella Cattaneo and Marianne Kolding, https://ec.europa.eu/digital-agenda/en/news/final-report-study-smart-20130043-uptake-cloud-europe.
- Streibich, Karl-Heinz (2013): Making the software industry stronger. Opportunities and challenges (German: Die Stärkung der Software Industrie. Chancen und Herausforderungen). A presentation by the CEO of Software AG, Darmstadt, Germany, June 21, 2012, http://docplayer.org/9654049-Die-staerkung-der-software-industrie-chancen-und-herausforderungen.html
- BITKOM (2014): IT SMEs in Germany (German: Der IT-Mittelstand in Deutschland). A study by the German digital association. www.bitkom.org/Publikationen/2014/Studien/BITKOM-Mittelstandsbericht-2014/20141017-mittelstandsbericht.pdf.

According to the European industry association for the digital economy (DigitalEurope 2010), the main barriers to the development of a European Internet economy are:

1. Missing ICT infrastructure
2. Market fragmentation
3. Not enough R&D spending
4. Lack of e-skills
5. Missing trust and security on the Net
6. Missing e-health services due to missing standards
7. Not enough e-energy services due to missing smart grid incentives
8. No common framework for e-government
9. National protection of markets even within the EU
10. Not enough leadership by the European Commission

Problems, challenges and risks for the European Internet economy as seen by the Strategic Policy Forum on Digital Entrepreneurship (ed.) (2015), p 7:

1. Leadership and collaboration
• Crisis of confidence • Insufficient business and political leadership • Doubt and fear of the risks among business leaders • Failure to maximize the benefits of, and share best practices arising from over 1,000 separate European initiatives
2. Trust
• Insufficient trust in the European industry's ability to retain commercial ownership of its industrial and commercial data • Potential for many competing and fragmented standards for industrial data
3. Skills and support
• Insufficient practical support and incentives for digital transformation • Inadequate digital leadership in transforming organizations

• Shrinking supply of digital leaders • Shrinking supply of specialist skills
4. Policy, rules and regulations
• Planned and current laws and regulations inadvertently hold back digital transformation and the realization of the benefits • Politicians, regulators and officials make poor laws because they have an insufficient understanding of digital technologies and trends • Politicians and their officials make laws that inadvertently hamper digital transformation and the realization of the benefits • Failure to capitalize on the incentives for digital transformation that e-procurement would provide

Barriers to the European Internet industry as seen by RAND Europe; WIK Consult; IDC; IC Focus; ISMB, Fi3P (2012, final report, executive summary):

1. Lack of access to skilled and flexible human and financial capital
2. Insufficient or poorly-formed R&D investment
3. Inadequate market access for innovative business and service models
4. Weak coordination between the Internet industry and other sectors
5. Economic, cultural and legal barriers

Barriers to the uptake of cloud computing in Europe according to IDC (2012), p. 34:

1. Legal jurisdiction is not in the country of the user of services
2. Security & data protection
3. Trust
4. Data access and portability
5. Data location
6. Local support

7. Change control
8. Ownership of customization
9. Evaluation of usefulness
10. Slow Internet connection
11. Local language
12. Missing tax incentives

Challenges for the software industry (in Germany) according to Streibich (2013):

1. Lack of government support for companies' R&D activities (no lighthouse projects, no adequate tax relief)
2. Lack of venture capital
3. Many small enterprises
4. Market fragmentation
5. Lack of global players in the fields of IT and Internet

Barriers to the development of (German) small and medium-sized companies in the IT sector according to BITKOM (2013):

1. Lack of skilled labour, especially female IT specialists
2. IT security (cyber crime, espionage)
3. Missing broadband Internet infrastructures in rural areas
4. Low R&D spending by IT SMEs
5. Too much bureaucracy, high taxes, no start-up culture
6. Weak use of cloud computing because of security concerns

7.3. Preliminary list of updated barriers

On the basis of the 2010 report, the findings from the studies presented above, as well as additional background information and internal expertise, the project team discussed possible barriers in an internal expert workshop on February 12, 2016, in Karlsruhe. Five experts from Fraunhofer ISI and PAC were present in this half-day workshop. The result of the discussions is the following list of updated barriers, which is considered a preliminary updated list of barriers. The figures reflect the project team's internal prioritization of the barriers.

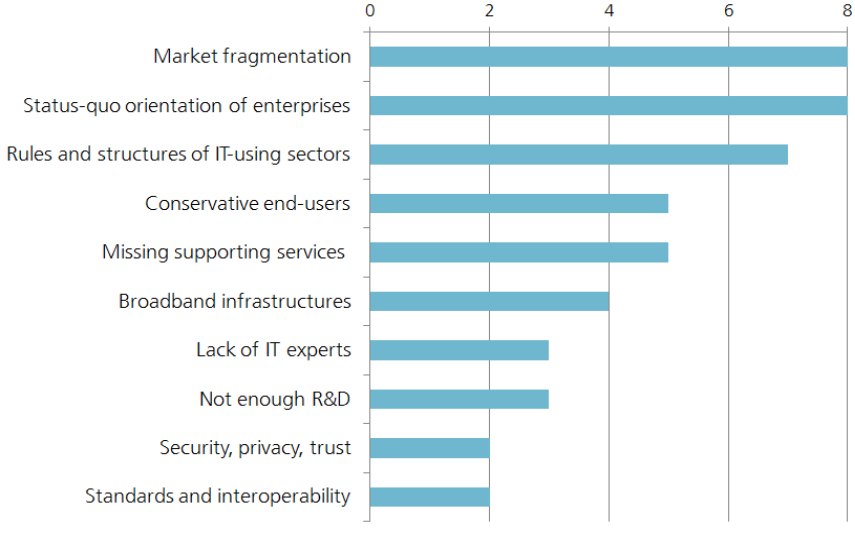


Fig. 47: Prioritization of the barriers

This list was presented at the external expert workshop in Brussels on April 19, 2016, where it was discussed and adapted.

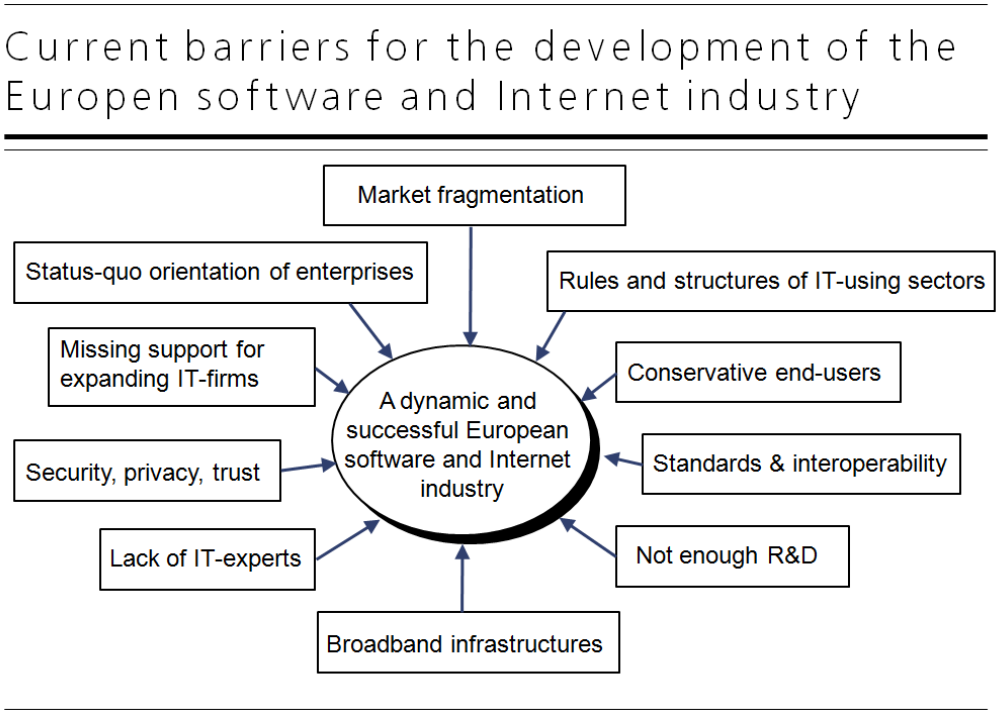


Fig. 48: Overview of current barriers for the development of the SSBS industry

1. Market fragmentation
Market fragmentation in the EU28 member states was considered the most important barrier to the development of a larger SSBS market. Different laws, administrative burdens, languages and different ways of doing things were seen as reasons why the European SSBS market is not as successful as it could potentially be.
2. Status-quo orientation of European enterprises
It was observed that European enterprises often chose to stay within established markets and fields of business, trying to survive within these limits as long as possible. European companies were characterized as being risk-averse, less inclined to embrace change or actively seek new ways of doing things than, for example, US enterprises. A common attitude in European companies is that they are software users and not software developers, whereas in fact they are actively adapting and developing software in many fields. This specific mentality prevents companies from identifying and grasping new software-based market opportunities. Related to this is the missing spirit for setting up new companies. A start-up culture is seen to be lacking in Europe.
3. Existing rules and governance structures within IT-using sectors
Structural barriers within IT-using sectors such as energy, health, industrial

production, traffic, government and education limit the potential of software applications. Established procedures and formal requirements hamper the development and commercial rollout of smart energy grids, connected e-health services or digital factories, for example. Software is a game changer in many fields and some sectors have successfully prevented change by pointing to traditional routines and regulations.
4. Conservative users sticking to old habits
What was identified as "status-quo orientation" of businesses can also be said of a large share of European end users of software: They seem to be conservative in their use of media and IT, and they tend to stick to old habits rather than enjoy trying out new things and devices. The limited openness to change and experiments also has negative consequences for the level of creativity in the development and acceptance of new software and applications. In addition, there are some distinctive cultural characteristics. In some countries, for example, software needs to be from domestic software producers, otherwise it will not be bought.
5. Missing supporting services for new software and applications
Whereas it was agreed that European software engineering generally was of high quality, it was also observed that supporting services to develop and market new software and apps were often missing. Supporting services include venture capital, legal experts, marketing know-how, etc.
6. Inadequate broadband infrastructures
There is still a lack of broadband Internet capacity in Europe – be it fixed or mobile networks, in urban or rural areas. As capacity requirements have increased, especially for bandwidth-intensive cloud services and media-intensive applications, broadband availability has become a main factor for the success of new software applications. The availability of broadband Internet includes regulations stipulating that new, small Internet companies can offer their services on the Internet without being charged extra by big network operators (network neutrality).
7. Lack of specialized IT and Internet experts
The software industry is still lacking highly talented and educated software programmers, application designers and Internet experts. Although the lack of skilled people has been discussed for years and pointed out many times, it is still the case in a sector that is highly knowledge-based and in which innovation cycles are short. This also means that knowledge about operating systems, software platforms, programming languages, Web programming, etc. needs to be updated regularly. In many cases, this cannot be done by universities, but through continuous, life-long learning.

8. Not enough R&D spending
Research and development is considered a key factor for the thriving of a genuine European software industry. Due to their knowledge-based nature and the breadth of the application spectrum, software-developing companies as well as publicly funded research institutions need to invest in new developments and in combining knowledge to develop new, successful applications. It was stated that R&D spending in Europe was substantially below spending in other countries. US expenditure on R&D still exceeds European expenditure even when discounting the R&D spending by the biggest five software and Internet companies in the United States.
9. Missing security, privacy and trust in new services
A lack of security and trust in IT systems as well as privacy concerns are important barriers to the rollout of cloud computing services for advanced manufacturing, for networked applications in the health sector, as well as for new traffic applications, for example to enable multimodality. On the other hand, there are many genuinely European software solutions and specific European approaches that can enhance security and privacy. Thus, this barrier can also be seen as a strategic opportunity for the European software industry to develop a safe, genuinely European software approach that inspires trust.
10. Missing standards and interoperability
A lack of standards and interoperability are widely seen as barriers to the development of the European software industry and may also be linked to the fragmentation barrier (top barrier in this list). However, it was noted that in an age of widely available standard operating systems and universal Web programming standards and protocols (Unix, XML, IP, etc.), this barrier was not as relevant as it may have been in the past. Standards and issues of interoperability become relevant again when it comes to new application areas such as the Internet of Things, smart home, industrial IoT/Industry 4.0, etc.

7.4. Short description of the updated top 10 barriers

In this section the project team looks at the identified barriers in more detail. For this purpose, pieces of information from the 2010 report[38] and explanations from the internal expert workshop will be used, which resulted in the updated list. By combining these two sources, the project team takes advantage of the methodological rigor of the 2010 study with its wealth of assessments (from literature reviews, interviews, workshops) and the current assessments, which were

[38] The quotations in this section are all taken from the report "D3 Baseline Scenario for 2020" and can be found there in section 6.3 "Results from the interview process" on pages 276-308.

gained through a head-start approach using a smaller set of current studies and the expertise of an expert team to update the list of barriers.

1. Market fragmentation

In the 2010 report, "market fragmentation" was also a highly relevant obstacle. The description on p. 284 reads as follows: "Unlike other sectors, network effects are dominating the software business, i.e. the size of the market plays an important role for the success of software and software based service companies. Contrary to the US, the EU market for software, digital goods and services is still fragmented and the national markets are too small. There are still big differences, e.g. in VAT levels, liability rules etc. (…) In effect, most European markets are dominated by few non-European players, while the rest of the market actors is a large number of SMEs. Although the number of SMEs is a good sign for the dynamics of the industry, they often compete on the same markets and market segments. This impedes the development of more competitive medium-sized players."

Causes and impacts of market fragmentation were further explained on pages 301f of the 2010 report: "Some reasons result from different regulations like the complexity of the various VAT and financial systems; the existence of different standards and regulations in different countries or variations in employment law and between different countries (…). Other reasons result from cultural differences like different working culture or values. Another point is that only a few European SSBS firms operate worldwide, while most of the firms, especially SMEs, are only active on their national home markets and partly in neighbouring markets (…). All this forms still significant impediments to geographical expansion and hinders the expansion and growth of SSBS and especially SBIS companies and limits their competitiveness against non-European, multinational companies."

In addition, the 2010 study highlights the importance of the advertising market for the development of an Internet market. Here, fragmentation is also considered a relevant obstacle in Europe: "The limitations and fragmentations of the European advertising market through public regulations and also through cultural differences (languages, acceptance, etc.) can build a barrier for the development of especially emerging technologies and business models, which partly rely on advertising as a revenue model." (p. 287)

2. Status-quo orientation of European enterprises

In the 2010 study, this barrier is not explicitly addressed as a separate point, but implicitly mentioned under several other barriers. For example, it says that the uptake of IT services by SMEs in Europe is still lagging behind. Under the heading "Low adoption/penetration levels in SMEs" on p. 289, the relevant paragraph reads as follows: "The low level of diffusion, especially of emerging technologies within SMEs, which form with nearly 99% by far the biggest part of the European economy, is (…) clearly identified as the major reason for Europe's lagging behind in the productivity growth (…). This does not only impact the EU economy as a whole, it especially impacts the development of the SSBS industry and the emerging segments of. For the success of new technologies like web-based services

offered by European companies the fast penetration in their European home markets is a decisive key factor. Since the majority of SMEs is reluctant to adopt them for reasons like a lack of market information or cultural-based restraints, this builds a barrier for the take up of SBIS."

And concerning change management requirements, the 2010 report states: "The adoption of new technologies, businesses and services like SBIS is often hindered by the fact that users tend to stick to existing technologies (…). Especially the shift to Enterprise 2.0 has a major impact on the organization of the company, so an implementation process has to be accompanied by a change management of business processes. Path dependencies of SSBS or a lack of change management has a negative impact on SSBS demand and thus on the European SSBS industry as well as the European economy as a whole." (p. 293)

The fact that this aspect was not identified as a separate barrier, but evolved as a sub-aspect in the context of several other barriers in the 2010 report surely has to do with its focus on quantitative factors. It is very difficult to measure mentalities, attitudes towards change or perceptions of market opportunities that are addressed here. But from today's point of view, this barrier has become of central importance: Software and Internet applications are ubiquitous today and many companies have already transformed into software-producing companies without having noticed. For example, automobile producers make extensive use of software they programmed themselves – in the production process, in their products and in the area of sales and after-sales. However, automobile companies mostly describe themselves as software users rather than software producers, not grasping the full business potential of their own transformation. This means that certain path dependencies, and especially the mentality of sticking to traditional ways of doing business, need to be overcome.

The second dimension of this obstacle is the missing culture of founding new companies. Here, the 2010 report is very precise and states the following under the heading "Lack of entrepreneurship": "The SSBS industries' dynamics are high and this implies a strong demand for entrepreneurship activities. And although the innovativeness of Europe's software developments is high, entrepreneurship in SSBS is insufficient. One reason for this is a lack of entrepreneurial skills of software engineers. The quality of technical education in Europe is considered to be high, but the skilling of students in entrepreneurship is far away from that. As several studies indicate, the lack of a more risk-taking entrepreneurial and innovative spirit seems to be one of the reasons of the commercialisation gap between invention and innovation in the ICT and especially SSBS industry in Europe (…). Therefore this lack of entrepreneurial spirit and skills is a clear barrier to the growth of the industry especially in emerging segments like SBIS." (p. 292)

3. Existing rules and governance structures within IT-using sectors

Whereas barrier 2 ("status-quo-orientation of European enterprises") addresses the mindset of business leaders in Europe and their inclination to cling to established business traditions, approaching new fields of business only with reluctance and reservation, this barrier addresses structural aspects. Basically, Internet and software-based innovations have the potential to make entire sectors more

efficient, more user-friendly and more productive. However, the digital conversion of sectors such as energy (smart grids), health (e-health), traffic (intelligent traffic), public administration (e-government), education (e-learning) and manufacturing (digital factory, industrial IoT) is not proceeding as fast as would be possible. Reasons for this are structural barriers: Established procedures and formal requirements currently hamper the development and commercial rollout of many new services in the different fields of application. Software is a game changer, but some of the sectors have successfully prevented change by pointing to traditional routines and regulations.

Interestingly, in the 2010 study, this barrier was not explicitly addressed. Although it was indirectly mentioned in the context of cloud computing and when stating the lack of adoption of software and software-based services in enterprises, this barrier was apparently not as present in the 2010 study as it is today. The current relevance of the application sectors reflects a development that has been discussed under different labels, such as Internet of Things, advanced manufacturing (Industry 4.0/industrial IoT), digital society, gigabit society, etc.

4. Conservative users sticking to old habits

The 2010 report addresses this barrier in different contexts. For example, under the heading "Path dependency" on page 293 it states: "The adoption of new technologies (…) and services like SBIS is often hindered by the fact that users tend to stick to existing technologies and reject the new one (…). Therefore end-users should be actively involved in the innovation process to make sure that new products and services are in-line with users demands." (p. 293).

Furthermore, under the heading "Lack of usage of IT" the report underlines the importance of user uptake of new technologies and notes that this applies to private end users as well as to companies in Europe: "The use and therefore the demand for new and innovative software products and services in Europe is less developed as in other regions of the world. This low responsiveness to new products and the lower adoption rate of IT in European companies, administrations and homes is according to several studies the reason for the lagging behind of Europe in the productivity growth (…). Since software is the key factor for the productivity growth by ICT (…) the increase of the usage of SSBS and especially SBIS is a crucial point to improve the competitiveness of Europe. Moreover this ongoing lack is also a clear barrier to competitiveness and growth of the European SSBS industry. As a result, European SSBS firms get less stimulus from their home markets and they are neither able to develop and create lead markets nor establish new products and services (…). Furthermore the lack of usage also impacts the development of IT-skills and the overall economic growth and employment due to the fact that software intensity is one of the major determinants for the increase of productivity in traditional industries." (p. 294f).

5. Missing supporting services for new software and applications

Concerning the support for innovative SSBS companies, the 2010 report notes: "Although 99% of the European SSBS firms are SMEs, the conditions for them are not considered to be favourable. The support for growth and expansion, for

example in form of access to finance, is less developed in most EU member states. Also the public R&D funding or public procurement procedures are perceived as too complicated and unfavourable, e. g. because of long paying periods, especially for innovative SSBS SMEs. Other points are for example complex regulations that hinder the establishing companies or the change of their legal status (…). The improvement of the acknowledgment and support of innovate SMEs would not only have positive effects on the industry, but also a positive effect on the region's overall economy." (p. 304).

6. Inadequate broadband infrastructures

Concerning Internet access infrastructure, the 2010 report notes a lack of broadband availability in Europe, especially in rural areas: "For several new SBIS applications such as smart homes or Internet of things, a highly reliable and fully developed broadband network infrastructure is required (…). These functionalities also require a more high-speed broadband as available at the moment in the most developed areas (above 50 MBits). A lack of (high speed) broadband infrastructure in Europe would prevent the adaption of these technologies and impact the development of development of new services in the context of the Internet of services and finally lead to a legging-behind of European SBIS companies. Even in central Europe there are (rural) areas with very limited available bandwidth, not mentioning areas in Eastern and South Eastern Europe". (…) Also, "the use of software and services by mobile devices (smart phones, netbooks, etc.) plays a central role in most Future Internet scenarios for both the development of the Internet as well as of the SSBS industry and SBIS in particular. Therefore, the build-up of next generation mobile network (infrastructure and services) will be a crucial milestone to make Europe to the leading area in the use of the new services and enable European SBIS providers to take a leading position." (p. 279f)

7. Lack of specialized IT and Internet experts

Under the heading "E-skills", the 2010 report states: "As indicated by several studies there is a lack of IT skills in Europe, especially on the level of consumers and business users. This shortage has severe consequences. It prevents people from participating in the digital world. It hinders the uptake of innovative SSBS and reduces the attractiveness of Europe as a lead market and thus as location for SSBS and IT companies (…). The impact on the competitiveness of both the European SSBS industry as well as the European economy as a whole is immense and builds a clear barrier to growth and employment in Europe." (p. 295)

Concerning the lack of skills, the 2010 report further notes: "A simple technical skilling is not sufficient anymore for the requirements of the increasing complexity of software technologies. The ubiquity of software implies that engineers and technicians in this field should be able to work and cooperate with other fields, where the software is applied, as well as to quickly adopt new skills demanded. Moreover, Europe's SSBS industry suffers a lack of skilled personnel and at the same time an alarming trend of decrease in graduates in this field (…). All this hampers the growth of the European SSBS industry and impacts the overall economic growth and employment negatively" (p. 294). The report also deplores a

lack of mobility of highly skilled labour across borders for regulatory and cultural reasons (see p. 294).

The lack of skills also includes managerial skills in the 2010 report: "The lack of managerial skills is closely connected, but not the same as the lack of entrepreneurship. While the latter aims more at mindset to risk the undertaking of new businesses, the lack of managerial skills addresses a problem that occurs in both, start-ups as well as existing firms. Most of the SSBS-skilled workforce is not adequately prepared for the requirements of project, technology and business management (…). This causes severe problems especially in the all-day business as well as in strategic planning and results in a barrier for the growth of firms. This problem not only occurs in SMEs and start-ups. In addition, there is a close link between the development of management skills and the demand for innovative software-based management systems." (p. 292f).

8. Not enough R&D spending

The 2010 report states that the "level of R&D spending of European SSBS companies was for a long time lower than the level of main competitors like the US or Japan. As shown in studies the European software sector (numbers for NACE 72) lags behind in almost every R&D related measures in comparison to the US (…). As a result of the Lisbon strategy this level is raising, but especially SMEs are still lagging behind. There are various reasons for this like the access to financing solutions or the complex R&D funding processes (…). In total, this development has a negative impact on the industry as well as on society, because it hinders innovation". (p. 286, see also p. 301)

The report sees a lack of tax incentives for R&D as one of the reasons for the low level of corporate R&D spending. Although some EU member states have already introduced tax incentives for R&D, there are many different approaches. The 2010 report concludes that this lack of harmonization "within and between the EU member states in comparison to other countries impacts the development of a European SSBS industry." (p. 303)

9. Missing security, privacy and trust in new services

According to the 2010 report, the security of SSBS technologies is a "decisive, but also multifaceted point for the further development of the industry for several reasons. It encompasses topics like reliability, data security or secure transactions. (…) Security, especially of web-based services, is seen very critical by businesses and consumers as shown by press coverage. On the other hand a lot of security problems arise not because of the lack of appropriate technologies, but because of non-technical factors such as the lack of knowledge of or disinterest in security requirements of it or other human factors (…). Both leads to a low acceptance and use especially of new software based businesses and services. This does not only hinder the development of the European SSBS companies, it also contributes to the low growth of the EU economy as a consequence of a low adaption of ICT, where software and software based services are key factors (…)" (p. 254f)

And concerning privacy, the report notes: "Privacy concerns are the most crucial determinants for the acceptance of SSBS, especially for emerging web-based technologies in the Internet of Services (…). The further virtualisation of data processing and storage as well as the increasing market for cloud solutions leads to an increased demand for trustworthy services. Due to the different regulations on privacy protection in the different countries within the EU as well as outside the EU, companies are challenged to adjust their SSBS products and services to this. But this challenge can also be seen as a chance because there is a huge market for convenient solutions due to rising awareness for security and privacy problems." (p. 293f)

10. Missing standards and interoperability

Concerning standards and interoperability, the 2010 report states: "Standardisation is due to its complexity one of the most controversial topics. In the case of the SSBS industry this is especially problematic, because the processes of standard-setting bodies are rather slow, while the industry has a high rate of innovations. Therefore, the dominating global market players tend to create their own de facto standards using network effects, leading to lock-in effects or natural monopolies. It is difficult for European SSBS companies to compete with these standards and normally follow these market players. Moreover, within the active and efficient standardisation bodies related to SSBS or SBIS (…) European companies are lacking of participation and as a consequence their influence is limited. Additionally, European SSBS companies pursue different strategies concerning standards (open vs. market). This situation hampers the competitiveness of the European SSBS industry strongly (…)." (p. 277f)

The report underlines the importance of interoperability, "because the ability to communicate and interact with other systems is a pivotal factor (network effects). In reality many of the existing, mostly dominant market players pursue very restrictive approaches to interoperability. They mostly aim at controlling their own proprietary software world to prevent others to enter these areas by restrictive IPR use or non-disclosure of specifications. This reduces the possibility for companies to create new products and services based on existing technologies and hinder therefore innovation and the uptake of new market segments(…). Moreover this kind of behaviour has also a negative impact on the economy as a whole, because it leads into lock in effects or path dependencies which reduce the possibilities for customers to choose and use technologies from more than one supplier (…). Finally, the need of interoperability will raise with the merging of SBIS (…)." (p. 278)

7.5. Contributions to a strategy for the development of a genuinely European software industry

Lack of big software companies in Europe: Barrier or potential driver?

In the 2010 study, the lack of big companies in the SSBS sector is seen as an obstacle to the development of the industry: "No EU leader – The European SSBS industry consists nearly to 99% of SMEs. Only in few segments, some European

companies have significant role like SAP for the ERP market, but this singularity leads to the problem that for example SAP revenues make 36% of total revenues of the 100 biggest software companies (…). Beside the fact that this makes the development of the industry dependent to one company, there is the more important fact that big players normally create a certain kind of ecosystem. Within this ecosystem smaller firms with innovative products can grow easier and gain significant market shares. Therefore, the lack of EU leaders is a barrier for the development of the European SSBS industry as a whole." (p. 286f)

However, the heterogeneity within Europe and the many customer-centric approaches may also be seen as a strength. After all, it was agreed in the expert discussion that it would not make much sense to build a new Microsoft, Google or Facebook in Europe. Instead, it may be argued that the strength of Europe lies in its adaptive capacities and in the expertise related to fields of application, be it in industrial production, the service sector or other application areas.

Open source software: Barrier or potential driver?

In the 2010 study, the deployment of open source software (OSS), and especially of free/libre open source software (FLOSS) was considered to be an obstacle to the thriving of a European software industry. The report says: "The commoditisation of services and software, provided by web offers or through FLOSS solutions is considered to be a possible barrier, because it destroys existing revenue models. Especially the shift in the value creation from the producers to third-party service providers is critical, because of the unclear mechanism of participation in new revenue models." (p. 288)

From today's point of view, this assessment of the impact of open source software seems outdated. The argument that established revenue models of the software industry were being eroded by open source software being available for free can no longer be upheld. Instead, there are many examples of successful OSS applications that are generally viewed as innovation drivers. Furthermore, working business models have been developed and have proved to be successful.[39]

Current fields of application of open source software are operating systems (GNU/Linux and its derivative, Android, an operating system for mobile devices) and Web software (e.g. Apache HTTP Server, the e-commerce platform osCommerce, the cloud computing software OpenStack, Internet browsers Mozilla Firefox and Chromium, the project which mainly contributed to the development of the freeware Google Chrome, and the full office suite LibreOffice). Furthermore, open source software is used in platforms such as FIWARE, the programming suite for Future Internet applications in the EU in the context of smart cities, sustainable transport, smart logistics and smart energy, or the UniversAAL platform, which enables applications in the area of ambient assisted living. As Europe is especially active in developing and offering advanced open source software, this approach

[39] See, for example, Schireson, Max; Thakker, Dharmesh (2016): The money in Open Source Software, In: TechCrunch, Feb 9, https://techcrunch.com/2016/02/09/the-money-in-open-source-software/

might very well become one of the key drivers for a genuinely European software industry in the future.

Missing IT security and privacy: Barrier or potential driver?

Although a lack of privacy, security and trust is generally considered a barrier to the proliferation of software and Web-based services[40], these requirements may very well turn into an advantage for Europe because Europe provides the IT-security and privacy-friendly legal environment for such services to succeed in the market. In fact, users – both consumers and businesses – need to trust software companies in order to take up the services they offer. IT-security and privacy-friendly software companies have a competitive edge here, and the privacy-friendly environment in Europe may be considered as an incentive that may encourage innovative technology companies to set up shop in the EU as well as develop their own genuinely European trusted solutions.

A recent policy paper by the European Commission highlights this fact by listing the activities of companies that invested in Europe:

- Apple is investing €1.7 billion in new European data centres.
- Cloud computing company Salesforce.com expanded its investment in Europe by opening new data centres in the UK (2014) and Germany (2015). It plans to open another data centre in France. According to Salesforce.com's management, the new data centre represents a "doubling down on Europe", which in turn reflects Europe's status as the fastest growing region for Salesforce in fiscal year 2013.
- IBM opened new cloud data centres in the UK, Germany, France and Italy to offer privacy-friendly services.
- Zettabox.com is an example of a genuinely European cloud storage solution. Its slogan is "It's better in Europe". Zettabox decided to base its operations entirely in Europe in order to provide a high-quality cloud service with the highest possible level of protection of personal data.[41]

European strengths in the light of current developments

These thoughts may encourage us to think about what the genuine strengths of the European software industry might be in the first place. Following the discussions in the internal expert workshop and the review of relevant literature, the project team proposes the following aspects:

- Strong manufacturing and services sector. Companies know the application contexts in detail and can react to changes in their

[40] Especially in the field of cloud computing, security has long been seen as a major obstacle to the wider use by European companies; see, for example, Saran, Cliff (2014): Cloud security remains a barrier for CIOs across Europe. In: Computerweekly.com, December, 9, www.computerweekly.com/news/ 2240236318/Cloud-security-remains-a-barrier-for-CIOs-across-Europe.

[41] See DG Justice and Consumers (2016): The EU Data Protection Reform and Big Data, March 2016, http://ec.europa.eu/justice/data-protection/files/data-protection-big-data_factsheet_web_en.pdf

customers' business; customization of standard products in different contexts

- Internet of Things
- Mastering complexity
- Open source software
- Security, privacy and trust
- Big data

7.6. Final list of barriers

The preliminary list of barriers was discussed with external experts in a workshop in Brussels on April 19, 2016. The outcome of the discussions was a final list of barriers for the software and Internet sector in Europe:

1. Lack of skills, lack of specialized IT and Internet experts
2. Lack of entrepreneurial spirit
3. Missing supporting services
4. Market fragmentation
5. Status-quo orientation of companies, incl. existing rules and governance structures in IT-using sectors
6. Trust, privacy, security
7. Policy strategies not suited to support ICT innovations
8. Not enough R&D
9. Not enough broadband access
10. Not enough support for open source software

8. Policy Initiatives

8.1. Current policy initiatives related to the development of the software industry in Europe

The aim of this section is to provide an up-to-date picture of what is currently being done at the EU level to support the development of the software industry in Europe. Over the past five years, since the finalization of the SMART 2009/0041 study in 2010, new developments have taken place on the political level. An overview of the topics covered by current policy actions is necessary as an input for updating the projection of the economic and social impacts of the European software and services industry over the next 5-10 years (2020–2026) if no changes in current policies are implemented. The project team will define the current (2016) state of affairs – as will be illustrated in this task – as 'no changes' or as the baseline scenario.

The list of current policy measures and initiatives is also needed to update the assessment of the economic and social impacts of recommended policy actions because the suggested policy measures have to be synchronized with the existing ones.

The following table is the result of desk research and document analysis. Altogether, the project team has identified and analysed 11 relevant policy measures and programs launched at European level during the past six years (2010-2016). The project team does not differentiate between initiatives that have been completed and formally put into legislation, and actions that are merely an element of a targeted strategy or initiative. To define the formal stage of each policy activity would be a separate exercise. The following table shows what topics have been tackled by European policy-makers during the past few years. It thus displays a specific topical spectrum that was used as an input for the expert workshop and for the following analysis. The project team does not assess the policy actions or measure their impact. Instead, the topical spectrum is used as an indicator of the areas where policy actions are underway or missing.

Table: Policy initiatives of the European Commission with relevance to the software and Internet sector (from 2010)

Name of the program, measure, action plan, etc.	Year started/ adopted / agreed	Topics covered
Digital Single Market (DSM) Strategy, Topic 1: Access for consumers and businesses to online goods and services across Europe Source: https://ec.europa.eu/digital-single-market/en/access-digital-single-market	6 May 2015	**- Rules to make cross-border e-commerce easier** To enable cross-border e-commerce to flourish, the Commission will update EU rules (e-commerce directive), clarify contractual rights, and develop enforcement (cross-border enforcement cooperation). **- Enforcing consumer rules** The Commission will review the Regulation on Consumer Protection Cooperation. **- More efficient and affordable parcel delivery** The Commission will launch measures to improve price transparency on the delivery market and enhance regulatory oversight of parcel delivery. **- Putting an end to unjustified geo-blocking** The Commission will make proposals on how to put an end to unjustified geo-blocking, which limits consumers' opportunities and choice to buy in other countries. **- Launching an antitrust investigation into e-commerce** The Commission launched a Competition Sector Inquiry to identify potential competition concerns affecting European e-commerce markets. **- A modern, more European copyright framework** The Commission will propose modernized rules to reduce national discrepancies, encourage wider access, promote cultural diversity and ensure that everyone respects the rules of the game. **A review of the Satellite and Cable Directive** The Satellite and Cable Directive will be reviewed to assess if its scope needs to be enlarged to include broadcasters' online transmissions and to explore how to boost cross-border access to broadcasters' services in Europe. **- Reducing VAT burdens** Companies trying to trade across borders face the obstacle and complexity of different VAT systems. The Commission will propose to reduce this burden – for example through a single interaction point, a common threshold, and simpler, single audits.
Digital Single Market (DSM) Strategy, Topic 2: Environment for digital networks and services to flourish by	6 May 2015	**- Overhaul of the telecom rules** The Commission proposes to improve spectrum coordination and spectrum assignment at national level, create incentives for investment in high-speed broadband, ensure a level playing field for all market

Name of the program, measure, action plan, etc.	Year started/ adopted / agreed	Topics covered
providing high-speed, secure and trustworthy infrastructures and services supported by the right regulatory conditions Source: https://ec.europa.eu/digital-single-market/en/environment-digital-single-market		players, and create an effective institutional framework. **- Comprehensive analysis of the role of online platforms** The Commission will tackle issues of transparency, use of information (i.e. the right to be forgotten), relationships between platforms and suppliers, and how to treat illegal content on the Internet. **- Reinforcing trust and security in digital services and in the handling of personal data** The new EU data protection rules agreed at the end of 2015 will be the basis for a review of the e-privacy directive. **- Proposed partnership with businesses on cyber security** The public-private partnership on cyber security will focus on technologies and solutions for online network security. **- Review of the audiovisual media framework for the 21st century** Adapt the Audiovisual Media Services Directive to new business models for content distribution.
Digital Single Market (DSM) Strategy, Topic 3: Economy & Society – maximize the growth potential of the European digital economy and of society Source: https://ec.europa.eu/digital-single-market/en/economy-society-digital-single-market	6 May 2015	**- Proposing a European free flow of data initiative** The Commission will tackle restrictions on data location and access to encourage innovation. **- Proposing a European Cloud Initiative** The European Cloud Initiative has the aim to build trust and confidence in cloud computing in Europe and includes: • **Europe-wide certification**, including elements of network and • information security; • Provisions for **personal data protection**; • **Service level agreements**; • **Interoperability and data portability**; • **Contractual terms and conditions**; • The prospect of a **European cloud services capability**, and the establishment of a European Research Open Science Cloud. The initiative is related to several other actions of the Digital Single Market strategy, such as harmonized rules for online purchases, standards and interoperability, and builds on the Commission's experience with the implementation of the September 2012 European Cloud Computing Strategy.

Name of the program, measure, action plan, etc.	Year started/ adopted / agreed	Topics covered
		- Defining priorities for standards and interoperability The Commission will concentrate on standards and interoperability in areas critical to the Digital Single Market, such as health, transport, planning and energy. **- Supporting an inclusive digital society** An inclusive digital society is one where citizens have the right skills to seize the opportunities of the digital world and boost their chance of getting a job. A new e-government plan will also connect business registers across Europe, ensure that different national systems can work together, and that businesses and citizens have to provide their data "once only" to public administrations.
Digital Agenda for Europe. Driving European growth digitally, as part of "Europe 2020" Source: https://ec.europa.eu/digital-single-market/en/europe-2020-strategy	19 May, 2010	**- Achieving the digital single market** See Digital Single Market Strategy above. **- Enhancing interoperability and standards** Enhancing interoperability of devices, applications, data repositories, services and networks; in order to do this, it is essential that the Commission continue the review of its standard-setting policy. It will also promote appropriate rules for intellectual property rights. **- Strengthening online trust and security** Strengthening Europe's policy to combat cyber crime, child pornography and breaches of privacy and personal data security; the Commission has implemented measures on network and information security and the fight against cyber attacks. **- Promoting fast and ultrafast Internet access for all** Europe needs competitively priced fast and ultrafast Internet access for all. To achieve this, the EU must establish next-generation access networks (NGAs). The Commission is channelling some of its public funds, via different instruments, to invest in broadband infrastructure. **- Investing in research and innovation** Europe invests in world-class ICT research and innovation in order to boost growth and jobs through innovative public-private partnerships and by exploiting the opportunities available through Horizon 2020 research funding programs. We aim at catching up with our main competitors in ICT research and digital innovation. **- Promoting digital literacy, skills and inclusion** In order to promote employment in the ICT field, and in

Name of the program, measure, action plan, etc.	Year started/ adopted / agreed	Topics covered
		jobs which require digital skills, the Commission created the Grand Coalition for Digital Jobs and Skills in 2013. This is a multi-stakeholder partnership that endeavours to facilitate collaboration among business and education providers, public and private players to take action to attract young people into ICT education, and to retrain unemployed people. **- ICT-enabled benefits for the EU society** The EU must exploit the potential offered by the use of ICT in the areas of climate change, managing ageing populations through e-health and telemedicine systems and services, digitalization of content through Europeana, and intelligent transport systems.
General Data Protection Regulation (GDPR) in the EU Source: http://europa.eu/rapid/press-release_IP-15-6321_en.htm	27 April, 2016	The new rules give individuals more control over their personal data. Most notably, this includes: **- Easier access to your own data:** Individuals will have more information on how their data is processed, and this information should be available in a clear and understandable way. **- A right to data portability:** It will be easier to transfer your personal data between service providers. **- A stated "right to be forgotten":** If you no longer want your data to be processed, and provided that there are no legitimate grounds for retaining it, the data will be deleted. **- The right to know when your data has been hacked:** For example, companies and organizations must notify the national supervisory authority of serious data breaches as soon as possible so that users can take appropriate measures. The new rules are also relevant for enterprises. By unifying Europe's rules on data protection, lawmakers are creating a business opportunity and encouraging innovation. The advantages according to the EU are: - **One continent, one law**: The regulation will establish one single set of rules, which will make it simpler and cheaper for companies to do business in the EU. **- One-stop shop**: Businesses will only have to deal with one single supervisory authority. **- European rules on European soil:** Companies based outside of Europe will have to obey the same rules when offering services in the EU. **- Risk-based approach**: The rules will avoid a burdensome one-size-fits-all obligation and take into account the respective risks. **- Rules fit for innovation**: Data protection by design and privacy-friendly techniques such as

Name of the program, measure, action plan, etc.	Year started/ adopted / agreed	Topics covered
		pseudonymisation will be encouraged to reap the benefits of big data innovation while protecting privacy.
European Cloud Computing Strategy Source: https://ec.europa.eu/digital-single-market/en/european-cloud-computing-strategy	27 Sept, 2012	A report on the implementation of the European Cloud Computing Strategy was published in July 2014 as a Staff Working Document accompanying the Data-driven Economy Communication. The strategy included the following three key actions: **1.Safe and fair contract terms and conditions** Identifying and disseminating best practices in respect of model contract terms. One of the deliverables of this key action is the Service Level Agreement Standardisation Guidelines by the C-SIG SLA Subgroup. https://ec.europa.eu/digital-single-market/en/news/cloud-service-level-agreement-standardisation-guidelines **2.Cutting through the jungle of standards** The Cloud Standards Coordination (CSC) Phase 1 took place in 2013 and primarily addressed the Cloud Computing standards roadmap. In December 2013 the results were publicly presented in a workshop organized by the EC. The CSC Final Report is available online. The Commission worked with the support of the European Union Agency for Network and Information Security (ENISA) and other relevant bodies to assist the development of EU-wide voluntary certification schemes and establish a list of such schemes by 2014. **3.Establishing a European Cloud Partnership** The European Cloud Partnership (ECP) brought together businesses and the public sector to work on common procurement requirements for cloud computing in an open and fully transparent way. The ECP Steering Board has also published the Trusted Cloud Europe Document. Part of the ECP is the Cloud-for-Europe (C4E) initiative, aiming at helping Europe's public authorities procure cloud products and services, so as to build trust in European cloud computing.
e-skills for the 21st century Source: http://ec.europa.eu/growth/sectors/digital-economy/e-skills/index_en.htm	2007	Started in 2007, the EU actions on e-skills were financed by the Competitiveness and Innovation Framework Programme (CIP) of DG Growth. New initiatives until 2020 will be financed by the programme for the Competitiveness of Enterprises and Small and Medium-sized Enterprises (COSME) of DG Growth. The actions include: **- Building a European E-competence Framework,** which is a reference of 40 skills required in the ICT workplace. It uses a common language for skills and proficiency levels that can be understood across Europe for all types of organizations that need to take decisions on recruitment, career paths, training, or assessment.

Name of the program, measure, action plan, etc.	Year started/ adopted / agreed	Topics covered
		It was developed by the European Committee for Standardisation (CEN), which is funded by the Commission. **- Initiating the Grand Coalition for Digital Jobs** In order to increase the supply of ICT practitioners by 2015 and to ensure there are a sufficient number of skilled people to meet future demand for ICT skills, the Commission launched the Grand Coalition for Digital Jobs at the conference on 'e-Skills and Education for Digital Jobs' in Brussels in March 2013. It is a multi-stakeholder partnership that facilitates collaboration between businesses, education providers, and public and private players to attract young people into ICT education, and to retrain unemployed people. **- Organizing diverse events and conferences,** such as the e-Skills 2013 Conference, the European e-Skills 2014 Conference, e-Leadership and IT Professionalism or the Cross Atlantic Round Table on IT and Labour Market Disruptions.
Initiatives of DG Growth for digital entrepreneurship Source: http://ec.europa.eu/growth/sectors/digital-economy/entrepreneurship/index_en.htm		To support digital entrepreneurship, DG Growth has started several initiatives. These include: **- Study: Doing business in the digital age** This study identified the key technological trends and carried out a comparative analysis of national strategies and private initiatives to encourage digital entrepreneurship. It proposed a five-pillar strategy and 21 recommendations for actions cutting across policy areas such as boosting digital and entrepreneurial skills, leveraging the Single Market, innovation campaigns, awareness and mentoring, and access to finance. **- Strategic Policy Forum on Digital Entrepreneurship** The Strategic Policy Forum on Digital Entrepreneurship was set up in 2014 to outline what should be the short- and long-term strategy for digital entrepreneurship in Europe, to implement this strategy and share experiences and advise the European Commission on key priorities. **- Member States Board on Digital Entrepreneurship** The Member States Board on Digital Entrepreneurship was set up to reinforce the implementation of a strategy on digital entrepreneurship in Europe. **- The Digital Entrepreneurship Monitor** The Digital Entrepreneurship Monitor is an online tool to monitor key technological and market trends, emerging

Name of the program, measure, action plan, etc.	Year started/ adopted / agreed	Topics covered
		business opportunities, new business paradigms and their impact on the European economy, and policy initiatives all over Europe. It includes statistics and initiatives to support digital entrepreneurs, and reports on business opportunities and digital technologies. **- Raising awareness: Watify and the Euromentors Association for Digital Entrepreneurs** A major pan-European awareness raising campaign (Watify) and an eMentoring ecosystem (Euromentors Association for Digital Entrepreneurs) have been set up to help European entrepreneurs catalyse and support new business opportunities offered by digital technologies. The Euromentors Association for Digital Entrepreneurs will inspire and support new entrepreneurs and intrapreneurs. Actions will include training, advice and hands-on coaching on how to do business in the digital age and match-making events among stakeholders to explore new partnerships.
Stimulating innovation for European enterprises through the smart use of ICT initiatives Source: http://ec.europa.eu/growth/sectors/digital-economy/ebsn/index_en.htm	2008-2014	The aim of this action that ran from 2008-2014 was to modernize industrial value chains and help small businesses better connect to larger enterprises and become fully integrated in the chain, offering them a better position in the globalized business environment. As part of the initiative, six demonstration actions were started in support of the automotive, fashion, transport and logistics, tourism, agro-food and construction sectors.
Digitising European Industry package (part of the DSM initiative) Source: https://ec.europa.eu/digital-single-market/en/digitising-european-industry	19 Apr, 2016	The Digitising European Industry package contains a range of actions which have an overlap with other DSM actions, but which focus on the needs of the manufacturing sector and what is commonly called 'Industry 4.0' or advanced manufacturing. The package includes the following actions: **- Priority standards to boost digital innovation** The Commission proposes concrete measures to speed up the standard-setting process by focusing on the five priority areas 5G, cloud computing, Internet of Things, data technologies and cyber security. It will also co-finance technology testing and trials to accelerate the setting of standards, including in relevant public-private partnerships. **- Digital public services** An eGovernment action plan will modernise digital public services and make the EU a better place to live, work and invest. The Commission put forward 20 measures to be launched by the end of 2017. **- The European Cloud Initiative** The Commission is setting up a European Cloud

Name of the program, measure, action plan, etc.	Year started/ adopted / agreed	Topics covered
		Initiative to strengthen Europe's position in data-driven innovation and improve competitiveness. **- The Internet of Things** Today, less than 1% of objects are connected to the Internet, but there are likely to be almost 6 billion IoT connections within the EU by 2020. The Commission's initiative intends to build a single market for a trusted IoT, and invest in innovation. **- Free flow of data** Unnecessary restrictions should be removed and national systems be better aligned to allow a better flow of data within the EU and to stimulate the development of new technologies such as cloud computing. The Commission will assess the different legal and technical obstacles and will then define measures to address them. **- Skills and jobs** Together with all stakeholders, the Commission will reinforce the role of industry and research organisations in the Grand Coalition for Digital Jobs and stimulate further commitment from businesses to taking action. It will also improve the understanding of skills requirements for new technologies in all sectors of the economy. **- Coordination among member states** Building on and complementing the many national initiatives for digitising manufacturers, such as Industrie 4.0 in Germany, Smart Industry in the Netherlands and in Slovakia, Fabbrica Intelligente in Italy or Industrie du Futur in France, the Commission plans to use its policy instruments, financial support, coordination and legislative powers to trigger further investments in all industrial sectors. This includes working with member states to focus investment on public-private partnerships; pooling resources for ground-breaking developments in digital technologies and platforms, including high-performance cloud infrastructure for science and innovation as well as large-scale test-beds to accelerate standards setting.
ICT Standardisation Rolling Plans (in cooperation with standardisation bodies) Source: http://ec.europa.eu/growth/sectors/digital-economy/ict-standardisation/index_en.htm	2013, 2015, 2016	The Rolling Plans on ICT Standardisation are the result of collaborations with major standardisation stakeholders through the Multi-Stakeholder Platform on ICT Standardisation. Priority actions aim to ensure interoperability and facilitate ICT uptake in key areas. The 2016 rolling plan, for example, offers details on the international contexts for the following areas: - E-health, accessibility of ICT products and services, Web accessibility, e-skills and e-learning, emergency communications and eCall. - E-procurement, e-invoicing, card/Internet and mobile payments, eXtensible Business Reporting Language

Name of the program, measure, action plan, etc.	Year started/ adopted / agreed	Topics covered
		(XBRL) and Online Dispute Resolution (ODR). - Smart grids and smart metering, smart cities, ICT environmental impact, European Electronic Toll Service (EETS) and Intelligent Transport System (ITS). - Cloud computing, (open) data, e-government, electronic identification and trust services including e-signatures, radio frequency identification (RFID), Internet of Things (IoT), network and information security (cyber security) and e-privacy. Previous ICT standardization rolling plans were issued in 2013 and 2015.
e-invoicing initiative Source: http://ec.europa.eu/growth/single-market/public-procurement/e-procurement/e-invoicing/index_en.htm	2010	Based on the Communication 'Reaping the benefits of e-invoicing for Europe' in 2010, the European Commission started several actions to support the uptake of e-invoicing by ensuring legal certainty and promoting the development of interoperable e-invoicing solutions based on a common standard with particular attention to SMEs: **- Standardisation and e-invoicing** The European Committee for Standardisation (CEN), which is funded by the Commission, runs a number of actions on e-invoicing implementation issues. A series of informal meetings with representatives of standards organisations produced the report 'e-Invoicing Standardisation Overview, issues and conclusions for future actions', September 2012. Following the adoption of Directive 2014/55/EU on e-invoicing in public procurement, and in accordance with the provisions of Article 3 within, the Commission issued a standardisation request to the European standardisation organisations in December 2014. The work is being carried out by the CEN Project Committee on Electronic Invoicing (CEN/PC 434). **- Single Euro Payment Area (SEPA)** SEPA is a banking industry initiative that makes electronic payments across the euro area as easy as domestic payments within one country. Due to the strong link between invoices and payments, SEPA is an ideal launching pad for interoperable e-invoicing schemes because it pushes process integration across the financial supply chain. **- European Multi-Stakeholder Forum on Electronic Invoicing** The European Multi-Stakeholder Forum on e-Invoicing brings together delegates from national e-invoicing forums and stakeholders from the user side of the market. Its objective is to help pave the way for a broad-scale adoption of e-invoicing at national and EU levels. The Forum creates a unique opportunity to exchange experiences and best practices across borders. It also discusses issues of common interest, with the possibility to issue recommendations to the

Name of the program, measure, action plan, etc.	Year started/ adopted / agreed	Topics covered
		Commission. The Forum is chaired by the Commission and meetings are held twice a year.

8.2. Identification of policy actions at EU level to overcome barriers

Starting point for the identification of necessary policy measures for the development of the European software and Internet industry is the list of policy measures compiled in the 2010 study. On pages 142f of the report the following 30 policy measures were suggested:

1. Knowledge Base

1- Increase level of R&D funding of SBIS-related projects within the FP funding
2- Ease the access for SBIS SME to the ICT FP fund
3- Set up a virtual network to connect national software clusters

2. Knowledge Diffusion and Networking

4- Support the creation of creative, local platforms
5- Initiate a cross-border network of National Thematic Networks to provide information, networks, best practice repositories, and meeting points for Access on Finance, SME Funding, International and Cross-border Business.

3. Entrepreneurial Activities

6- Promote partnerships between small SBIS firms and trusted intermediaries
7- Support the use of public data and content by better access

4. Financial Capital Development

8- Foster the potential of pre-commercial procurement to support innovative SME and enforce take-up of ETP (missing link of R&D funding)
9- Establish European scheme for high-risk, R&D-intensive start-ups

5. Regulatory Environment

10- Promote interoperability and open standards in public procurement and public R&D funding
11- Suggest directive on interoperability
12- Licensing schemes
13- Review current IPR regime
14- Promote efficient use of radio spectrum

6. Market Creation

15- Suggest directive on digital goods and services as follow-up to directive on e-commerce (e.g. clarifying VAT rules)
16- Enforce interoperable e-ID to make internet transactions trustworthy
17- Create a platform for public procurement authorities to inform and combine procurement power in SSBS/SBIS
18- Supervision of procurement procedures

19- Initiate European Cloud Network (connecting national clouds and others to increase visibility)
20- European SLA as quality sign

7. Creation of Legitimacy

21- Review of Data Protection Directive
22- Micro-payment initiative
23- Consumer rights alignment
24- Initiate ERA-NET to coordinate research between member states and with the EU

8. Human Capital Development

25- Initiate and promote e-entrepreneurial skills program
26- Set up research on business and innovation in SSBS/SBIS
27- Strengthen focus on software and software-based services in e-skills program

9. Strategic Intelligence

28- Improve surveys by EUROSTAT based on new NACE structures, establish foresights
29- Build up a monitoring system for the segment
30- Set up high-level group for coordination

When reviewing each of these measures, the project team found that many of the policy actions mentioned were still relevant today. The following table will concentrate on the policy measures that are relevant in the light of the list of obstacles identified in the previous chapter. More information on the proposed measures can be found in deliverable D3 – "2nd Interim Study Report".

Barrier	**Policy measures as suggested in 2010 report (table on p. 142 of final report and D3 recommendations)**
1. Market fragmentation	- Suggest directive on digital goods and services as follow-up to directive on e-commerce (clarifying, e.g., VAT rules). - Enforce interoperable e-ID to make Internet transactions trustworthy. *Measures proposed by the current study*: - Harmonize the internal market through the creation of a single market. Several initiatives, including the aim of the single European information space within the i2010 program, already address this issue. However, complementary actions could especially foster the uptake of the SBIS segment. This includes clarification on VAT rules, consumer rights and liability for services developed, executed and delivered in different EU member states.
2. Status-quo orientation of European enterprises	- Support the creation of creative local platforms to support open and social innovations. - Establish European scheme for young, high-risk, R&D-intensive start-ups. *Measures proposed by the current study*: - Capital development I: Set up special investment and loan programmes for European SSBS companies, especially for start-ups, including support for business angels. - Capital development II: Set up special investment

Barrier	Policy measures as suggested in 2010 report (table on p. 142 of final report and D3 recommendations)
	programmes addressing medium-sized companies in the third development stage of growth after venture capital in order to stabilize their growth.
3. Existing rules and governance structures within IT-using sectors	*Measures proposed by the current study*: - Eliminate outdated regulations that prevent the successful diffusion of SBIS. A high-level group of experts from the different Commission services should accompany and monitor the development of regulations for the emerging Internet of services and give recommendations to the Commission and the EU member states on adjusting regulatory issues in order to improve uptake. - Initiate public-private partnerships (PPPs) in order to motivate companies to develop and try out new software- and service-based activities. In 2009, the EU launched several PPPs in the context of the Internet of services. - Take on an active role in the development of Future Internet/ Internet of Things by strengthening R&D programmes supporting Future Internet technologies and by establishing technology platforms or public-private partnerships with software companies and IT-using organisations.
4. Conservative users sticking to old habits	*Measures proposed by the current study*: - Set up initiatives to raise awareness of European software solutions and products in order to draw attention to alternatives to US products (Firefox instead of Microsoft's Internet Explorer).
5. Missing supporting services for new software and applications	- Initiate network of National Transfer Accounts (NTAs) to provide information, access to networks, best-practice repositories, meeting points in order to improve SME funding and internationalisation/cross-border business. - Promote partnerships between small SBIS firms and trusted intermediaries in order to promote European SSBS/SBIS solutions. - Initiate and promote e-entrepreneurial skills programme to improve management skills in the SSBS industry. *Measures proposed by the current study*: - Encourage national governments and trade associations to build networks of excellence for SSBS SMEs in order to share best practices in several fields (financing, public procurement, cross-border) and implement measures to connect and coordinate these networks on a European level.
6. Inadequate broadband infrastructures	- Promote efficient use of radio spectrum. *Measures proposed by the current study*: - Set obligatory targets for the quality and level of fixed-line and mobile broadband availability.
7. Lack of specialised IT and Internet experts	- Strengthen the focus on software and software-based services in e-skills programmes in order to enhance e-skills for users. - Set up research on business and innovation in SSBS/SBIS. *Measures proposed by the current study*: - Start initiatives to increase the share of technical education in school curricula. This can only be done in cooperation with the different national authorities. The aim is to raise awareness for technical jobs. - Existing e-skills programmes should be enforced and

Barrier	Policy measures as suggested in 2010 report (table on p. 142 of final report and D3 recommendations)
	complemented by measures aiming at skills in the field of social media and other areas of SBIS. - Initiate programmes for lifelong learning focusing on e-skills. Join in with national governments and trade associations to offer further education and knowledge transfer. - Improve the mobility of young talents for SSBS within the EU as well as from non-EU states. While mobility within the EU can be tackled through special programmes on EU level, e.g. grants and promotion as well as the reduction of regulations, mobility from outside the EU has to be approached on national levels.
8. Not enough R&D spending	- Shift focus of financial support to SBIS in related projects in FP. - Ease access for SMEs to ICT FP funding. - Set up thematic networks to connect national clusters. *Measures proposed by the current study*: - Harmonise tax incentives for R&D so that all European SMEs can profit from tax reliefs for R&D activities. - Increase support for knowledge transfer from research to commercial applications in the field of SSBS. One option is to start initiatives to initiate and enforce the establishment of specific networks for knowledge transfer; another is to enforce cooperation in public-private partnerships.
9. Missing security, privacy and trust in new services	- Initiate ERA-NET to coordinate research between member states and with the EU to increase support for IT security research. - Review of Data Protection directive. - Micro-payment initiative. - Consumer rights alignment. - Initiate a European Cloud Network by connecting national clouds. - Establish and promote a European Service Level Agreement (SLA) as a quality sign. *Measures proposed by the current study*: - Although there are EU directives on data protection, the implementation differs between member states, which causes problems for cloud-based business models. To improve this situation, existing considerations on EU level should be coordinated by a high-level group to align actions in favour of both users and the industry. - Besides awareness-raising actions like trust seals, another possible measure is to enforce public services to implement secure and reliable services based on the respective technologies. - Integrate security in all R&D programmes, especially those related to Web services. - Support e-government applications as pilots for security and reliability of software, and especially Internet-based services.
10. Missing standards and interoperability	- Support open standards in public procurement and R&D funding. - Suggest directive on interoperability. - Support the use of public data and content through better access. *Measures proposed by the current study*: - Promote the participation of European institutions and companies, especially SMEs, in standardisation forums and

Barrier	Policy measures as suggested in 2010 report (table on p. 142 of final report and D3 recommendations)
	institutions. - Launch directives and guidelines to enforce the interoperability of software or to implement open standards.

8.3. Analysis of impacts if certain policy actions are put in place

In this chapter, an updated ex ante assessment of selected policy actions will be carried out. The European software and Internet industry currently faces a set of barriers which stand against a more dynamic development of the sector as a whole. Concerning the identification of concrete barriers and their prioritization, the project team can rely on a strong empirical base which was built in this study.[42] Concerning policy actions, the project team do not yet have a very strong empirical base. Although there is a systematic account of possible policy measures and expected impacts (from the 2010 study) as well as a preliminary list of current policy initiatives suited to overcome the identified barriers (from the external expert workshop), what is still needed is a way to prioritize necessary policy actions. This will be done in the following section by carrying out an ex ante impact assessment of possible policy actions. The policy actions to be examined are those related to the barriers, which were discussed in the expert workshop in April 2016. The range of policy actions will be complemented by initiatives suggested in the 2010 study.

The aim of the impact assessment is to be able to determine concrete policy actions with the strongest economic and/or societal impacts. Although the ex ante impact assessment method has its limitations,[43] it will give an indication of what policy measures will have the highest impact and should thus be prioritized. The result will be a ranked list of policy measures.

This list will then be the central input for the policy recommendation part of this study. For the final policy recommendations the project team also has to take into account what policy measures have currently been adopted or are already underway on the level of the European Union. Also, the central results of the other parts of this study will be considered.

Starting point for the ex ante impact assessment is the list of the top 10 policy measures that was established during the expert workshop in Brussels in April 2016 (see figure "List of top 10 policy measures for a successful future"). These policy activity fields were directly derived from the list of barriers that was compiled in the expert workshop as well. Thus the policy action list displays an implicit prioritization. However, the experts in the workshop did not do a ranking of the different actions. To achieve a ranking, an ex ante impact assessment will be carried out in this section, taking into account the information given in the 2010

[42] The empirical base consists of results from the 2010 study, literature review updates, and internal and external expert workshops.
[43] This is simply because it deals with future developments and because data is often not available in the required form (aggregation level, time horizon, sectors in question, etc.).

report as well as results from selected current studies (examples see figure "Examples of recent studies analysed").

The aim of this task is to find out what policy actions will result in the most significant economic and social changes in the next 5–10 years if put in place. The method implies that current policy measures, which were recently adopted or implemented and which already address the topics to be analysed, are included in the examination at this stage. In a second step (in the policy recommendation chapter), a cross-check of the list of necessary policy actions vis-à-vis actions already underway will be carried out.

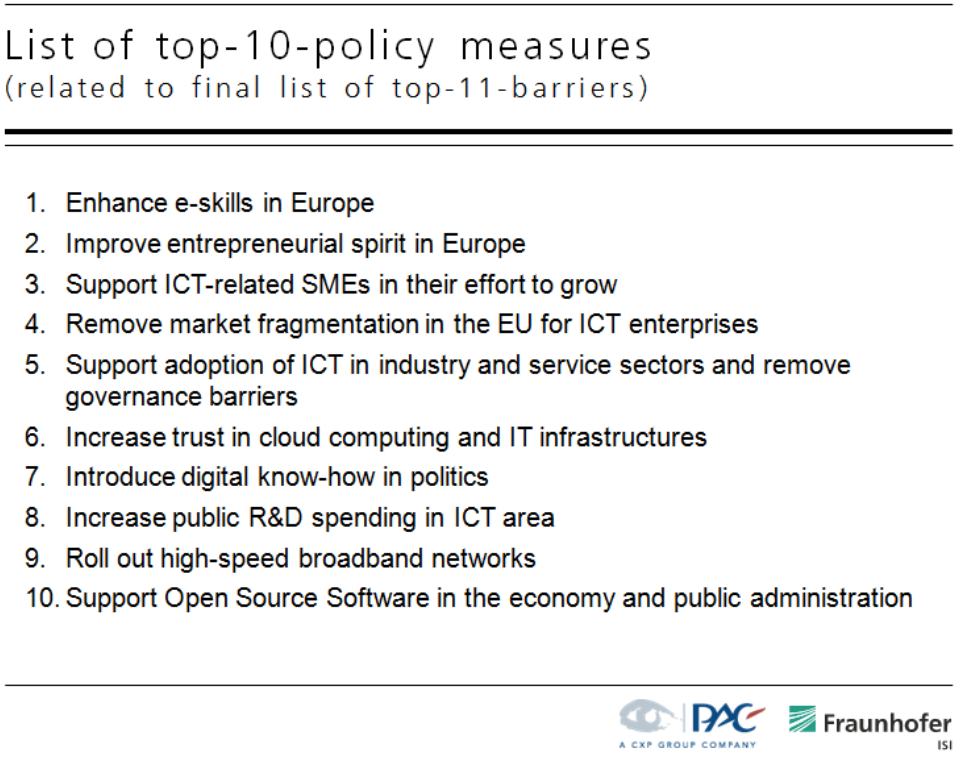


Fig. 49: List of top 10 policy measures for a successful future of the software and Internet industry in Europe

The structure of this section is as follows: First the barrier in question that requires some form of policy action will shortly be described. The characterization of the barrier is complemented by additional expert input collected during the expert workshop in Brussels in April 2016. Then the related policy actions are listed. These are based again on discussions in the expert workshop as well as on suggestions from the 2010 study. In a next step, will shortly describe analyses the available empirical material concerning economic and social impacts if certain policy actions are put in place. This section again draws on the insights of the 2010 study as well as on studies published since then. Finally, based on the assessments gathered in the previous sections, the project team summarises the economic and social

impacts of removing the barrier as a whole in a table indicating "low" (+), "middle" (++) or "high" (+++) impacts.

Examples of recent studies analysed for the socio-economic impact assessment are:

- Baal, Sebastian van; Beckert, Bernd; Bertenrath, Roman et al. (2016): Der Weg in die Gigabitgesellschaft. Wie Netzausbau zukünftige Innovationen sichert. Eine Studie der IW Consult unter Mitwirkung des Economica Instituts für Wirtschaftsforschung und des Fraunhofer ISI im Auftrag des Vodafone Instituts für Gesellschaft und Kommunikation, Juni. http://www.vodafone-institut.de/de/studie/wege-die-gigabit-gesellschaft-neue-studie-des-vodafone-instituts/
- Centre for Economics and Business Research (2015): The Economic Impact of Basic Digital Skills in the UK. A report for Tinder Foundation and Go ON UK. November, www.cebr.com/the-economic-impact-of-digital-skills-and-inclusion-in-the-uk_final/
- Ericsson; Arthur D. Little; Chalmers University of Technology (2013): Economic effects of broadband speed. 3/221 01-FGB 101 0003, September, www.ericsson.com/res/thecompany/docs/corporate-responsibility/2013/ericsson-broadband-final-071013.pdf

1. Enhance e-skills in Europe

Short description of the related barrier: "Lack of skills, lack of specialised IT and Internet experts"

The software industry still lacks highly talented and educated software programmers, application designers and Internet experts. New IT trends such as machine-to-machine communications and cloud computing are creating new opportunities, but experts see the danger of Europe missing out on them if it does not produce enough experts in the field.[44] In a speech held in 2015, European Commission Digital Single Market chief Andrus Ansip said that Europe might face a huge deficit in skilled ICT workers: "Despite rapid growth in the ICT sector, creating some 120,000 new jobs a year, Europe could face a shortage of more than 800,000 skilled ICT workers by 2020. We still see big differences in skills levels between EU countries, and different implementation of national skills programmes designed to minimize Europe's digital divide".[45]

Additional expert input

- Lack of specialised experts/IT experts
- Lack of digital skills
- Insufficient education in entrepreneurship and technical studies in software engineering

[44] See, for example, Fadilpašić, Sead (2014): Europe faces shortage of 800,000 IT workers by 2020. In: BetaNews, http://betanews.com/2015/04/15/europe-faces-shortage-of-800000-it-workers-by-2020
[45] ibid.

- Less investment in skills and research in Europe compared to the US and Asia.

Suggested policy actions

In the external expert workshop, the following policy actions related to this barrier were suggested:

- Support media competencies, focus curricula in schools and higher education on digital topics.
- eSkills (STEMS, MINT) are important, but it should not be forgotten that language and communication skills are necessary as well.
- Enhance digital autonomy, digital sovereignty (using and producing IT).
- Beyond education: young and old are to educate each other, lifelong learning, circularity, gradual retirement.
- Skills: more IT skills, more business and entrepreneurial skills in schools and higher education, even though this may require a change in attitudes.

In addition, the 2010 study suggested the following policy actions:

- Existing e-skills programmes should be enforced and complemented by measures aiming at skills in the fields of social media, privacy and security, and other areas of SBIS (e-skills for users).
- Start initiatives to increase the share of technological education in school curricula. This can only be done in cooperation with the different national authorities. The aim would be to raise the awareness for technological jobs.
- Initiate and promote e-entrepreneurial skills programme (management skills).
- Improve the mobility of young talents for SSBS within the EU as well as from non-EU states. While mobility within the EU can be tackled by special programmes at EU level, e.g. through grants and promotion as well as the reduction of regulations, mobility from outside the EU has to be approached at national level.

Economic and social impacts

Well-trained digital professionals as well as skilled end-users are important prerequisites for the software and Internet sector to thrive in the future.

Concerning the supply of people with professional computer knowledge and programming skills, the so-called 'e-skills monitor 2009', a study by research institutes Empirica and IDC, detected a large gap in almost all European countries.[46]

The 2015 study by IDEAS consult for the European Parliament, "LABOUR MARKET SHORTAGES IN THE EUROPEAN UNION", reveals that there are specific shortages

[46] Empirica; IDC 2009: Monitoring e-Skills demand and supply in Europe. Foresight report. December 2009, authors: GABRIELLA CATTANEO, MARIANNE KOLDING, ROSANNA LIFONTI et al., http://ec.europa.eu/enterprise/sectors/ict/files/e-skills_foresight_scenarios__2015_en.pdf.

of information and communications technology professionals in Ireland, Spain, Greece, and the Netherlands.[47]

An e-skills shortage means that market potentials cannot be developed accordingly, business ideas cannot be realized, and growth and competitiveness in Europe are hampered.

In some areas, however, a shortage of IT skills is a global phenomenon. For example, in the area of cyber security, demand for experts is expected to rise to 6 million globally by 2019, with a projected shortfall of 1.5 million, as Michael Brown reports, the CEO at Symantec, the world's largest security software vendor.[48]

Concerning demand for software and IT services, the e-skills of the general population are also highly relevant. As the 2010 report notes, "more skilled users are likely to demand more SBISs across the board, which would benefit SMEs as well as larger businesses" (p. 270).

However, enhancing e-skills in the population would not only generate economic effects, it would also serve societal needs, as digitally competent users are users who participate, communicate and collaborate more than users who do not know how to use certain digital tools and applications. In contrast to the finding from the 2010 study that 40% of the EU's population could be considered as computer-illiterate in 2008 (p. 269f), the situation has changed since then. Today, many more people know how to use a computer, laptop or smartphone and the generation of the so-called 'digital natives' has grown into the current workforce. However, a 2014 study for the European Commission found that even the younger generation, which grew up with computers, needed to enhance their digital competence. Also, there is still a gender and a social gap when analysing digital competence.[49]

Concerning the impacts of better e-skills, a UK study of 2015 claims that they positively affect productivity (time savings, earnings), employability and employment, that they enable financial savings from online retail and that they allow for online transacting with government. For a ten-year period, the researchers estimated the overall gains of a higher e-skill level in the UK population at over GBP 14 billion.[50]

Focusing on the performance of the European software and Internet market, the assessment of the 2011 study still holds true: "The competitive position of EU-

[47] IDEAS (2015): LABOUR MARKET SHORTAGES IN THE EUROPEAN UNION. Study for the European Parliament, www.europarl.europa.eu/RegData/etudes/STUD/2015/542202/IPOL_STU%282015%29542202_EN.pdf, p. 120.

[48] Source: Morgan, Steve (2015): Cybersecurity job market to suffer severe workforce shortage. In: CSO, July 28, www.csoonline.com/article/2953258/it-careers/cybersecurity-job-market-figures-2015-to-2019-indicate-severe-workforce-shortage.html

[49] European Commission (2014): The International Computer and Information Literacy Study (ICILS). Main findings and implications for education policies in Europe. Study by the International Association for the Evaluation of Educational Achievement (IEA), November, http://ec.europa.eu/education/library/study/2014/ec-icils_en.pdf.

[50] Centre for Economics and Business Research (2015): The economic impact of Basic Digital Skills and inclusion in the UK. A report for Tinder Foundation and GO ON UK, November 2015, www.tinderfoundation.org/sites/default/files/research-publications/the_economic_impact_of_digital_skills_and_ inclusion_in_the_uk_final_v2.pdf, p. 8.

based companies could be strengthened due a larger and more sophisticated home market. If the skill level of European users is markedly higher than that of users in other regions, European SBIS providers might be able to occupy a high-end niche of the market in terms of product sophistication (…) Enhancing users' skills can be expected to lead to greater confidence when using SBISs and thus to greater demand. Better skills would also increase the benefits users derive from SBISs in terms of productivity, thus leading to growth in the wider economy" (p. 270f).

Summary

Policy measure	Economic impact	Societal impact
1. Enhance e-skills in Europe	+++	+++

2. Improve entrepreneurial spirit in Europe

Short description of the related barrier: "Lack of entrepreneurial spirit"

In the software and Internet industry, start-ups experimenting with new technology and new market opportunities play an important role. However, it can be observed that in Europe, entrepreneurial start-up activities are not as strong as elsewhere in the world, especially in the USA. It seems that entrepreneurial spirit, innovative behaviour and the embracing of new technologies are underdeveloped in Europe. In fact, it seems that entrepreneurs and digital innovators have a bad image in Europe, which results in a lack of innovation. Consequently, talented and commercially oriented developers go to the Silicon Valley instead of trying to succeed in Europe. This, in turn, results in a severe brain drain. The missing entrepreneurial culture also has consequences for non-commercial players who, in the long run, will lose their ability to adapt to changed circumstances.

Additional expert input

This barrier was brought up in the expert workshop as a new barrier and was ranked very high by the experts. However, educational and cultural aspects, lifestyles and attitudes are affected here, so apart from policy, other players and institutions, such as teachers, enterprises, universities, associations, etc. also play a role here.

Suggested policy actions

In the external expert workshop, the following policy actions related to the barrier were suggested:

- Support entrepreneurship
- Raise the visibility of the European software industry in education, but also as best-practice studies illustrating software-based global success stories from Europe, such as BlaBlaCar, Gemalto, Plumelabs and others, for example coming from the ODINE programme (see https://opendataincubator.eu).

Whereas in the 2010 study, the missing entrepreneurial spirit was not addressed explicitly, several discussion points indirectly address the issue:

- Enhance the skills of students, especially students in the software area and in technological studies, to embrace risk-taking entrepreneurial activities and to develop an innovative spirit.
- Establish a European scheme for young, high-risk, R&D-intensive start-ups, including financing instruments for follow-up stages.
- Measures to close the commercialization gap between invention and innovation. Here, measures that help innovative start-ups to team up with established companies are of importance. This could be done by establishing or supporting platform partnerships. For example, telecom operators, which have a stronger position in Europe than in the US, could offer service platforms new entrants can use to market their services. Policy could support this by promoting the approach of teaming up with trusted intermediaries, by funding the development of related R&D and by providing guidelines concerning operational roles.
- Set up initiatives to raise awareness of European software solutions and products in order to publicise alternatives to US products (Firefox instead of Microsoft's Internet Explorer).

Economic and social impacts

Start-ups are vital to the creation of new technological innovation systems, because they are often more creative, faster and willing to experiment with new technologies and applications. And they are responsible for a significant share of new jobs created in Europe.

A recent study by Eurofound[51] states that at European level, despite the low number of young entrepreneurs, almost 49% of all young people aged 15–34 consider a career as an entrepreneur to be desirable. This share varies considerably among European member states. It ranges from 32% in the United Kingdom, Denmark, the Netherlands, Slovakia, Sweden and Germany to 57% or more in Mediterranean countries such as Portugal, Greece, Italy and Croatia, the Baltic states and some Eastern European countries such as Romania and Bulgaria. This contrasts with 73% of US citizens questioned in a 2010 Eurobarometer survey[52] saying that they have a favourable image of entrepreneurs.

Together with desirability, it is important to see how feasible people perceive an entrepreneurial career to be. A positive perception of how feasible it is to become an entrepreneur can indicate favourable conditions for making entrepreneurship grow and flourish in a country. According to the Eurofounds study, at European level, 41% of young people find it feasible to become an entrepreneur (Eurofounds 2015, p. 22). A comparison with other economies reveals that in several other countries the entrepreneurial choice is perceived as more feasible than it is in

[51] Eurofound (2015), *Youth entrepreneurship in Europe: Values, attitudes, policies*, Publications Office of the European Union, Luxembourg.
[52] Eurobarometer (2010): European attitudes to Entrepreneurship, http://europa.eu/rapid/press-release_MEMO-10-232_en.htm?locale=en

Europe. In particular, in Brazil, the US, Russia and China, 50% or more of young people consider it feasible to become an entrepreneur (Eurofounds 2015, p. 23).

The study states that there is agreement on the positive effects of culture and social attitudes on entrepreneurship, although the magnitude of these effects is disputed among researchers (p. 22). While social and cultural factors influencing entrepreneurial activities are one thing, in this study the project team is interested in socio-economic impacts if policy measures are able to increase entrepreneurship in Europe – which also implies enhancing its image.

Concerning the impacts of policy measures which succeed in increasing the entrepreneurial spirit in Europe, it can be stated that positive effects will be generated in the areas of innovation, job creation and increased competition. Social impacts can be a generally more dynamic society, a new balance of income distribution, and even philanthropy, as 90 per cent of entrepreneurs donate parts of their money or dedicate time to help other entrepreneurs or non-profit organisations.[53]

Related specific measures suggested in the 2010 study were to establish a European scheme for young, high-risk, R&D-intensive start-ups, including financing instruments for follow-up stages and measures that help innovative start-ups to team up with established companies.

The primary impact of greater support for small, innovative start-ups is that on innovation. The 2010 study states that "start-ups that combine small size with high R&D intensity are more likely than other innovative companies to produce groundbreaking innovations, i.e., they introduce fundamentally new products and services to the market, rather than improving on existing technologies (...). Such innovations are likely to have a larger social value in the long run, not least through the potential for follow-on innovation by other firms (including larger and more established firms). Thus innovations made by this particular group of companies are likely to contribute disproportionately to productivity, growth and employment over the longer term (2010 study, p. 199f).

A direct impact of platforms on which start-ups and established players can connect is to increase innovation and research because, especially for SMEs, they offer a chance to bring innovative services to a broad market faster. This allows faster returns on investment and enables more spending for further innovations. The 2010 study continues: "For intermediaries as platform operators the chance is to increase the use of their services and also participate in a fair way from the revenues of the suppliers. Due to the fact that areas like health, education and similar services are growing markets it is also to expect that these areas will profit from innovative new services. Platform models and partnerships also offer possibilities to impact security positively" (2010 report, p. 188f).

[53] According to an Ernst & Young-study entitled 'Entrepreneurs & Philanthropy". Cited by Trenchard, Richard (2015): What impact do entrepreneurs have on Society? http://www.virgin.com/entrepreneur/what-impact-do-entrepreneurs-have-on-society.

Summary

Policy measure	Economic impact	Societal impact
2. Improve or unleash the entrepreneurial spirit in Europe	+++	++

3. Support ICT-related SMEs in their effort to grow

Short description of the related barrier: "Missing supporting services"

Software engineering by European firms is generally perceived as being of high quality, which is supported by the fact that there are many specialized software firms working, for example, for the manufacturing sector or for big national companies where IT systems are mission-critical.[54] However, the experts in the workshop observed that supporting services to develop and market new software and apps were often missing. Supporting services include venture capital, marketing know-how, partners, sharing of experiences and best practices, access to legal experts, etc.

Additional expert input

- As there is no single European market yet, scaling-up is a big problem
- Lack of funding (e.g. from VCs) for start-ups and innovative SMEs
- Missing marketing know-how transfer, lack of help through best practices

Suggested policy actions

In the external expert workshop, the following policy actions related to the support of innovative start-ups and SMEs were suggested:

- Improve funding for entrepreneurs
- Support scaling-up and avoid protection
- Enhance practical orientation and communication of best practices. More test beds, pilots, demonstrations to showcase new technologies, esp. to SMEs
- Ensure the knowledge base for the development of the sector
- Promote co-creation, support creativity in software development without picking winners

In addition, the 2010 study suggested the following policy actions:

- Establish a European scheme for young, high-risk, R&D-intensive start-ups

54 As a pars pro toto for a European region see: Vöhringer, Sascha (2012): Die Software-Branche und ihre Bedeutung für Baden-Württemberg. In: Statistisches Monatsheft Baden-Württemberg 8/2012, www.statistik.baden-wuerttemberg.de/Service/Veroeff/Monatshefte/PDF/Beitrag12_08_07.pdf.

- Initiate a network of National Transfer Accounts (NTAs) to provide information, access to networks, best-practice repositories, meeting points in order to improve SME funding, public procurement, cross-border and international activities
- Promote partnerships between small SBIS firms and trusted intermediaries (see also section 2: "Improve entrepreneurial spirit in Europe")
- Initiate and promote an e-entrepreneurial skills programme to improve management skills in the SSBS industry (see also section 1: "Enhance e-skills in Europe")

Economic and social impacts

In order to grow and extend their activities into new markets or technologies, innovative ICT-related SMEs need specific support. However, as stated in the 2010 report, many problems, such as access to credit and financing solutions support for SMEs or for cross-border operations, are already addressed by national or European programmes. The 2010 report therefore says that "the problem is not the lack of concrete measures, but more often the lack of knowledge about them" (2010 report, p. 183). To improve the situation, a stronger promotion as well as support in information sharing and coordination between companies are suggested.

Concerning the economic and social impacts of better support for ICT-related firms, the 2010 report lists productivity and performance gains: "Actions aimed at improving networking and spreading valuable knowledge within the European software and Internet industry can help to make the sector more productive. Such actions would benefit SMEs in particular, which otherwise face greater difficulties in accessing relevant networks and knowledge (information asymmetries). The proposed actions would lead to a more competitive industry, both within the EU and vis-à-vis the international competition, by overcoming coordination failures and improving the allocation of resources (such as finance)." (2010 report, p. 184).

Evaluations of national programmes with the same aim have shown that the impact can be considerable. According to the UK Department of Trade and Industry, £1million spent on trade development support yields net additional benefits in the region of £17m. On top of this, evaluations show substantial qualitative benefits for many of the participating businesses, including increased skills and upgrades to products or practices, which suggests increased capabilities and absorptive capacity, particularly for innovative firms.[55]

In fact, supporting start-ups and innovative SMEs in the ICT sector in becoming larger companies and being able to address bigger markets is mainly necessary because European companies cannot upscale their processes as companies in the US or other English-speaking countries can. US companies with an attractive software or Internet application can upscale their markets almost at once, whereas European companies have to deal with many different national markets, languages

[55] The 2010 study (p. 184) cites two studies: UK Department of Trade and Industry (2006): International Trade and Investment – the Economic Rationale for Government Support. DTI Economics Paper,18, and London Economics (2008), Evaluation of UK Trade & Investment's Tradeshow Access Programme (TAP).

and cultures. Thus supporting actions are closely connected to overcoming market fragmentation, which will be discussed in the following section.

Summary

Policy measure	Economic impact	Societal impact
3. Support ICT-related SMEs in their effort to grow	++	+

4. Remove market fragmentation for ICT enterprises in the EU

Short description of the related barrier: "Market fragmentation"

Market fragmentation in the EU28 member states was considered the most important barrier to the development of a larger software and IT services market. Different laws, administrative procedures, languages and different ways of doing things were seen as reasons why the European ICT-related market is not as successful as it could potentially be.

Additional expert input

- Barrier to creating global Internet leaders
- Cultural barriers, different languages in Europe
- Different copyright laws in Europe

Suggested policy actions

In the external expert workshop, the following policy actions were suggested to overcome market fragmentation in Europe:

- Harmonize VAT, taxes, cross-border business, etc.
- Regulatory harmonization, but not overregulation: Regulate only when regulation is warranted. REFIT exercise, self-regulation and co-regulation are to be preferred
- Harmonize property rights and provide varieties of ownership instead of only one possibility, be open to new models
- Use common standards and focus on interoperability

In addition, the 2010 study suggested the following policy actions:

- Harmonize the internal market through the creation of a single market. Among the initiatives already addressing this barrier, specific actions could foster the uptake of the SBIS segment. This includes, for example, consumer rights and liability provisions for services developed.
- Enforce interoperable e-ID to make Internet transactions trustworthy
- Support open standards in public procurement and R&D funding and suggest a directive on interoperability

Economic and social impacts

First of all, it has to be noted that in economic terms, fragmentation is not always bad. Fragmentation can reflect differentiation, e.g. a natural experiment on different ways of doing things, finding the 'right approach' for different local conditions. These can be regional or sectoral. Fragmentation can also reflect comparative advantages as it facilitates complementarity rather than competition among substitutes. Finally, it can give new approaches 'room to grow' that they might not have in a more uniform environment. For example, if people can switch 'too easily', they do not have an incentive to learn about software solutions in depth and to feed this information back to software providers.

On the other hand, for individual companies, market fragmentation in Europe is a real obstacle to their own growth: Whereas US companies have easy access to a 300-million people market, European companies struggle with different cultures, languages, laws, etc. Thus overcoming or significantly decreasing the level of fragmentation would have enormous economic impacts. The 2010 report emphasises that the software and Internet industry heavily relies on network effects: "Unlike other sectors, network effects are dominant in the software business, i.e. the size of the market plays an important role for the success of software and software based service companies. (...) Most European markets are dominated by few non-European players, while the rest of the market actors consists of a large number of SMEs. Although the number of SMEs is a good sign for the dynamics of the industry, they often compete on the same markets and market segments. This impedes the development of more competitive medium-sized players" (2010 report, p. 284).

A study by consulting firm Copenhagen Economics[56] highlighted the importance of overcoming parts of the fragmentation, for example by measures such as the E-Commerce Directive for the creation of a European Digital Single Market (DSM). The report found that realising the DSM is crucial for the European economy, showing that failing to implement the DSM would cost Europe 4% of GDP by 2020. Put positively: Implementing the DSM will result in an additional increase of European GDP of 4% by 2020. The DSM is expected to lead to a price convergence for many goods and services. The report concludes that the EU risks falling behind if the barriers to a Digital Single Market are not addressed.

A harmonization of e-commerce regulations within the EU would in fact help the software and Internet industry by boosting demand, as there would be more security and transparency for consumers, especially in cross-border transactions. Increased cross-border trade would also lead to more competition (thus potentially lower prices) and enable providers of software and IT services to achieve economies of scale, which are not obtainable if markets are geographically limited to individual member states. Higher growth, employment and productivity result from this increase in competition, as does more innovation (see 2010 report, p. 225).

[56] Copenhagen Economics (2010): "The Economic Impact of a European Digital Single Market." *Report for the European Policy Centre.*

In addition, a more coherent internal market would be more attractive to international software and Internet service providers and thus lead to increased trade and investment. However, a more homogeneous EU market could lead to greater geographic concentration of the industry, thus potentially having a negative impact on individual regions.

Concerning social impacts, measures to increase harmonization would result in better access to social, health or education systems.

Summary

Policy measure	Economic impact	Societal impact
4. Remove market fragmentation in the EU for ICT enterprises	+++	+

5. Support the adoption of ICT in the industry and service sectors and remove governance barriers

Short description of the related barriers: "Status-quo orientation of industry" and "Existing governance structures in IT-using sectors"

This policy measure addresses two barriers which are interconnected: the status-quo orientation of industry, which implies that the industry and service sectors are not adopting IT and Internet technologies as broadly as they could, and the existing governance structures in IT-using sectors, which are structural barriers hampering the use and development of IT and related services in traditional sectors. The first barrier mainly addresses attitudes to change and mentalities that prevent companies from grasping new software-based market opportunities, the second barrier is a structural one. In fact, Internet and software-based innovations can make entire sectors more efficient, more user-friendly and more productive. However, the digital conversion of sectors such as energy (smart grids), health (e-health), traffic (intelligent traffic), public administration (e-government), education (e-learning) and manufacturing (digital factory, Industry 4.0/industrial IoT) is not proceeding as fast as would be possible. Established procedures and formal requirements currently limit the development and commercial rollout of many new services in the different fields of application. Software is a game changer, but some of the sectors have successfully prevented change, pointing to traditional routines and regulations.

Additional expert input

- Businesses do not see themselves as software developers and digital innovators, but as merely passive users
- Current status quo: "Software science mentality" (passive). While business users are considered as consumers, in fact they should be co-producers and contributors. Currently there is a lack of interaction with software developers.

- Regulations governing downstream sectors, product market sectors, the labour market and the way of doing business
- Ossified rules within the sectors
- Balancing deregulation and re-regulation instead of focusing on getting rid of any regulation. For example, security, privacy and trust require adequate new regulations and not deregulation. However, there are surely outdated sector structures and procedures that need to be overcome in the course of digitalisation.

Suggested policy actions

In the external expert workshop, the following policy actions were suggested to overcome these barriers:

- Adoption of ICT by SMEs: Convince IT-using sectors of the need to digitalise and use software, cloud services, etc. Communicate best practices, build platforms.
- Support, but no state aid, for financial technologies, blockchain, new forms of enterprises

In addition, the 2010 study suggested the following policy actions:

- Support the creation of creative, local platforms to support open and social innovations
- Initiate public-private partnerships (PPPs) in order to motivate companies to develop and try out new software and services-based activities
- Take on an active role in the development of Future Internet/ Internet of Things by strengthening R&D programmes supporting Future Internet technologies and by establishing technology platforms or public-private partnerships with software companies and IT-using organisations.
- Eliminate outdated regulations that prevent the successful diffusion of SBIS. A high-level group of experts from the different Commission services should accompany and monitor the development of regulations for the emerging Internet of services and give recommendations to the Commission and the EU member states on adjusting regulatory issues in order to improve uptake.

Economic and social impacts

Unlocking the creative potential of IT users and turning their activities into new software-based businesses as well as increasing the overall level of digitisation in industrial and services sectors like energy, traffic, health, education and public administration will result in many economic and social gains.

The "status-quo orientation" of businesses in Europe obviously limits more dynamic developments and has negative consequences for the acceptance of new software and applications. Also, there are some cultural peculiarities; in some countries, for example, software needs to be from domestic software producers, otherwise it will not be bought.

The low responsiveness to new products and the lower adoption rate of IT in European companies, administrations and households is the reason for Europe's lagging behind in productivity growth. Since software and ICT are key factors for productivity growth, the increase in the usage of software and IT services is a crucial point to improve Europe's competitiveness. As a result, European software firms get fewer stimuli from their home markets and are restricted in their ability to develop and create lead markets by establishing new products and services. Furthermore the lack of usage also affects the development of IT skills as well as overall economic growth and employment due to the fact that software intensity is one of the major determinants of the increase of productivity in traditional industries (see 2010 report, p. 294f).

In addition, structural barriers within IT-using sectors like energy, health, industrial production, traffic, government and education limit the potential of software applications. Established procedures and formal requirements restrict, for example, the development and commercial rollout of smart energy grids, connected e-health services or digital factories.

Interestingly, in the 2010 study, this structural aspect was not addressed explicitly. Although it was indirectly mentioned in the context of cloud computing and when mentioning the weak adoption of software and software-based services in enterprises, this barrier was not as present in the 2010 study as it is today. The current relevance of the application sectors reflects a trend that has been discussed under different labels, such as Internet of Things, advanced manufacturing (industrial IoT/ Industry 4.0), digital society, gigabit society, etc.

A 2012 study by German ICT association BITKOM and Fraunhofer ISI[57] estimates that the consistent digitisation of the application fields in question would result in economic gains of EUR 55.7 bn in Germany by 2022. The figure includes efficiency gains as well as additional revenues from new applications. What it does not include are effects that may be achieved in manufacturing by introducing advanced manufacturing technologies (Industry 4.0/industrial IoT).

Concerning societal impacts, an accelerated digitisation in IT-using sectors could result in more user-friendly applications in the areas of energy, traffic, health, education and public administration, as well as more highly skilled jobs in the manufacturing sector.

Summary

Policy measure	Economic impact	Societal impact
5. Support the adoption of ICT in the industry and services sectors and remove governance barriers	+++	+++

[57] BITKOM; Fraunhofer ISI (2012): Gesamtwirtschaftliche Potenziale Intelligenter Netze in Deutschland. http://www.bitkom.org/Publikationen/2012/Studie/Gesamtwirtschaftliche-Potenziale-intelligenter-Netze-in-Deutschland/Studie-Intelligente-Netze2.pdf.

6. Increase trust in cloud computing and IT infrastructures

Short description of the related barrier: "Missing trust, privacy, security"

A lack of security and trust in IT systems as well as privacy concerns are important barriers to the rollout of cloud computing services for advanced manufacturing, for networked applications in the healthcare sector, as well as for new traffic applications, for example to enable multimodality. On the other hand, there are many genuinely European software solutions and specific European approaches which are suited to enhance security and privacy. Thus this barrier can also be seen as a strategic opportunity for the European software industry to develop a genuinely European, safe and trusted software approach.

Additional expert input

- Reliability of software systems (smart grid)

Suggested policy actions

In the external expert workshop, the following policy actions were suggested to overcome these barriers:

- Support the establishment of a trusted cloud (users, vendors, providers)
- Promote the use of cloud computing
- Algorithmic regulation: Combination of data collected, manipulation of search results, big data analytics potentials, etc.

In addition, the 2010 study suggested the following policy actions:

- Coordinate research on IT security between member states and with the EU
- Review of Data Protection directive: The EU General Data Protection Regulation has been adopted, but implementation in the member states is critical. This may still cause problems for cloud-based business models. To improve this situation, discussions at EU level should be coordinated by a high-level group to align actions in favour of both users and businesses.
- Micro-payment initiative
- Consumer rights alignment
- Initiate a European Cloud Network by connecting national clouds, and establish and promote a European Service Level Agreement (SLA) as a quality sign
- Integrate security in all R&D programs, especially those related to Web services
- Support e-government applications as pilots to demonstrate the security and reliability of software, and especially of Internet-based services

Economic and social impacts

According to the 2010 report, the security of software and IT services is a crucial, but also multifaceted driver for the further development of the industry for several reasons. It encompasses topics like reliability, data security or secure transactions.

Security, especially of Web-based services, is seen as critical by businesses and consumers. On the other hand, many security problems arise not because of the lack of appropriate technologies, but because of non-technical factors such as the lack of knowledge about or disinterest in security requirements or other human factors. This leads to low acceptance and use, especially of new software-based services. This not only hinders the development of the European software and IT services companies, it also contributes to the weak growth of the EU economy as a consequence of weak ICT adoption, for which software and software-based services are key factors.

Concerning privacy, the report notes: "Privacy concerns are the most crucial determinants for the acceptance of SSBS, especially for emerging web-based technologies in the Internet of Services (…). The further virtualization of data processing and storage as well as the increasing market for cloud solutions leads to an increased demand for trustworthy services. Due to the different regulations on privacy protection in the different countries within the EU as well as outside the EU, companies are challenged to adjust their SBSS products and services to this. But this challenge can also be seen as a chance because there is a huge market for convenient solutions due to rising awareness for security and privacy problems" (2010 report, p.293f).

It seems that Europeans have stricter requirements concerning software security and stability, as well as regarding privacy in Web-based services. As the European software and Internet industry has to react to this, IT security and privacy requirements may also turn into a European strength instead of a barrier.

Summary

Policy measure	Economic impact	Societal impact
6. Increase trust in cloud computing and IT infrastructures	++	++

7. Introduce digital know-how in politics

Short description of the related barrier: "Policy strategies not suited to support ICT innovations"

The impression that policy measures are sometimes not in accordance with the actual requirements of the sector was originally discussed in the expert workshop held in Brussels in April 2016. In the 2010 report, this issue was not addressed at all. Thus there is no systematic assessment of this barrier. One main issue here is that policy seems to be too far removed from the concrete needs of the sector as a whole, either because the topics to be dealt with are too complex or too technological, or because policy is generally focused on other success criteria for its work (re-election, track record, policy achievements, harmonization, etc.).

The other issue discussed in this context in the workshop was that policy still seems to adopt measures that favour established industrial players, especially telecom operators and big companies, instead of supporting new entrants in the ICT field. Thus regulations seem to prolong the privileges of established players, allowing incumbents to maintain their market dominance, thus hampering innovation.

Suggested policy actions

In the external expert workshop, the following policy actions were suggested to overcome this barrier:

- Digital 'boot camps' for politicians in order to increase ICT knowledge in politics
- Policy has to be digital by design
- Regulatory convergence is required, cross-check between regulatory areas
- Enable experiments instead of calculating expected impacts and trying to quantify the effects of technologies
- The European Commission is not (just) the Chamber of Commerce for Europe. Policy outcomes must not only be measured in terms of higher profits for firms (or tax revenues). Profitability as the only way to measure economic success is a short-sighted strategy. Especially when established players are supported and winners are picked, the result will be a cartel-like situation which may be highly effective and which will by definition extract more from a given market. However, this scenario prevents change, innovation and a dynamic and competitive market. Thus the EU needs to balance economic, societal and environmental outcomes. This is very important for industries such as the software sector, where the money earned in the industry is not directly proportional to the value created by the industry.

Economic and social impacts

The suggested policy actions concern two different but interconnected issues: Increasing ICT knowledge in the policy area (politicians, public administration decision-makers, regulators, etc.) and balancing the interests of incumbents and newcomers as well as, more generally, balancing economic, societal and environmental issues.

The effects of better informed policy decisions in the ICT field are undisputed. More adequate decisions on how to regulate the ICT market, on what to support in the field of R&D, and on what strengths to focus on will certainly lead to more innovation, faster growth and a higher level of competitiveness in the European Union. Also, the social impacts would be enormous, as this would lead to the creation of a whole range of new services in the fields of traffic, energy, public administration, health, education, etc.

However, not only policy-making in a narrow sense is of relevance here, but the entire policy cycle needs to be considered, from policy formulation through policy negotiation to decision-making and the implementation of measures. It is thus not enough to teach politicians the basics of ICT. Instead, all players in the policy cycle

need to become better informed about ICT and generally focus more on ICT-related issues.

Looking at the impressive list of current initiatives at EU level in the field of ICT, there certainly is no lack of ICT-related initiatives, action plans, directives or related research funding. Whether or not all these initiatives are efficient (e.g. yielding the desired results) obviously remains to be seen. However, this seems to be a question of implementation rather than of concept and decision-making.

In addition, the notion that more ICT knowledge in policy-making will automatically lead to the "right" decisions being taken seems to be technocratic to a certain extent. As in all complex systems, there is not one single correct and adequate way to success. Instead, many different strategies are possible. This is also true for the second topic in this area, the balancing of the interests of incumbents and newcomers.

The discussion on protecting national or European champions vs. encouraging new entrants is not new.[58] However, the rigidity of stating negative impacts of closed markets ("walled gardens") and incumbent support has been questioned in the wake of current developments in the software and Internet economy. The situation in the digital age does not seem to be as clear-cut as it used to be. For example, incumbent telecommunications operators in many European countries are important innovators in the ICT field. The 2010 report calls telecom operators "ICT powerhouses" that strongly leverage ICT in Europe (2010 report, p. 26). The report lists more than 12 innovative market activities by telecom operators in Europe, innovation activities ranging from IT and Web services to mobility services, M2M services, Internet of Things, cloud computing, online games to social Web applications (see 2010 report, p. 36ff).

On the other hand, important Internet companies are US-based (Google, Apple, Amazon, Facebook and others). Although some of them maintain closed platforms and restrict the use of hardware, they are considered highly innovative and they are very successful in their markets.

All in all, this means that the regulatory situation has grown very complex and easy answers are not available anymore. In fact, regulators need to decide on a case-by-case basis and make their assumptions transparent instead of following clear-cut principles that are apparently no longer valid.

[58] See, for example: Freeman, Christopher (1991): Networks of innovators: A synthesis of research issues. In: *Research Policy* 20, 499–514, Beyer, Jürgen (2006): *Pfadabhängigkeit. Über institutionelle Kontinuität, anfällige Stabilität und fundamentalen Wandel*. Frankfurt/New York: Campus, Braun, Viktor; Herstatt, Cornelius (2008): The Freedom-Fighters: How incumbent corporations are attempting to control user-innovation. In: *International Journal of Innovation Management* 12(3), 543–572, Dolata, Ulrich (2014): Märkte und Macht der Internetkonzerne. Konzentration, Konkurrenz, Innovationsstrategien. SOI Discussion Paper 2014-04. Stuttgart: Institut für Sozialwissenschaften, Organisations- und Innovationssoziologie.

Summary

Policy measure	Economic impact	Societal impact
7. Introduce digital know-how in politics	++	+

8. Increase public R&D spending in the ICT area

Short description of the related barrier: "Not enough R&D"

Research and development is considered a key factor for the thriving of a genuinely European software industry. Due to its knowledge-based nature and the breadth of the application spectrum, software-developing companies as well as publicly funded research institutions need to invest in new developments and in combining knowledge to develop new successful applications. R&D spending in Europe is substantially lower than in other countries. Spending on R&D in the US exceeds European spending even when the R&D expenditure of the five biggest software and Internet companies in the United States of America is not considered.

Additional expert input

- Not enough R&D spending by enterprises, but also lack of continuous public support for R&D activities, e.g. research programmes are of limited duration. In some cases it is thus not possible to continue potentially successful research.

Suggested policy actions

In the external expert workshop, the following policy actions were suggested to overcome this barrier:

- Partnerships between universities and businesses
- Users and providers are to improve their communications

In addition, the 2010 study suggested the following policy actions:

- Shift focus of financial support to SBIS-related projects in FP
- Ease access for SMEs to the ICT Framework Programme fund
- Set up thematic networks to connect national clusters
- Harmonise tax incentives for R&D so that all European SMEs can profit from tax relief for R&D activities
- Increase support for knowledge transfer from research to commercial applications in the field of SSBS. One option is to start initiatives to establish specific networks for knowledge transfer, another is to promote cooperation in public-private partnerships.

Economic and social impacts

The economic and social impacts of increasing R&D spending in Europe are well documented in the 2010 report (see p. 154-170). The 2010 report identifies the following impacts:

The reallocation of research funds of the European framework programme to topics of software and software-based services will increase the output of European R&D in general. This will expand the market as new customers start demanding the respective services as a result. An increase in research funding will also lead to an increase in the employment of researchers in the ICT area. Moreover, more R&D is likely to lead to more commercially viable innovations. To the extent that these are produced in Europe, employment in companies in the software and software-based services sector will rise. On the other hand, digitisation may lead to job losses in other parts of the economy.

In general, an increase in R&D funding for ICT is likely to increase productivity throughout the economy as businesses become more productive by using the new software and IT services. This will accelerate growth – at least until a new equilibrium level of output has been reached.

Concerning Europe's competitiveness at an international level, the 2010 report is positive that an increase in R&D spending levels in Europe will result in a closing of the gap between the EU and major competitors such as the United States of America and Japan: "Over time, higher research output will result in an increased number of innovative software and Internet services being brought to market. If they are brought to market by European firms, this improves their competitiveness vis-à-vis their international competitors. However, if production of new SBIS is carried out by European firms, but outside the EU, this does not increase the competitiveness of the EU overall" (2010 report, p. 165).

Opening research funding programmes in Europe especially for SMEs will result in more innovation activities on the part of these enterprises. This could lead to an increase in the size of the software and IT services market if additional demand is directed towards these services. However, the overall effect on innovation depends on the relative productivity of research undertaken by SMEs and larger companies. If SME research replaces more productive research by non-SMEs, the impact of innovation will be reduced in relation to the status quo. SMEs as a group are less mobile internationally than larger companies, so the employment effect within the EU is likely to be greater if more ICT innovations are produced by SMEs (see 2010 report, p. 168).

Concerning the social benefits of increasing relevant R&D, the 2010 report lists positive effects in the areas of health service delivery, smart mobility, access to public administrations, better social inclusion due to easy-to-use solutions for mobile devices, more effective and enriching forms of learning, and better access to education in general (see 2010 report, p. 166).

Summary

Policy measure	Economic impact	Societal impact
8. Increase public R&D spending in the ICT area	++	++

9. Roll out high-speed broadband networks

Short description of the related barrier: "Not enough broadband"

There is still not enough broadband Internet capacity available in Europe – both in fixed or mobile networks, and in urban or rural areas. As capacity requirements have increased, especially for bandwidth-intensive cloud services and media-intensive applications, broadband availability has become a main factor for the success of new software applications. The availability of broadband Internet includes the possibility for new, small Internet companies to offer their services on the Internet without being charged extra by big network operators (network neutrality).

Additional expert input

- Lack of bandwidth inhibits innovation

Suggested policy actions

In the external expert workshop, the following policy activity was suggested to overcome this barrier:

- Encourage investment in broadband infrastructure

In addition, the 2010 study suggested the following policy action:

- Promote efficient use of the radio spectrum

Economic and social impacts

Although the impacts of high-capacity Internet connections can only be determined in an indirect and mediated way, it is striking that there are many studies available that calculate and assess the respective economic and social impacts. There are studies by economic think tanks like IW Consult in Germany[59], by governments like the UK[60], by companies like Ericsson[61], or by organisations like the United Nations[62]

[59] Baal, Sebastian van; Beckert, Bernd; Bertenrath, Roman et al. (2016): Der Weg in die Gigabitgesellschaft. Wie Netzausbau zukünftige Innovationen sichert. Eine Studie der IW Consult unter Mitwirkung des Economica Instituts für Wirtschaftsforschung und des Fraunhofer ISI im Auftrag des Vodafone Instituts für Gesellschaft und Kommunikation. Juni, http://www.vodafone-institut.de/de/studie/wege-die-gigabit-gesellschaft-neue-studie-des-vodafone-instituts/

[60] SQW (2013): The UK Broadband Impact Study. www.gov.uk/government/uploads/system/uploads/attachment_data/file/85961/UK_Broadband_Impact_Study_-_Literature_Review_-_Final_-_February_2013.pdf

[61] Ericsson (2013): Socioeconomic effects of Broadband Speed, http://www.ericsson.com/res/thecompany/docs/corporate-responsibility/2013/ericsson-broadband-final-071013.pdf

that try to trace the impacts of better Internet connections in a wide spectrum of application fields.

Concerning economic impacts, the 2016 study by IW Consult estimates that an increase of 1% in the number of optical fibre Internet access points will result in an increase in German GDP of 0.002%. Other studies emphasise the contributions to overall connectedness, to innovation activities and competitiveness.

The social impacts of increased broadband coverage are also discussed. For example, the study by Ericsson mentions social effects due to better access to services, improved healthcare, and higher personnel productivity due to more flexible work arrangements or better access to educational services.

Generally it can be said that broadband Internet access is a catalyst for transformation. By connecting people to each other and to vital information and services, broadband can create opportunities that yield social and economic benefits for communities, businesses, schools, hospitals, and families.[63]

Although not ranked very high in the list of necessary policy measures in the 2010 report, broadband is considered an important prerequisite for the development of the software and IT services sector: "For several new applications such as smart homes or Internet of things, a highly reliable and fully developed broadband network infrastructure is required (…). These functionalities also require more high-speed broadband as is available at the moment in the most developed areas (above 50 Mbits/s). A lack of high speed broadband infrastructure in Europe would prevent the adaption of these technologies and impact the development of new services in the context of the Internet of services and finally lead to a lagging-behind of European SBIS companies." The report concludes: "Therefore, the build-up of next generation fixed and mobile networks (infrastructure and services) will be a crucial milestone to make Europe the leading area in the use of the new services and enable European SBIS providers to take a leading position" (2010 scenario report, p. 279f).

Summary

Policy measure	Economic impact	Societal impact
9. Roll out high-speed broadband networks	+++	+++

[62] United Nations Development Programme (2013): The Broadband Opportunity: The Time Is Now. www.undp.org/content/dam/guyana/docs/The%20Broadband%20Opportunity%20-%20The%20Time%20Is%20Now.pdf

[63] See United Nations Development Programme 2013, p.1.

10. Support open source software in the economy and public administration

Short description of the related barrier: "Not enough support for open source software"

This topic was brought up by the external experts in the workshop in Brussels in April 2016. It was not on the original list of barriers prepared for the workshop. During the discussion it emerged that open source software in its different forms and application models could be seen as an opportunity to develop a unique European strength in the software and IT services area. However, to enable such a development, more support is needed from policy-makers and administrations.

Additional expert input

- Use open source software as an economic strategy (co-production) and not as an ideology, learn from US experiences with integrating open source into working business models
- Conservative end users are not easily encouraged to switch to open source software products

Suggested policy actions

In the external expert workshop, the following policy actions were suggested to overcome this barrier:

- Enhance communication within the developing community as well as with potential users, strengthen the knowledge base and sharing of best practices between enterprises
- Support technologies that help find and use open source software
- Support open source software and reusable commercial software

Economic and social impacts

In the 2010 study, the deployment of open source software, and especially of free/libre open source software (FLOSS) was considered an obstacle for the thriving of a European software industry: "The commoditization of services and software, provided by web offers or through FLOSS solutions is considered to be a possible barrier because it destroys existing revenue models. Especially the shift in the value creation from the producers to third-party service providers is critical because of the unclear mechanism of participation in new revenue models" (2010 report, p. 288).

From today's point of view, this assessment of the impact of open source software seems to be somewhat outdated. There are many examples of successful open source software applications that are commonly viewed as innovation drivers. Also, the commercial impact of open source software is significant.

According to Carlo Daffara, a researcher in the field of IT economics who contributed to several European Commission research projects involving open source, the European economy saves around EUR114billion per year by using open source software solutions. Apart from direct cost savings, other benefits of open

source are reduced project failure and lower cost of code maintenance. The reinvestment of these savings leads to an increase in productivity and efficiency worth at least EUR342billion annually, according to estimates published by the researcher. "Decidedly not a marginal contribution to the European economy", Carlo Daffara said in a press statement.[64] To value the use of open source, data from code reuse surveys was combined with macroeconomic estimates. Quoting several sources, he estimates that about 35 per cent of the software used in the past five years was directly or indirectly derived from open source. To translate this into savings, the researcher draws on estimates of the total value of the IT sector. Industry groups and analysts estimate this to be between EUR374billion and EUR399billion.

Especially in the context of IT diffusion in application areas, open source software plays an important role, not least because European companies and organisations are increasingly critical of US software products as mission-critical data is stored and processed outside the EU. In fact, open source software may become one of the key drivers for a genuinely European software industry in the future.

Summary

Policy measure	Economic impact	Societal impact
10. Support open source software in the economy and public administration	++	+

[64] see Gijs Hillenius (2012): Contribution of open source to Europe's economy: 450 billion per year, October, https://joinup.ec.europa.eu/news/contribution-open-source-europes-economy-450-billion-year

8.4. Summary of the ex ante impact assessment

The ex ante impact assessment of policy actions can be summarised in the following top 10 list:

Policy measures	**Economic impact** (low, medium, high)[65]	**Societal impact** (low, medium, high)	**Rank** (based on the level of impact)
Enhance e-skills in Europe	+++	+++	1 (6)
Support the adoption of ICT in the industry and service sectors and remove governance barriers	+++	+++	1 (6)
Roll out high-speed broadband networks	+++	+++	1 (6)
Improve or unleash the entrepreneurial spirit in Europe	+++	++	2 (5)
Remove market fragmentation in the EU for ICT enterprises	+++	+	3 (4)
Ensure or increase trust in cloud computing and IT infrastructures, privacy and security	++	++	3 (4)
Increase public R&D spending in the ICT area	++	++	3 (4)
Support ICT-related SMEs in their effort to grow (capital, marketing know-how, partners, sharing of experiences and best practices)	++	+	4 (3)
Introduce digital know-how in politics	++	+	4 (3)
Support open source software in all sectors of the economy and public administration	++	+	4 (3)

[65] The scale refers to the impacts found in the ex ante assessment and reads as follows: low=+, medium=++, high=+++.

Although this ranking reflects the assessments of the ex ante analysis, it is a preliminary ranking in this study. The reason for this is that the experts in the conducted workshops have created a ranking of their own, highlighting the importance of certain areas compared to others. In the next chapter the project team will present policy initiatives by the European Commission already underway and then complement the preliminary list of policy priorities with the expert assessments from the workshops to present a final list of policy recommendations.

8.5. Initiatives by the European Commission already underway

In this section the project team compares the programmes, initiatives or actions already launched by the European Commission in order to support the development of the software and software-based services sector with the priority list given above.

However, the ongoing European initiatives are not examined in detail. The project team is aware that the different policy initiatives have different purposes, use different instruments, show different levels of formality, have different budgetary weights and are implemented in quite different ways. The intention of this section is merely to name the European initiatives in the selected priority areas and show possible references.

A more detailed list of EC initiatives can be found in chapter 8.1 "Current policy initiatives related to the development of the software industry in Europe".

Policy measures suggested by this study	**Ongoing policy initiatives by the European Commission (in 2016)**
Enhance e-skills in Europe	▪ e-skills strategy for growth and jobs (2012) ▪ Grand Coalition for Digital Jobs (2013) ▪ The European e-Competence Framework (2014) ▪ Promoting digital literacy, skills and inclusion (within Digital Agenda for Europe, 2010)
Support the adoption of ICT in the industry and service sectors and remove governance barriers	▪ "Digitising European Industry" initiative (2016) ▪ Coordination of national initiatives for advanced manufacturing within the "Digitising European Industry" initiative (2016) ▪ Stimulating innovation for European enterprises through the smart use of ICT initiatives (2008-2014) ▪ Future Internet Public-Private Partnership (FI-PPP, 2011)
Roll out high-speed broadband networks	▪ Broadband Europe initiative within the Europe 2020 strategy (2015) ▪ Financing high-speed broadband by the European Fund for Strategic Investments (2015)

Policy measures suggested by this study	**Ongoing policy initiatives by the European Commission (in 2016)**
	▪ Revision of EU state aid rules for the broadband sector (2014) ▪ Actions within the Digital Single Market (DSM) strategy (2015): - Overhaul of telecoms rules - Review of the Satellite and Cable Directive ▪ Promoting fast and ultra-fast Internet access for all (within Digital Agenda for Europe, 2010)
Improve or unleash the entrepreneurial spirit in Europe	▪ Action plan "Entrepreneurship 2020" (2013) ▪ Actions of DG Growth (2014): - Member States Board on Digital Entrepreneurship - The Digital Entrepreneurship Monitor
Remove market fragmentation in the EU for ICT enterprises	▪ Enterprise Europe Network (2007) ▪ Actions within the Digital Single Market (DSM) strategy (2015): - Rules to facilitate cross-border e-commerce - Reducing VAT burdens - Putting an end to unjustified geo-blocking - Enforcing consumer rules - More efficient and affordable parcel delivery - A modern, more European copyright framework ▪ Free flow of data as part of the "Digitising European Industry" initiative (2016) ▪ e-invoicing initiative (2014)
Ensure or increase trust in cloud computing and IT infrastructures, privacy and security	▪ Cloud Computing part of the "Digitising European Industry" initiative (2016) ▪ General Data Protection Regulation (GDPR) in the EU (2015) ▪ Actions within the Digital Single Market (DSM) strategy (2015): - Reinforcing trust in digital services and in the handling of personal data - Proposing a partnership with businesses on cyber security - Strengthening online trust and security (within the Digital Agenda for Europe, 2010) ▪ European Cloud Computing Strategy (2012)

Policy measures suggested by this study	**Ongoing policy initiatives by the European Commission (in 2016)**
Increase public R&D spending in the ICT area	▪ SME Instrument focusing on Open Disruptive Innovation in Horizon 2020 (2014) ▪ FET Open (2009) ▪ Eurostars (2013)
Support ICT-related SMEs in their effort to grow	▪ "Startup Europe Partnership" initiative (2014) ▪ FIWARE Accelerator Programme (2014) ▪ Access to Risk Finance in H2020 (2014) ▪ Web Investors Forum (2015) ▪ Crowdfunding Network (2015) ▪ Coworking Assembly (2015) ▪ Accelerator Assembly (2015) ▪ Small Business Portal (2010, DG ENTR) ▪ Euromentors Association for Digital Entrepreneurs at DG Growth (2014)
Introduce digital know-how in politics	▪ Launching an antitrust investigation into e-commerce (within the Digital Single Market (DSM) strategy, 2015) ▪ Comprehensive analysis of the role of online platforms (within the Digital Single Market (DSM) strategy, 2015) ▪ Strategic Policy Forum on Digital Entrepreneurship by DG Growth (2014) ▪ Study: Doing business in the digital age, by DG Growth (2013)
Support open source software in all sectors of the economy and public administration	▪ OSS Strategy (2014)

Fig. 50: Recommended policy actions vis-à-vis ongoing European policy initiatives

The table only lists policy initiatives started after 2010. It does not claim completeness, but it shows that there are manifold initiatives in all priority areas. As mentioned above, not all initiatives may have the same impact or are equally well-designed or budgeted. However, the list shows that the European Commission has been very active over the past five years in addressing the main issues for the development of the software and software-based services industry. Especially the "Digital Single Market Strategy" started in May 2015 and the 2016 "Digitising European Industry" initiative point into the direction of the consortium's suggested

measures. They reflect the Commission's increased awareness of the need to support the ICT sector and to overcome central barriers.

8.6. Policy recommendations to support the software and IT services sector in Europe

In this section the project team presents the policy recommendations, dividing them into the top 5 and the lower 5 policy recommendations. They are a major result of this study. The Executive Summary of this report only contains the top 5 recommendations. The policy recommendations identify the subject areas that are of special importance for the development of the software and IT services industry in Europe in 2016, and they suggest a set of policy actions in addition to ongoing initiatives by the European Commission.

The policy recommendations are derived from the analysis in six different sections of this study:

1) The analysis of the structure of the software and IT services market;

2) The expert workshop held in Brussels in April 2016, where barriers and policy actions were discussed;

3) The ex ante impact assessment of policy actions;

4) The expert knowledge from the interviews with stakeholders and the in-house development analysis;

5) The discussions of experts at the final conference in Brussels in October 2016, where the project team's policy recommendations were discussed and complemented;

6) Discussions with the European Commission on the current state of initiatives and on assigning different actions to their related flagship initiatives.

All ten proposed policy recommendations can be thematically grouped into three areas: 1) for a more dynamic user landscape; 2) for better framework conditions; 3) focus on enabling factors. The resulting table below lists all 10 policy recommendations in these three areas.

A. For a more dynamic, innovative user landscape
Enhance e-skills in Europe
Support the adoption of ICT in the industry and service sectors
Support open source software
B. For better framework conditions

Remove market fragmentation
Increase trust in cloud computing and IT infrastructures
Introduce digital know-how in politics
C. Focus on enabling factors (spirit, SMEs, broadband and R&D)
Unleash the entrepreneurial spirit in Europe
Support ICT-related SMEs in their effort to grow
Roll out high-speed broadband networks
Increase public R&D spending in the ICT area

Fig. 51: Policy recommendations from the consortium grouped into three areas

In the next section it will be described in more detail what the project team has identified as relevant policy actions. The description takes into account the fact that there are measures by the European Commission already underway to address many of the identified issues. Apart from listing those initiatives, the project team provides additional ways to support the development of the software and Internet industry in Europe. The major inputs for these additional measures were the two expert workshops held in Brussels in April and October 2016, as well as additional research done following the workshops. The ranking of the policy recommendations is the result of bringing together the inputs and insights of the different steps mentioned above. In the first section, the project team will present the top 5 policy recommendations of this study.

The top 5 policy recommendations

Top 5 policy recommendations
1. Enhance e-skills in Europe
2. Support the adoption of ICT in the industry and service sectors
3. Support open source software
4. Increase trust in cloud computing and IT infrastructures
5. Increase public R&D spending in the ICT area

1. Enhance e-skills in Europe

The consortium's no. 1 recommendation is to enhance e-skills in Europe on all levels. E-skills refer to the ability to write code as well as use software and apps in a sophisticated and well-informed way. The issue of Internet literacy and the lack of talented and well-educated ICT experts is a recurring topic in discussions about the future of IT, the software industry and IT services in general. Although the e-skills shortage in Europe is not as dramatic as it used to be thanks to a general increase in e-skills, the topic is recurring and of growing relevance as digital services become more important in all industry sectors as well as in everyday life.

Concerning EU initiatives in the field of e-skills, a wide range of actions and measures is currently underway under the "e-skills for growth and jobs" flagship initiative by DG Internal Market, Industry, Entrepreneurship and SMEs, but also within the Digital Single Market (DSM) Strategy, which addresses e-skills in "Pillar VI: Enhancing digital literacy, skills and inclusion".

Examples of actions within these initiatives are the "Grand Coalition for Digital Jobs"[66], the "European e-Competence Framework"[67], the "e-skills strategy for growth and jobs"[68] or the different actions under the headline "Promoting digital literacy, skills and inclusion.[69]

[66] https://ec.europa.eu/digital-single-market/en//digital-skills-jobs-coalition
[67] http://www.ecompetences.eu/
[68] http://ec.europa.eu/growth/sectors/digital-economy/e-skills_en/
[69] https://ec.europa.eu/digital-single-market/en/our-goals/pillar-vi-enhancing-digital-literacy-skills-and-inclusion

Source: https://ec.europa.eu/digital-single-market/en//digital-skills-jobs-coalition

Fig. 52: e-skills topics and measures by the EC

The latest initiative is the "New Skills Agenda for Europe"[70], which was launched in June 2016. Current EU initiatives both aim at increasing the level of Internet knowledge and user empowerment, which targets the demand side for software services, as well as improving the formal education of software specialists, which targets the supply side of the software and Internet industry. A roadmap developed in the context of the "Digital Skills and Jobs Coalition" shows the different e-skills measures by the European Commission.

Pillar VI of the Digital Single Market Strategy foresees 13 different actions to enhance digital literacy, skills and inclusion (see table below).

[70] http://ec.europa.eu/social/main.jsp?catId=1223

• Action 57: Prioritise digital literacy and competences for the European Social Fund
• Action 59: Prioritise digital literacy and skills in the 'New skills for jobs' flagship
• Action 61: Educate consumers on the new media
• Action 63: Evaluate accessibility in legislation
• Action 65: Help disabled people to access content
• Action 67: Member States are to implement provisions on disability
• Action 126: Grand Coalition for Digital Jobs and Skills
• Action 58: Develop a framework to recognise ICT skills
• Action 60: Increase the participation of women in the ICT workforce
• Action 62: EU-wide indicators of digital competences
• Action 64: Ensure the accessibility of public sector websites
• Action 66: Member States are to implement digital literacy policies
• Action 68: Member States are to mainstream eLearning in national policies

Source: https://ec.europa.eu/digital-single-market/en/our-goals/pillar-vi-enhancing-digital-literacy-skills-and-inclusion#Library

Fig. 53: EU actions under "Pillar VI: Enhancing digital literacy, skills and inclusion" of the Digital Single Market Strategy

Based on the findings from this study, the project team recommends continuing to focus on e-skills in Europe. Especially the approach of including a wide spectrum of stakeholders as embraced by the Grand Coalition for Digital Jobs seems promising. Also, the project team recommend monitoring the success of the measures taken at EU level as well as at national level. In addition to the initiatives already underway, the following actions are recommended:

- Measures beyond formal education: Young and old people are to educate each other; share experiences and skills; enhance lifelong learning; and enable gradual retirement.
- Enhance actions to bridge the gender gap in technological, and especially computer-related studies.
- Support the creation of online communities for the exchange of IT/digital experts across EU countries. This enables young and skilled but jobless people, for example in Spain or Greece, to work for IT companies within the EU from their home countries.

2. Support the adoption of ICT in the industry and services sectors and remove governance barriers

Advanced manufacturing, new data-based business models, digitisation in the energy sector (e-energy, smart grids), e-health, digital mobility services, e-education and e-government are the keywords when describing this policy recommendation. A special focus is currently being placed on the digitisation of industrial production, a topic where Europe with its strong industrial base may take the lead.

The EU is currently very active in supporting the concept of advanced manufacturing (Industry 4.0/industrial IoT) and pushing other sectors to embrace new digital business models and opportunities.

The current flagship initiative is "Digitising European Industry (DEI)"[71] started in 2016, which will also coordinate national initiatives for advanced manufacturing. Also of importance are the initiatives "Stimulating innovation for European enterprises through the smart use of ICT"[72] and the "Future Internet Public-Private Partnership (FI-PPP)".[73]

Under the "Digitising European Industry" initiative, a range of actions are planned or continued that aim at supporting the digitalisation of European manufacturing companies (Industry 4.0/industrial IoT). The initiative bundles different actions (see table below).

• Coordination of European, national & regional initiatives
• Digital innovation hubs
• Regulatory framework
• Public-private partnerships
• Industrial platforms and large-scale pilots
• Skills and training
• Internet of Things
• European Cloud Initiative
• Standards
• eGovernment action plan

Source: https://ec.europa.eu/digital-single-market/en/digitising-european-industry

Fig. 54: "Digitising European Industry" actions

The consortium recommends continuing measures focusing on the adoption of ICT in traditional manufacturing and services sectors. Some of the preliminary policy

[71] https://ec.europa.eu/digital-single-market/en/digitising-european-industry
[72] http://www.technopolis-group.com/?report=evaluation-of-the-eu-initiative-on-stimulating-innovation-for-european-enterprises-through-smart-use-of-ict
[73] https://www.fi-ppp.eu/

recommendations, experts came up with in the workshop in March 2016, featured in the "Digitising European Industry" initiative presented by the European Commission just one month later. Thus the project team recommends pushing forward the measures taken in April 2016 under the "Digitising European Industry" initiative, monitoring their success and refining the strategy according to the achieved outputs.

- In addition, the project team believes that the opportunity for Europe to become the world-leading market goes beyond Industry 4.0/industrial IoT. In fact, the innovative combination of the Internet of Things, big data applications, artificial intelligence and digitalisation in general can become a genuinely European strength. Vis-à-vis the strengths of the USA in software and the strengths of Asia in hardware, Europe's strength lies in the management of complex systems. Software and digital technologies allow the "digital representation" of all kinds of objects and systems. The term "digital representation" means that all physical objects, as well as persons, increasingly have digital twins. Production processes, construction plans, factory organisation as well as personal mobility patterns, health data, shopping habits – more and more processes and characteristics are linked to digital data. An innovative and – as regards personal data – anonymised combination of the various different data sets can lead to new applications with high economic and personal potential. Thus European policy should focus on enabling innovation in the field of digital representation in all application sectors (manufacturing, energy, mobility, health, public administration, education, etc.).

3. Support open source software in all sectors of the economy and public administration

Open source software could develop into a unique strength of the European software and Internet sector if supported adequately. In this area, the flagship initiative by the European Commission is the OSS Strategy by DG Informatics (DIGIT), which has been running since 2000 and was updated just recently [74].

We recommend further exploring ways in which European enterprises can profit from open source software and supporting the adoption in a variety of application fields. In fact, the project team thinks that open source is very well suited to the use in commercial contexts. However, European companies and users do not yet know enough about the commercial use of OSS. OSS is an important component of the future of the European software industry.

In addition to what is already being done by the European Commission, the project team recommends:

- Helping enterprises use open source software as an economic strategy and grasp the opportunities for co-production. Learning from US experiences with integrating open source into working business models.

[74] See http://ec.europa.eu/dgs/informatics/oss_tech/index_en.htm

- Enhancing communication within the OSS developing community as well as with potential users, strengthening the knowledge base and sharing of best practices between enterprises.
- Supporting technologies that help find and use open source software.
- EU institutions should become OSS users themselves, even more than they already are. This would provide relevant use cases, ensure long-term support, and secure high-level quality control.

4. Increase trust in cloud computing and IT infrastructures, privacy and security

Although trust and privacy concerns seem to be less of an issue for the digital natives, IT security and trust do play an important role in the context of industrial use or for SMEs undergoing digital transformation. Thus privacy and security issues in cloud computing as well as on a more general level have been the subject of manifold initiatives by the Commission in recent years.

Relevant initiatives include the European Cloud Computing Strategy (2012), the Cloud Computing part of the "Digitising European Industry" initiative (2016), the General Data Protection Regulation (GDPR) in the EU (2015), and – as the new flagship initiative – the Digital Single Market (DSM) strategy, which includes the following initiatives:

- Reinforcing trust and security in digital services and in the handling of personal data;
- Proposing a partnership with businesses on cyber security; and
- Strengthening online trust and security.

It is also worth mentioning here the Cloud Select Industry Group (CSIG) of the EC.[75]

We recommend continuing these initiatives and monitoring their impacts because they address a major aspect of the successful future of the software and Internet sector.

- One new area of policy activity has been evolving in the context of algorithms determining more and more aspects of daily life. In order to increase the transparency of these decisions and to avoid manipulations by big companies, future regulation should address the issues of big data analytics applications in daily life (e.g. for credit allowances, health

[75] The Cloud Select Industry Group (C-SIG) was established by the Directorate-General for Communications Networks, Content and Technology, Software and Services, Cloud Unit, with representatives from major European and multinational companies and organisations with significant involvement in cloud computing for the purpose of providing independent validation and advice on proposals. Currently, there are three different groups: The Cloud Select Industry Group on Code of Conduct, which is working on a code of conduct for cloud computing providers, the Cloud Select Industry Group on Service Level Agreements, which is working towards the development of standardisation guidelines, and the Cloud Select Industry Group on Certification Schemes, which deals with certification issues for cloud providers. Source: https://ec.europa.eu/digital-single-market/en/cloud-computing-strategy-working-groups.

insurance discounts, etc.), digital opting-out, accountability of automated decisions (e.g. in autonomous driving) and related issues.

5. Increase public R&D spending in the ICT area

We recommend increasing the amount of funding for R&D in the ICT area in order to keep Europe's software and Internet industry competitive. The EC is already funding many R&D projects in this area, for example with the SME Instrument focusing on "Open Disruptive Innovation" in Horizon 2020, under the FET Open and FET Proactive schemes, the ICT Leadership in Enabling and Industrial Technologies (LEIT) work programme under H2020, or with the Eurostars programme. While these initiatives point in the right direction, the project team suggests increasing the support of R&D activities by enterprises and ensuring its continuity. Research programmes and projects have a limited duration. SME R&D projects and the programme logic often do not fully match, especially when it comes to the flexibility of spending and the duration of funding.

Another reason why so few SMEs participate in Horizon 2020 projects is that they assume that participation involves too much administrative work, the chances to win a project are too slim, and there is not enough output from projects. Thus many companies prefer to cooperate directly with universities, sponsoring PhD candidates, for example.

Whereas support of basic research seems to be well covered by the ERC (European Research Council), IT-related engineering projects are clearly underrepresented. And in programmes that do support engineering research, such as the FET (Future & Emerging Technologies) programme, the current oversubscription is discouraging companies from applying. This is why the European Commission should substantially increase research funds for IT research, and especially for new and emerging IT-related technologies. This also applies to the software-related topics in H2020 calls (for example topic ICT10 – "Software Technologies" of ICT-LEIT work programme 2016-17), which are currently among the most oversubscribed. Here the project team sees a clear need for increased investments in public R&D funds for software.

In the next section, the lower 5 policy recommendations will be presented.

The lower 5 policy recommendations

Lower 5 policy recommendations
6. Remove market fragmentation
7. Introduce digital know-how in politics
8. Unleash the entrepreneurial spirit in Europe
9. Support ICT-related SMEs in their effort to grow
10. Roll out high-speed broadband networks

6. Remove market fragmentation in the EU for ICT enterprises

Market fragmentation in Europe was a recurring topic in this study as well as in the discussions in workshops and interviews. Compared to the United States of America, China and other regions in the world with their huge, seemingly homogeneous markets, Europe's fragmentation appears to be one central barrier to ICT market development.

One consequence of the fragmentation is that European companies are forced to focus on the needs of their local customers. Thus they know their customers very well and know how to deal with complexities. While this could be seen as the upside of fragmentation, the downside becomes apparent as soon as companies want to grow within Europe. Here market fragmentation becomes a relevant obstacle.

Fragmentation is considered a highly relevant barrier by the European Commission. This has resulted in many EU initiatives launched in the past few years. Especially the initiatives under the Digital Single Market (DSM) strategy (2015) have to be mentioned here. The related measures and their relevance for the software and Internet industry are, for example[76]:

- **Rules to facilitate cross-border e-commerce:** Many people in Europe remain reluctant to engage in online activities that could improve their daily lives. While 75% of Europeans used the Internet on a regular basis in 2014, only 15% shopped online in another country. Moreover, only 7% of SMEs are engaged in cross-border online sales. To promote cross-border e-commerce, the Commission has updated EU rules (the e-commerce directive), clarified contractual rights, and developed enforcement (cross-border enforcement cooperation). This could help both software companies and Internet service providers to conquer a bigger market and seize growth opportunities.
- **Putting an end to unjustified geo-blocking**: Geo-blocking is a practice used for commercial reasons by online sellers who deny access to websites from other countries. Geo-blocking thus limits consumers' opportunities and

[76] See https://ec.europa.eu/digital-single-market/node/78515

choice, causing dissatisfaction and fragmentation of the market. The Commission is working on prohibiting geo-blocking practices. This will prevent software companies, and especially online retailers, from setting different prices for the same product, for example in Romania and in the UK. Although this will affect their pricing models, in the long run it will strengthen consumers' trust in the Internet economy as it ensures that all consumers in Europe are treated equally.

- **Other measures** in this package are to enforce consumer rules, to launch an antitrust investigation into e-commerce, to design a modern, more European copyright framework, to review the Satellite and Cable Directive, and to reduce VAT burdens.

Also of relevance is the "Free flow of data" part of the "Digitising European Industry" initiative (2016) and the e-invoicing initiative (2014), which aim at making it easier for software and Internet companies to use data in a uniform way and at reducing administrative burdens in their daily cross-national dealings.

All these initiatives aim at overcoming fragmentation obstacles, which affect the software and Internet industry more strongly than other industries because of the inherently transnational character of its business. It would be an interesting task to relate the different measures taken by the European Commission to the specifics of the software industry and to assess the impacts of the measures. Unfortunately, this cannot be done in the framework of this study, but it remains a topic for further analysis.

Interestingly enough, all the policy measures discussed in this study's expert workshop as well as in the 2010 study are currently being addressed by EU initiatives, some of which were presented above. This does not mean, though, that there is no longer a need to keep fighting against market fragmentation. Rather, it indicates that the problem of market fragmentation is well understood and has become a priority for the Commission. The consortium suggests maintaining the high level of pressure to address this obstacle and monitoring its progress.

7. Introduce digital know-how in politics

In order to enhance the quality of decision-making in the ICT field, the consortium recommends developing strategies that improve the level of ICT knowledge. In fact, looking at the impressive list of current EU initiatives in the ICT area, it can hardly be said that there is a lack of ICT-related initiatives, action plans or related research funding. And as mentioned above, many EU initiatives, especially the most recent ones (Digital Single Market initiative and Digitising European Industry), are actually addressing many of the barriers identified in this study.

In addition to these measures to enhance expertise, the consortium recommends the following:

- Policy should be "digital by design".

- Regulatory convergence is required; there need to be better cross-checks between the different regulatory areas.
- Policy outcomes should not be measured by economic success alone. Economic, societal and environmental outcomes must be better balanced. This is very important for industries like the software industry, which is an enabler industry, helping other sectors to become more effective and profitable and also to achieve societal goals like better healthcare services, sustainable energy provision or multimodal traffic.

This recommendation is actually quite general, addressing regulatory as well as policy-making issues that impact SSBS, but only in an indirect way. However, following these recommendations would result in a higher priority of software and Internet-related issues and would enhance policy outcomes related to SSBS.

8. Unleash the entrepreneurial spirit in Europe

As regards the entrepreneurial spirit and the number of start-ups in the ICT area, Europe is perceived to be still lagging behind other regions, especially the United States of America. The European Commission addressed this issue in several initiatives, for example in the "Entrepreneurship 2020" action plan (2013), in the initiatives "Member States Board on Digital Entrepreneurship" and "The Digital Entrepreneurship Monitor" (2014) by DG Growth, and in the Start-up Europe initiative. The project team recommends broadening initiatives aiming at a change in attitudes towards entrepreneurship and at supporting those who are entrepreneurial pioneers. In addition, the project team suggest the following activity:

- An information campaign focussing on genuinely European software could start in schools and then be extended to address a broader audience. The aim is to communicate European strengths and show success stories of software-based firms, products and services from Europe.

9. Support ICT-related SMEs in their effort to grow

As innovative SMEs are still finding it difficult to grow into bigger firms, the project team recommends continuing and extending initiatives that help SMEs in their effort to be successful in larger markets.

At EU level, there are already many initiatives addressing this problem. The most recent are the "Startup Europe Partnership" initiative (2014), the FIWARE Accelerator Programme (2014), the Access to Risk Finance in H2020 (2014), the Web Investors Forum (2015), the Crowdfunding Network (2015), and the Euromentors Association for Digital Entrepreneurs at DG Growth (2014). In addition to the existing initiatives, the project team recommends the following:

- R&D projects should focus on SMEs' needs. In many cases, SMEs are highly innovative, conducting internal and cooperative software development projects. However, they often do not have sufficient financial resources to

successfully conclude these projects because they have to meet short-term expectations concerning profitability. R&D funding by the EU could make a difference here.

- Enhance practical orientation and the communication of best practices. More test beds, pilots, demonstrations to showcase new technologies, esp. to SMEs.
- Support co-creation and creativity in software development procedures.
- Support software companies in their attempts to address markets outside the EU, including the U.S. The aim is not to help them relocate their business, but to enter foreign markets. Especially when being successful in the United States, software firms often get credited for their success back at home in Europe.

10. Roll out high-speed broadband networks

Although the situation concerning broadband availability is very diverse in Europe, this aspect is considered a central success factor for the software and Internet industry. A main focus have to be rural areas and connections with low latency (industry-relevant qualities of Internet connections). The rollout of fibre-based, high-speed Internet connections should be one of the main concerns of the European Commission as it provides the foundation for the success of the European software and Internet industry.

Thus the project team recommends increasing the level of initiatives by the European Commission in this area, focusing especially on the deployment of fibre-based networks in rural areas and on enabling industry-relevant quality-of-service features like low latencies.

The current initiatives in this area are very important. They include, for example:

- Connectivity for a European Gigabit Society[77] within the DSM initiative (2016)
- Broadband Europe initiative under the Europe 2020 strategy[78] (2015)
- Financing high-speed broadband by the European Fund for Strategic Investments[79] (2015)
- Revision of EU state aid rules for the broadband sector (2013)[80]
- Initiatives within the Digital Single Market (DSM) strategy (2015):
  - Overhaul of telecoms rules
  - Review of the Satellite and Cable Directive
- Promoting fast and ultra-fast Internet access for all (part of Digital Agenda for Europe, 2010)

[77] https://ec.europa.eu/digital-single-market/en/connectivity-european-gigabit-society
[78] https://ec.europa.eu/digital-single-market/en/broadband-europe
[79] https://ec.europa.eu/digital-single-market/en/financing-broadband-project
[80] https://ec.europa.eu/digital-single-market/en/news/handbook-decision-makers-broadband-state-aid-rules-explained

In addition, it has to be mentioned that in the current work for a European Electronic Communication Code (EECC)[81], aiming at 100 Mbit/s connections is very helpful as it defines fibre-based networks as a universal goal for all European broadband initiatives.

The DSM initiative "Connectivity for a European Gigabit Society", which was adopted on 14 September 2016, is of particular relevance in this context. The gigabit initiative comprises a series of measures and legislative proposals intended to improve Internet connectivity in the EU.

• A new rule book for providers of Internet access and communication services – the European Electronic Communications Code
• Common EU broadband targets for 2025
• A plan to foster European industrial leadership in 5th-generation (5G) wireless technology
• A support scheme for public authorities that want to offer free Wi-Fi access to their citizens

Source: https://ec.europa.eu/digital-single-market/en/connectivity-european-gigabit-society

Fig. 55: Measures of the "Connectivity for a European Gigabit Society" initiative

While the list of current EU initiatives is impressive, many decisions are made at national level. The EC should encourage national governments to do more in this area. The challenge is to push national governments while at the same time providing a European regulatory framework that is flexible enough to allow member states to set up their own strategy, addressing country-specific issues. Furthermore, broadband connectivity is a continuous issue that cannot be considered done once 50 Mbit/s have been achieved, for instance. There are always next steps, new generations of network technology that need to be dealt with in order to keep up with the competition. This is why policy-makers need to constantly address the issue of broadband connectivity.

Broadband networks are of special relevance for SSBS not only because of the increasing demand for cloud and IoT services. They also provide the foundation for the connectivity of users who need high-speed Internet access (fixed or mobile) in order to be able to buy, use and consume software and Web-based services. And the vast base of high-speed Internet users, in turn, encourage software companies to innovate in order to offer a constantly evolving array of online services.

[81] https://ec.europa.eu/digital-single-market/en/news/proposed-directive-establishing-european-electronic-communications-code

9. Options for Future Research

This study provides an extensive overview of the current and expected future growth and structure of the European software and IT services market, carves out the economic and social impact of the European software and services industry, identifies and describes the key drivers for the industry's growth and competitiveness, takes a specific look at the extent and role of in-house software development, and derives policy recommendations to remove barriers and foster the development of the European software industry. However, due to time and budget restrictions, the study cannot cover each and every interesting aspect related to the project team's research. The consortium recommends covering the following research activities in the future:

- The cloud computing segment described in the segmentation directly corresponds to the 'paid web-based (PWB)' segment of the previous study or, in other words, to the 'software-based Internet services' segment, excluding online advertising. Due to restrictions of time and budget, the consortium does not cover online advertising in this mission. However, this could be an interesting market segment for further analysis.
- In-house software development is a trend significantly gaining in traction in European companies, as described above. However, the project team's analyses on the factors impacting make-or-buy decisions were largely based on selected insights from the expert interviews conducted in selected industries and countries. Although interesting insights were gained, the project team recommends a representative B2B survey across several European countries in order to deep-dive into this topic.
- Potential challenges or opportunities for software developers were not covered by this study. However, it might be interesting to see how the developments around software as a service or DevOps, for example, are changing the approaches and requirements of software developers.
- A more comprehensive view on the developments in the games market would be beneficial. This regards its segmentation, growth trends, and country-specific analyses. So-called "serious games" are, for example, rapidly gaining in importance in the business area in particular, e.g. for training activities or the visualisation of prototypes. Thus the games market is worth taking a more detailed look.
- The project team has highlighted that a new area of policy activity is evolving in the context of algorithms determining more and more aspects of daily life. In order to increase the transparency of automated decisions and to avoid manipulations by big companies, we recommend that future regulation should address the issues of big data analytics applications in daily life (e.g. for credit allowances, health insurance discounts, etc.), digital opting-out, accountability of automated decisions (e.g. in autonomous driving) and related issues. In order to be more specific and to identify concrete policy needs, further research is necessary.
- The project team's method of identifying policy measures to support the development of SSBS in Europe included analysing ongoing initiatives by the

European Commission: For each policy area of relevance the project team identified the EC policy measures, initiatives and programmes that are already underway, followed by an assessment on whether or not a particular activity may be suited to support the future development of SSBS. Due to the broad spectrum of current measures, this assessment was rather generic, as it could not include all the specific sub-measures, the assigned budgets, the planned implementation process, and the full range of possible impacts. To improve the assessment of specific measures it would be necessary to carry out an implementation study analysing all aspects of the policy measures taken. Thus, in a future study, the project team suggests taking a closer look at the implementation of the policy measures listed in the respective table in section 8.5 (Initiatives of the European Commission already underway). This would allow the Commission to gain a systematic overview of the extent to which its measures are well targeted and well implemented, and which have the highest impacts.

10. Annex 1: PAC's SITSI® Research Methodology

SITSI®[82] stands for Software and IT Services Industry and is the umbrella brand for all off-the-shelf studies published by Pierre Audoin Consultants (PAC). Since its launch in 1992, SITSI® Research has evolved into a unique and comprehensive online research source on local markets and their respective players across the globe.

SITSI® provides data, analyses and recommendations to enable you to better understand the changes in ICT markets and technological environments. Comprising more than 2,000 documents based on a huge collection and detailed analyses of market and company data, SITSI® Research is organized around two pillars:

- Market Analysis
- Vendor Analysis

Both are analysed by geography, by vertical industry sectors, by software & IT services and by horizontal offerings & hot topics.

In-depth analysis of local markets is at the heart of our research and results in the PAC Reference Model. This detailed, multidimensional analysis drives our unique bottom-up approach, enabling us to provide a granular and reliable global market view.

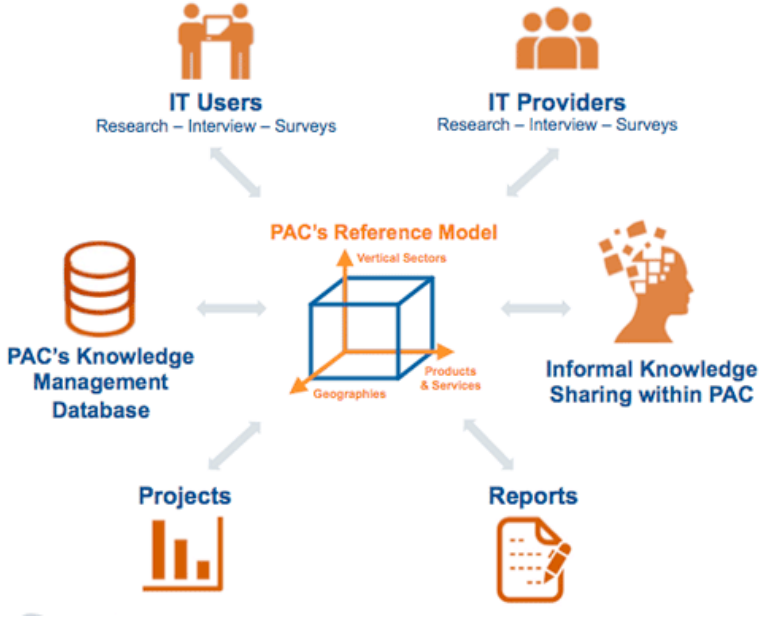


Fig. 56: PAC's reference model

[82] To view a detailed description of PAC's methodology, see: https://www.pac-online.com/sites/pac-online.com/files/upload_path/PDFs/PAC_Market_Model.pdf

Thousands of mostly face-to-face interviews with decision makers from both IT users and IT suppliers, complemented by more than a hundred surveys each year and an efficient research organization, build the basis of our knowledge.

Through a tried-and-tested recurring process of bottom-up and top-down assessment and validation, supported by both our knowledge management database and regular dialog and workshops among our global team of analysts, we make sure we leverage the comprehensive knowledge built from all our projects and reports.

We segment the IT market as follows:

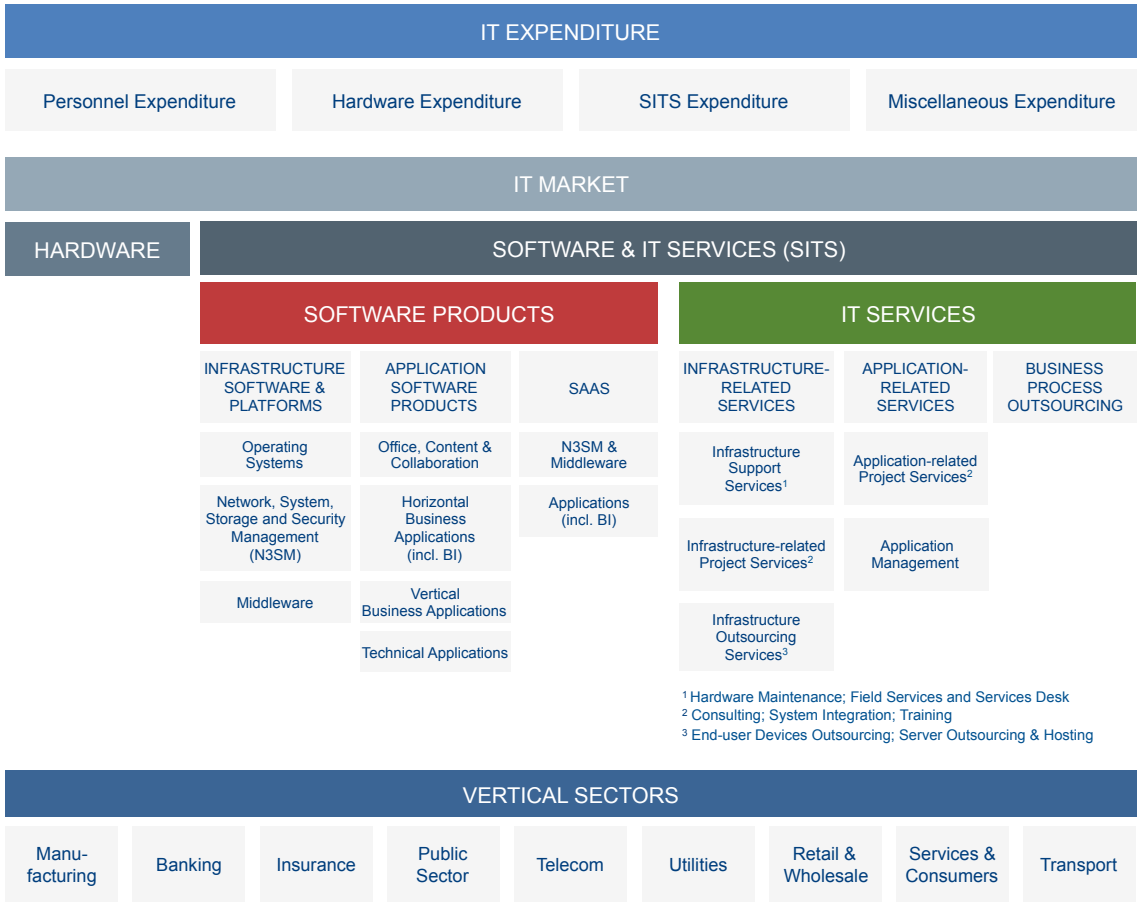


Fig. 57: PAC's market segmentation

11. Annex 2: Interview Guide Used for Expert Interviews

To analyse the in-house software development activities of European companies, the project team conducted semi-standardized expert interviews based on the following interview guide:

- Company demographics (number of employees, industry, position of interviewee)
- Is your company developing software on its own?
- If so: To **what extent**? // If not: **Why not**?
- If so: In **what areas**? Why there?
- What are the **driving factors** for in-house development in your company? (e.g. none of the software available meets the company's needs / software development is an integral part of the company's product & portfolio strategy / specific requirements due to the digital transformation trend / business or competitive pressure / need to differentiate through innovativeness / "everybody does it in our industry")
- What are the **benefits** of in-house development for your company? (e.g. faster time to market, delivery of new and innovative products & services, increase in competitiveness)
- What are the **challenges** of in-house development (availability of experts, labour costs, skills of the workforce)?
- Will the share of in-house development be **increasing/declining** over the next 2 years?
- Do you use a **cloud platform** for your in-house software development activities?
- Do you use **open source** software for it? Challenges? (legal aspects? licensing aspects? quality aspects?)
- Does your company **collaborate with external partners** for in-house SW development projects? Will this increase/decrease in the future? Why?
- How much of your in-house development is done **within the EU**?
- How would your company benefit if the EU were to support the development of the software market within the EU?
- As background information: How would you rate your company's **status of digital transformation** (impact of trends such as mobility, IoT, big data, analytics, etc.)?
- Do you know how much in-house software development is done **in your industry in general**? Tendency?

12. Annex 3: Policy Initiatives of the European Commission with Relevance to the Software and Internet Sector

Name of the program, measure, action plan, etc.[83]	Year started/ adopted/ agreed upon	Topics covered
Digital Single Market (DSM) Strategy, Topic 1: Access for consumers and businesses to online goods and services across Europe Source: https://ec.europa.eu/digital-single-market/en/access-digital-single-market	6 May 2015	**- Rules to facilitate cross-border e-commerce** To enable cross-border e-commerce to flourish, the Commission will update EU rules (e-commerce directive), clarify contractual rights, and develop enforcement (cross-border enforcement cooperation). **- Enforcing consumer rules** The Commission will review the Regulation on Consumer Protection Cooperation. **- More efficient and affordable parcel delivery** The Commission will launch measures to improve price transparency on the delivery market and enhance regulatory oversight of parcel delivery. **- Putting an end to unjustified geo-blocking** The Commission will make proposals on how to put an end to unjustified geo-blocking, which limits consumers' opportunities and choice to buy in other countries. **- Launching an antitrust investigation into e-commerce** The Commission launched a Competition Sector Inquiry to identify potential competition concerns affecting European e-commerce markets. **- A modern, more European copyright framework** The Commission will propose modernised rules to reduce national discrepancies, encourage wider access, promote cultural diversity and ensure that everyone respects the rules of the game. **A review of the Satellite and Cable Directive** The Satellite and Cable Directive will be reviewed to assess if its scope needs to be enlarged to include broadcasters' online transmissions and to explore how to boost cross-border access to broadcasters' services in Europe. **- Reducing VAT burdens** Companies trying to trade across borders face the obstacle and complexity of different VAT systems. The Commission will propose cutting this burden – for example through a single interaction point, a common threshold, and simpler, single audits.

[83] Disclaimer: This is an indicative, non-exhaustive list of relevant EU policies based on the opinion of the consortium.

Name of the program, measure, action plan, etc.[83]	Year started/ adopted/ agreed upon	Topics covered
Digital Single Market (DSM) Strategy, Topic 2: Environment for digital networks and services to flourish thanks to high-speed, secure and trustworthy infrastructures and services supported by the right regulatory conditions Source: https://ec.europa.eu/digital-single-market/en/environment-digital-single-market	6 May 2015	**- Overhaul of the telecoms rules** The Commission proposes improving spectrum coordination and spectrum assignment at national level, creating incentives for investment in high-speed broadband, ensuring a level playing field for all market players and creating an effective institutional framework. **- Comprehensive analysis of the role of online platforms** The Commission will tackle issues of transparency, use of information (i.e. the right to be forgotten), relationships between platforms and suppliers, and how to deal with illegal content on the Internet. **- Reinforcing trust and security regarding digital services and the handling of personal data** The new EU data protection rules, to be agreed by the end of 2015, will be the basis for a review of the e-privacy directive. **- Proposing a partnership with businesses on cyber security** The public-private partnership on cyber security will focus on technologies and solutions for online network security. **- Review of the audiovisual media framework for the 21st century** Adapting the Audiovisual Media Services Directive to new business models for content distribution.
Digital Single Market (DSM) Strategy, Topic 3: Economy & Society. Maximize the growth potential of the European digital economy and of society Source: https://ec.europa.eu/digital-single-market/en/economy-society-digital-single-market	6 May 2015	**- Proposing a European free flow of data initiative** The Commission will tackle restrictions on data location and access to encourage innovation. **- Proposing a European Cloud Initiative** The European Cloud Initiative aims at building trust and confidence in cloud computing in Europe and includes: • **Europe-wide certification**, including elements of network and • information security; • Provisions for **personal data protection**; • **Service level agreements**; • **Interoperability and data portability**; • **Contractual terms and conditions**; • The prospect of a **European cloud services**

Name of the program, measure, action plan, etc.[83]	Year started/ adopted/ agreed upon	Topics covered
		capability and the establishment of a European Research Open Science Cloud. The initiative relates to several other actions of the Digital Single Market strategy, such as harmonised rules for online purchases, standards and interoperability, and builds on the Commission's experience with the implementation of the September 2012 European Cloud Computing Strategy. **- Defining priorities for standards and interoperability** The Commission will concentrate on standards and interoperability in areas critical to the Digital Single Market, such as health, transport, planning and energy. **- Supporting an inclusive digital society** An inclusive digital society is one where citizens have the right skills to seize the opportunities of the digital world and boost their chance of getting a job. A new e-government plan will also connect business registers across Europe, and ensure that different national systems can work together and that businesses and citizens have to provide their data "only once" to public administrations.
Digital Agenda for Europe. Driving European growth digitally, as part of "Europe 2020" Source: https://ec.europa.eu/digital-single-market/en/europe-2020-strategy	19 May, 2010	**- Achieving the digital single market** See Digital Single Market Strategy above. **- Enhancing interoperability and standards** Enhancing interoperability of devices, applications, data repositories, services and networks. For this purpose, it is essential that the Commission continues the review of its policy on setting standards. It will also promote appropriate rules for intellectual property rights. **- Strengthening online trust and security** Strengthening Europe's policy to combat cyber crime, child pornography and breaches of privacy and personal data security. The Commission took measures on network and information security and the fight against cyber attacks. **- Promoting fast and ultrafast Internet access for all** Europe needs competitively priced fast and ultrafast Internet access for all. To achieve this, the EU must establish next-generation access networks (NGAs). Via different instruments, the Commission is channelling some of its public funds into broadband infrastructure. **- Investing in research and innovation**

Name of the program, measure, action plan, etc.[83]	Year started/ adopted/ agreed upon	Topics covered
		Europe invests in world-class ICT research and innovation in order to boost growth and jobs via innovative public-private partnerships and by exploiting the opportunities available through Horizon 2020 research funding programs. We aim at catching up with our main competitors in ICT research and digital innovation. **- Promoting digital literacy, skills and inclusion** In order to promote employment in the ICT field, and in jobs which require digital skills, the Commission created the Grand Coalition for Digital Jobs and Skills in 2013. This is a multi-stakeholder partnership that endeavours to facilitate collaboration among business and education providers, public and private players to attract young people to ICT education and to retrain unemployed people. **- ICT-enabled benefits for the EU society** The EU must exploit the potential offered by the use of ICT in the areas of climate change, managing ageing populations through e-health and telemedicine systems and services, digitalisation of content through Europeana, and intelligent transport systems.
General Data Protection Regulation (GDPR) in the EU Source: http://europa.eu/rapid/press-release_IP-15-6321_en.htm	27 April, 2016	The new rules give individuals more control over their personal data. Most notably, this includes: **- Easier access to your own data:** Individuals will have more information on how their data is processed, and this information should be available in a clear and understandable way. **- A right to data portability:** It will be easier to transfer your personal data between service providers. **- A clear "right to be forgotten":** If you no longer want your data to be processed, and provided that there are no legitimate grounds for retaining it, the data will be deleted. **- The right to know when your data has been hacked:** For example, companies and organisations have to notify the national supervisory authority of serious data breaches as soon as possible so that users can take appropriate measures. The new rules are also relevant for enterprises. By unifying Europe's rules on data protection, lawmakers are creating business opportunities and encouraging innovation. According to the EU, the advantages are: - **One continent, one law**: The regulation will establish one single set of rules, which will make it simpler and cheaper for companies to do business in the EU. **- One-stop shop**: Businesses will only have to deal with one single supervisory authority.

Name of the program, measure, action plan, etc.[83]	Year started/ adopted/ agreed upon	Topics covered
		- European rules on European soil: Companies based outside Europe will have to follow the same rules when offering services in the EU. **- Risk-based approach**: The rules will avoid a burdensome one-size-fits-all obligation and take into account the respective risks. **- Rules fit for innovation**: Data protection by design and privacy-friendly techniques such as pseudonymisation will be encouraged to reap the benefits of big data innovation while protecting privacy.
European Cloud Computing Strategy Source: https://ec.europa.eu/digital-single-market/en/european-cloud-computing-strategy	27 Sept, 2012	A report on the implementation of the European Cloud Computing Strategy was published in July 2014 as a Staff Working Document accompanying the Data-driven Economy Communication. The strategy included the following three key actions: **1.Safe and fair contract terms and conditions** Identifying and disseminating best practices for model contract terms. One of the deliverables of this key action is the Service Level Agreement Standardisation Guidelines by the C-SIG SLA Subgroup. https://ec.europa.eu/digital-single-market/en/news/cloud-service-level-agreement-standardisation-guidelines **2.Cutting through the jungle of standards** The Cloud Standards Coordination (CSC) Phase 1 took place in 2013 and primarily addressed the cloud computing standards roadmap. In December 2013, the results were publicly presented in a workshop organised by the EC. The CSC Final Report is available online. The Commission was supported by the European Union Agency for Network and Information Security (ENISA) and other relevant bodies in developing EU-wide voluntary certification schemes and establishing a list of such schemes by 2014. **3.Establishing a European Cloud Partnership** The European Cloud Partnership (ECP) brought together businesses and the public sector to work on common procurement requirements for cloud computing in an open and fully transparent way. The ECP Steering Board has also published the Trusted Cloud Europe Document. Part of the ECP is the Cloud for Europe (C4E) initiative, aiming at helping Europe's public authorities procure cloud products and services in order to build trust in European cloud computing.
e-skills for the 21st	2007	Started in 2007, the EU actions on e-skills were financed by the Competitiveness and Innovation

Name of the program, measure, action plan, etc.[83]	Year started/ adopted/ agreed upon	Topics covered
century Source: http://ec.europa.eu/growth/sectors/digital-economy/e-skills/index_en.htm		Framework Programme (CIP) of DG Growth. New initiatives until 2020 will be financed by the programme for the Competitiveness of Enterprises and Small and Medium-sized Enterprises (COSME) of DG Growth. The initiatives include: **- Building a European E-competence Framework,** which is a reference of 40 skills required in the ICT workplace. It uses a common language for skills and proficiency levels that can be understood across Europe for all types of organisations that need to take decisions on recruitment, career paths, training, or assessment. It was developed by the European Committee for Standardisation (CEN), which is funded by the Commission. **- Initiating the Grand Coalition for Digital Jobs** In order to increase the supply of ICT practitioners by 2015 and to ensure there are a sufficient number of skilled people to meet future demand for ICT skills, the Commission launched the Grand Coalition for Digital Jobs at the conference on 'e-Skills and Education for Digital Jobs' in Brussels in March 2013. It is a multi-stakeholder partnership that facilitates collaboration between businesses, education providers, and public and private players to attract young people to ICT education and to retrain unemployed people. **- Organizing diverse events and conferences,** such as the e-Skills 2013 Conference, the European e-Skills 2014 Conference, e-Leadership and IT Professionalism or the Cross Atlantic Round Table on IT and Labour Market Disruptions.
Initiatives by DG Growth for Digital Entrepreneurship Source: http://ec.europa.eu/growth/sectors/digital-economy/entrepreneurship/index_en.htm		To support digital entrepreneurship, DG Growth has started several initiatives. These include: **- Study: Doing business in the digital age** This study identified the key technological trends and carried out a comparative analysis of national strategies and private initiatives to encourage digital entrepreneurship. It proposed a five-pillar strategy and 21 recommendations for actions cutting across policy areas such as boosting digital and entrepreneurial skills, leveraging the Single Market, innovation campaigns, awareness and mentoring, and access to finance. **- Strategic Policy Forum on Digital Entrepreneurship** The Strategic Policy Forum on Digital Entrepreneurship was set up in 2014 to outline the short- and long-term strategy for digital entrepreneurship in Europe, to implement this strategy and to share experiences and advise the European Commission on key priorities.

Name of the program, measure, action plan, etc.[83]	Year started/ adopted/ agreed upon	Topics covered
		- Member States Board on Digital Entrepreneurship The Member States Board on Digital Entrepreneurship was set up to promote the implementation of a strategy on digital entrepreneurship in Europe. **- The Digital Entrepreneurship Monitor** The Digital Entrepreneurship Monitor is an online tool to monitor key technological and market trends, emerging business opportunities, new business paradigms and their impact on the European economy, and policy initiatives all over Europe. It includes statistics and initiatives to support digital entrepreneurs, and reports on business opportunities and digital technologies. **- Raising awareness: Watify and the Euromentors Association for Digital Entrepreneurs** A major pan-European awareness raising campaign (Watify) and an eMentoring ecosystem (Euromentors Association for Digital Entrepreneurs) have been set up to help European entrepreneurs catalyse and support new business opportunities offered by digital technologies. The Euromentors Association for Digital Entrepreneurs will inspire and support new entrepreneurs and intrapreneurs. Actions will include training, advice and hands-on coaching on how to do business in the digital age and match-making events among stakeholders to explore new partnerships.
Stimulating innovation for European enterprises through the smart use of ICT initiatives Source: http://ec.europa.eu/growth/sectors/digital-economy/ebsn/index_en.htm	2008-2014	The aim of this action, which ran from 2008 to 2014, was to modernise industrial value chains and help small businesses better connect to larger enterprises and become fully integrated in the chain, offering them a better position in the globalised business environment. As part of the initiative, six demonstration actions were started in support of the automotive, fashion, transport and logistics, tourism, agro-food and construction sectors.
Digitising European Industry package (part of the DSM initiative) Source: https://ec.europa.eu/digital-single-market/en/digitising-	19 Apr, 2016	The Digitising European Industry package contains a range of actions that have an overlap with other DSM actions, but that focus on the needs of the manufacturing sector and what is commonly called Industry 4.0/industrial IoT or advanced manufacturing. The package includes the following actions: **- Priority standards to boost digital innovation** The Commission proposes concrete measures to speed up the standard-setting process by focusing on the five

Name of the program, measure, action plan, etc.[83]	Year started/ adopted/ agreed upon	Topics covered
european-industry		priority areas 5G, cloud computing, Internet of Things, data technologies and cyber security. It will also co-finance technology testing and experiments to accelerate the setting of standards, including in relevant public-private partnerships. **- Digital public services** An eGovernment action plan will modernise digital public services and make the EU a better place to live, work and invest. The Commission has put forward 20 measures to be launched by the end of 2017. **- The European Cloud Initiative** The Commission is setting up a European Cloud Initiative to strengthen Europe's position in data-driven innovation and improve competitiveness. **- The Internet of Things** Today, less than 1% of objects are connected to the Internet, but there are likely to be almost 6 billion IoT connections within the EU by 2020. The Commission's initiative intends to build a single market for a trusted IoT and invest in innovation. **- Free flow of data** Unnecessary restrictions should be removed and national systems better aligned to allow a better flow of data within the EU and to stimulate the development of new technologies such as cloud computing. The Commission will assess the different legal and technical obstacles and will then define measures to address them. **- Skills and jobs** Together with all stakeholders, the Commission will reinforce the role of industrial and research organisations in the Grand Coalition for Digital Jobs and encourage further commitment by businesses to taking action. It will also improve the understanding of skills requirements for new technologies in all sectors of the economy. **- Coordination among member states** Building on and complementing the many national initiatives for digitising businesses, such as Industrie 4.0 in Germany, Smart Industry in the Netherlands and in Slovakia, Fabbrica Intelligente in Italy or Industrie du Futur in France, the Commission plans to use its policy instruments, financial resources, coordination and legislative powers to trigger further investments in all industrial sectors. This includes working with member states to focus on investment in public-private partnerships; pooling resources for ground-breaking developments in digital technologies and platforms, including high-performance cloud infrastructure for science and innovation as well

Name of the program, measure, action plan, etc.[83]	Year started/ adopted/ agreed upon	Topics covered
		as large-scale test beds to accelerate the setting of standards.
ICT Standardisation Rolling Plans (in cooperation with standardisation bodies) Source: http://ec.europa.eu/growth/sectors/digital-economy/ict-standardisation/index_en.htm	2013, 2015, 2016	The Rolling Plans on ICT Standardisation are the result of collaboration with major standardisation stakeholders through the Multi-Stakeholder Platform on ICT Standardisation. Priority actions aim to ensure interoperability and facilitate ICT uptake in key areas. The 2016 rolling plan, for example, offers details on the international contexts for the following areas: - E-health, accessibility of ICT products and services, Web accessibility, e-skills and e-learning, emergency communications and eCall. - E-procurement, e-invoicing, card/Internet and mobile payments, eXtensible Business Reporting Language (XBRL) and Online Dispute Resolution (ODR). - Smart grids and smart metering, smart cities, ICT environmental impact, European Electronic Toll Service (EETS) and Intelligent Transport System (ITS). - Cloud computing, (open) data, e-government, electronic identification and trust services including e-signatures, radio frequency identification (RFID), Internet of Things (IoT), network and information security (cyber security) and e-privacy. Previous ICT standardisation rolling plans were issued in 2013 and 2015.
e-invoicing initiative Source: http://ec.europa.eu/growth/single-market/public-procurement/e-procurement/e-invoicing/index_en.htm	2010	Based on the 2010 Communication 'Reaping the benefits of e-Invoicing for Europe', the European Commission started several actions to support the uptake of e-invoicing by ensuring legal certainty and promoting the development of interoperable e-invoicing solutions based on a common standard, paying particular attention to the needs of small and medium-sized enterprises (SMEs): **- Standardisation and e-invoicing** The European Committee for Standardisation (CEN), which is funded by the Commission, runs a number of actions on e-invoicing implementation issues. A series of informal meetings with representatives of standards organisations led to the report 'e-Invoicing Standardisation Overview, issues and conclusions for future actions', September 2012. Following the adoption of Directive 2014/55/EU on e-invoicing in public procurement, and in accordance with the provisions of Article 3 within, the Commission issued a standardisation request to the European standardisation organisations in December 2014. The work is being carried out by the CEN Project Committee on Electronic Invoicing (CEN/PC 434).

Name of the program, measure, action plan, etc.[83]	Year started/ adopted/ agreed upon	Topics covered
		- Single Euro Payment Area (SEPA) SEPA is a banking industry initiative that makes electronic payments across the euro area as easy as domestic payments within one country. Due to the strong link between invoices and payments, SEPA is an ideal launching pad for interoperable e-invoicing schemes because it pushes process integration across the financial supply chain. **- European Multi-Stakeholder Forum on Electronic Invoicing** The European Multi-Stakeholder Forum on e-Invoicing brings together delegates from national e-invoicing forums and stakeholders from the user side of the market. Its objective is to help pave the way for a broad-scale adoption of e-invoicing at national and EU levels. The forum creates a unique opportunity to share experiences and best practices across borders. It also discusses issues of common interest, with the possibility to issue recommendations to the Commission. The forum is chaired by the Commission and meetings are held twice a year.

13.Annex 4: Final Expert Workshop Report

Expert Workshop

Challenges & Opportunities for the European Software Industry

Date: October 6, 2016

Time: 11 a.m. – 5:30 p.m.

Location: DG CONNECT – European Commission, Avenue de Beaulieu 33 (room 0/54), 1160 Brussels, Belgium

This workshop is part of the EU project:

"The Economic and Social Impact of Software & Services on Competitiveness and Innovation" – SMART 2015/0015

on behalf of the EUROPEAN COMMISSION (DG CONNECT)

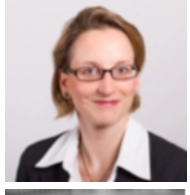
conducted by PAC, Le CXP and Fraunhofer ISI.

Agenda and Overview of presenters:

10.30 – 11.00	Arrival of participants; Coffee & tea
11.00 – 11.15	**Welcome and introduction** by *Mr. Pearse O'Donohue* (Acting Director "Future Networks", DG CONNECT, European Commission)
11.15 – 11.40	"**The European Software Market: Growth, Drivers & Trends**", *Dr. Katrin Schleife* (Pierre Audoin Consultants – PAC, a CXP Group Company)
11.40 – 12.05	Discussion
12.05 – 12.30	"**Ten policy recommendations to support the European software and Internet sector – Background and discussion**", *Dr. Bernd Beckert* (Fraunhofer ISI)
12.30 – 13.00	Discussion
13.00 – 14.00	Lunch
14.00 – 14.30	"**Research Priorities in the area of Software Technologies**", *Prof. Diomidis Spinellis* (Athens University of Economics and Business)
14.30 – 14.45	Discussion
14.45 – 15.15	"**Innovation Potential of Software Technologies in the Context of Horizon 2020**", *Prof. Mike Hinchey* (University of Limerick/Director of the Irish Software Research Centre)
15.15 – 15.30	Discussion
15.30 – 15.45	"**Current and Future Challenges of Software Engineering for Services and Applications**", *Dr. Sotiris Koussouris* (Cluster of European Projects on Software Engineering for Services and Applications)
15.45 – 16.00	Discussion
16.00 – 16.15	Coffee Break
16.15 – 16.30	"**HolaCloud Road mapping: New Research and Innovation Challenges in Software Engineering"**, *Dr. Lutz Schubert* (HolaCloud project)
16.30 – 17.00	Discussion
17.00 – 17.30	**Summary & Conclusions**, moderated by *Mr. Francisco Medeiros* (Deputy Head of Unit, Unit E2 – Cloud & Software, DG CONNECT, European Commission)

Overview of presenters:

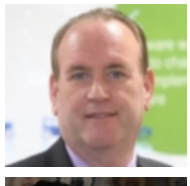
Mr. Pearse O'Donohue
(Acting Director "Future Networks", DG CONNECT, European Commission)



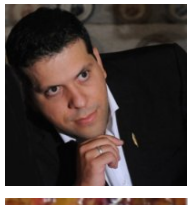
Dr. Katrin Schleife
(Pierre Audoin Consultants – PAC, a CXP Group Company)

Dr. Bernd Beckert
(Fraunhofer Institute for Systems and Innovation Research ISI)

Prof. Diomidis Spinellis
(Athens University of Economics and Business)

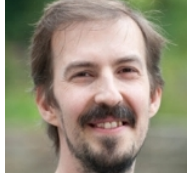


Prof. Mike Hinchey
(University of Limerick, Director of the Irish Software Research Centre)



Dr. Sotiris Koussouris
(Cluster of European Projects on Software Engineering for Services and Applications)

Mr. Francisco Medeiros
(Deputy Head of Unit, Unit E2 - Cloud & Software, DG CONNECT, European Commission)



Dr. Lutz Schubert
(HolaCloud project, University of Ulm)

List of participants

Workshop: "Challenges & Opportunities for the European Software Industry"

6th October 2016 - DG CONNECT - BU33 0/S54 - Brussels (Belgium)

LIST OF PARTICIPANTS

Surname	First Name	Company
ALONSO	Juncal	Tecnalia (Spain)
BECKERT	Bernd	Fraunhofer ISI (Germany)
BOGLIOLO	Annalisa	European Commission
BOULANGE	Thierry	European Commission
BRINKKEMPER	Sjaak	Utrecht University (The Netherlands)
CHAZERAND	Patrice	DigitalEurope (Belgium)
CHESTA	Cristina	Reply (Italy)
D'ELIA	Sandro	European Commission
DUPLICY	Jonathan	Innoviris (Belgium)
FALLMANN	Helmut	Fabasoft (Austria)
FERGUSON	Nicholas	Trust-IT Services Ltd. (UK)
HILLESHEIM	Stefan	DLR (Germany)
HINCHEY	Mike	Lero (Ireland)
KHAN SULLIVAN	Frank	Strategic Blue (UK)
KOUSSOURIS	Sotiris	National Technical University of Athens (Greece)
LACROIX	Michel	European Commission
PERINI	Anna	Fondazione Bruno Kessler (Italy)
PEZUELA	Clara	Atos (Spain)
PYROVOLAKIS	Odysseas	Independent expert (Belgium)
ROBIN	Valère	Orange (representing NESSI)
SCHLEIFE	Katrin	Pierre Audoin Consultants (Germany)
SCHUBERT	Lutz	University of Ulm (Germany)
SYMEONIDIS	Andreas	Aristotle University Thessaloniki (Greece)
SPINELLIS	Diomidis	Athens University of Economics and Business (Greece)
THOMAS	Cedric	OW2 (France)
ZORC	Samo	Ministry of Public Administration (Slovenia)

Purpose of the workshop

The aim of the final expert workshop was to inform relevant stakeholders and experts about the findings of the draft final study report, validate them and collect their views on them, as well as more general views, especially on current and future developments in the area covered by the study and on policy implications.

In addition, the workshop was associated with a number of further research studies related to the economic and social impact of software and to future research & innovation challenges for software technologies.

In the workshop, about 25 experts from research, industry associations, enterprises and the European Commission discussed the following:

- Policy recommendations derived from an ongoing study on how the European Commission can further support the European software industry in order to fully capture its potential and overcome potential barriers.
- Research & innovation challenges for software technologies and how the European Commission can further support the European industry & research community to continue its world-class research & innovation activities in the software space.

Summary of presentations and discussions

Introduction

Pearse O'Donohue (European Commission) opened the workshop and underlined the importance of software for the European economy. According to him, software is the conversion of knowledge into wealth and a driver of the digital economy. As a prime industrial differentiator and the basis for innovation, software could significantly increase Europe's industrial competitiveness and largely contribute to Europe's growth. In order to achieve these benefits, there is a need to continue investing in software research and innovation, and effectively take up research outcomes. Mr O'Donohue said the Commission had been and would continue to support research & innovation activities in the area of software technologies. From his point of view, this workshop was a first attempt to present the findings of these initiatives and open the floor for a constructive dialogue with all related stakeholders in order to improve Europe's position.

Morning Session

Growth, structure and trends of the European software market and industry

The morning session was focused on the SMART 2015/0015 research study. At the beginning, Katrin Schleife from PAC presented some of the main findings related to the growth, structure and trends of the European software market and industry. Another major focus area was the relevance of in-house software development for European companies in different vertical segments and the factors influencing companies' decision to develop software internally.

The study shows that the overall SSBS (software and software-based services) market in the EU28 region was worth EUR 229 billion in 2009 and grew by a yearly average of 1.5% until 2015. Its average yearly growth is expected to accelerate to 2.9% between 2015 and 2020. When taking a closer look at the different market segments, it becomes evident that software-related segments such as infrastructure software & platforms and application software products will grow only slightly between 2009 and 2020. One main reason is the maturity of these segments in various European countries. Growth in these areas mainly comes from investments by medium-sized businesses that in many cases do not have the same maturity level as large enterprises. In addition, the software markets are increasingly under pressure as more and more companies are shifting to cloud-based solutions. The market share of cloud computing will increase enormously until 2020 (around 18% of the SSBS market).

Services for the technical implementation of a software solution are hardly needed when companies start using a cloud service. This is one significant reason why the market for infrastructure-related IT services has been declining. Application-related IT services became the largest single SSBS market segment in 2015. This segment will remain of importance because these services are needed for modifications, improvements, upgrades, maintenance, and the management of existing solutions.

The global games market is prospering as a result of a range of innovations: powerful smartphones enable mobile gaming, improved broadband and infrastructure capacities allow high-performance online gaming, and innovative revenue and digital distribution models have greatly expanded the addressable market.

Understanding the role of in-house software development

Recently, software-related make-or-buy decisions have shown a stronger tendency towards the 'make' side, especially when it comes to product development. For many companies, software has become a critical success factor for products and services and is regarded as an innovation enabler. In some cases, companies have transformed their traditional products into digital entities and started selling services instead of just products. Software is going to be at the core of such business models.

Therefore, the question of whether to buy or make software is becoming increasingly strategic and is currently being discussed at board level in many companies. In the market, several different trends can be observed, including companies acquiring software houses in order to build internal resources, the extensive hiring of software-focused resources, and the extended cooperation between corporate clients and IT service companies.

In order to understand the impact of these trends on the software industry and to assess the change in the industry's structure, it is mandatory to understand the influencing factors of make-or-buy decisions that are currently at work. The project team's research shows that in general, companies show a stronger tendency towards conducting in-house software development if

- They are active in a sector where the level of maturity is generally low with regard to the use of standardized, off-the-shelf software solutions;
- The general quality and availability of a specific external solution is rather low (e.g. because the company is active in a small market segment);
- Their software requirements are too specific (e.g. because they are highly innovative and/or pioneers in digital transformation, or because they work in a highly specialized market segment);
- They do not want to give sensitive internal process know-how to external software partners;
- They have doubts about a quick and efficient communication with external software providers around software development and adjustment;
- They have a pronounced R&D strategy and see in-house software development as a relevant part of it;
- Their supplier and partner network is not that complex;
- They have a certain size and have sufficient internal IT resources and competencies;
- They used to do it in the past and they do not see any reason why they should not continue to do so in the future.

In order to estimate the **amount of in-house software development** in the nine analysed industries, the project team developed sector-specific market models. According to PAC data, the total market volume of internal software development is estimated to have been €52.3 billion in the EU28 in 2015. Given an average yearly growth rate of 1.8%, this figure is expected to rise to €57.2 billion by 2020. Vertical analyses show that except for the public sector, where the figure remains more or less the same, the market volumes of in-house software development will increase in all sectors in the EU28 between 2015 and 2020. The largest increase will be seen in the manufacturing industry. In this sector, product development as well as the development of software that is embedded in the products is part of the core business. In addition, topics such as Industry 4.0/industrial IoT and the Internet of Things (IoT) are currently adding strongly to manufacturers' propensity to develop software internally. Related solutions are often not yet available in the market, or companies just want to prevent internal know-how from leaving the company.

Compared with total software and IT services (SITS) spending, in-house software development expenditure amounted to 20.3% in 2015. This figure will slightly decline to 19.5% by 2020. This trend can be observed in the EU28 region for nearly all analysed industries. However, the falling percentages will not be due to a decline in in-house software development expenditure, but to a strong increase forecast for total SITS expenditure, which will grow at faster rates than in-house software development spending. The only exception is the manufacturing sector, where the growth of in-house software development will further increase and outpace external IT spending. Thus, internal software development will remain of great relevance in all analysed industries.

Discussion

In the following discussion it turned out that there were differing views on how to measure and segment the software market. However, differences in approach may partly be due to the fact that, for example, from a software development point of view it does not make much difference if an application is provided as a licence or as a service (Software as a Service, SaaS). However, in terms of revenue model it makes sense for companies to differentiate between the different channels through which software is provided. This is particularly true given that revenue streams strongly differ between software licences and SaaS.

Several participants underlined the high importance of in-house software development, thus supporting the view of the study's authors. One provocative view was that CIOs might tend to prefer in-house software development in order to secure their jobs in the long run.

In-house software development is not necessarily a bad thing because it is often complemented by hosting or other outsourcing activities.

It needs to be checked if the number of software companies in the EU and the US is "polluted" by the high number of freelancers.

Policy recommendations

In a next step, Bernd Beckert (Fraunhofer ISI) presented the top ten policy recommendations derived in the study and related to the most important barriers of software market growth. Based on this, the following 10 policy recommendations were presented and discussed:

A. For a more dynamic, innovative user landscape
1. Enhance e-skills in Europe
2. Support the adoption of ICT in industry and service sectors
3. Support open source software
B. For better framework conditions
4. Remove market fragmentation
5. Increase trust in cloud computing and IT infrastructures
6. Introduce digital know-how in politics
C. Focus on enabling factors
7. Unleash the entrepreneurial spirit in Europe

8. Support ICT-related SMEs in their effort to grow
9. Roll out high-speed broadband networks
10. Increase public R&D spending in the ICT area

The following sections show the main inputs and discussions from the experts:

1. E-skills

The e-skills shortage is not as dramatic as it used to be; there are many skilled and talented people available today. One indicator of this is the fact that more and more software development is done in-house. The conclusion to be drawn from the discussion is that there has been an increase in knowledge and skills over the last few years.

It is not skills that are the problem, but the cost of skilled people. This is the reason why much of the software programming these days is done in India or other countries with lower wages than Europe.

What exactly is meant by "e-skills"? Is it the ability to write code? As software programming becomes easier and easier, this may not be as relevant as it used to be. If e-skills shall be supported it needs to be decided whether more people are needed who can write complex code or people who can work with software that is rather easy to be programmed (and also ways need to be found to make programming more "usable").

2. Adoption of ICT in application sectors

Problem of vertical-specific, country-specific and general segmentation and legislation.

3. Open source software

Open source is very well suited to the usage in commercial contexts. It is not true that its revenue models are unclear. However, it is true that companies and users do not yet know enough about the commercial use of OSS. And OSS is important for the future of the European software industry.

4. Market fragmentation

In Europe, there is a strong IT services industry. The advantage of these companies is that they are close to the customers and know their needs. As such, segmentation and "fragmentation" is not necessarily a bad thing, but has in fact even turned into a competitive advantage. These companies and the sector as a whole have learned to deal with complexities and with ambitious local customers.

Supporting national champions should be a thing of the past. Instead, the EU should support innovative SMEs and help them grow and become international.

5. Increase trust in the cloud

The Cloud Select Industry Group (CSIG) of the EC should be mentioned here as one additional measure taken by the Commission to increase trust in the cloud and IT infrastructures.

Trust and privacy concerns are less of an issue for the digital natives than they are for those over 40. But in the context of industrial use or for SMEs, IT security and trust play an important role.

7. Entrepreneurial spirit

The question is whether there really is a lack of entrepreneurial spirit in Europe. The fact that there are so many software companies in Europe suggests that the spirit is not missing at all. A more relevant question seems to be why so many newly founded companies do not succeed, why they are not able to grow and scale up their business. This may be where support from the Commission is necessary.

Public procurement can be one way to stimulate the start-up scene in Europe. Today, many software applications come from US producers. The EU should rely more on software developed in Europe.

In the list of current initiatives, the Start-up-Europe initiative is missing. In this context, the idea of a one-stop shop for start-ups is being realized. This shows that quite a lot is being done for start-ups on the EU level.

9. Broadband

Low latency is a requirement which becomes more and more important if we continue to scale up bandwidth.

In general, better connectivity is needed; however, some member countries are more advanced in the broadband rollout than others. For example, in Slovenia, this no longer seems to be a problem.

It is worth mentioning that even the fastest Internet connection is no use if the last server you request has only a slow connection. Thus there is a need to look at the entire network.

10. R&D spending

Companies hardly participate in Horizon2020 projects because they reckon it involves too much administrative work, the chances to win a project are too slim, and there is not enough output from projects won. Companies prefer to cooperate directly with universities and sponsor PhD candidates, for example. Moreover, IP-related issues may be a reason for companies to refrain from EU-funded R&D projects.

In general, many more links between academia and industry R&D are needed. In fact, the ERC (European Research Council) as the most important EU instrument to support research only seems to encourage basic research. Engineering projects are not very well covered. In programmes that do support engineering research, such as the FET (Future & Emerging Technologies) programme, the current oversubscription is discouraging companies from applying.

It seems that companies can be more innovative than public R&D simply because there is more money available. Google and others have large cash reserves and can thus dominate research on artificial intelligence, for example.

General discussion:

The efforts of the EU need time to materialize, positive effects will not be felt overnight. In general, the study intends to be a kind of inventory of EU initiatives in all these fields. However, the list is not complete, there are many more initiatives underway, also by other DGs, that are not listed. And the Commission will come up with a whole series of new measures in the near future. This is why this study cannot exhaustively examine all EU initiatives.

There are fears that the European software industry may disappear just like the textile or shipbuilding industries. One indication is that Nokia was taken over by Samsung, and Ericsson by Huawei. The new owners take over the skilled people and the profitable patents and IP rights. The question for the future is whether or not Europe can keep talented people, given that some of the big European companies have been establishing new, innovative companies abroad, for example in the US.

Security by design is a genuine strength of European software companies and will be emphasized in the project team’s recommendations.

Afternoon Session:

Research and innovation challenges for software technologies

The experts in the workshop all agreed that software is pervasive to all modern technology and not just constrained to IT. In fact, most users will not even be aware of using software anymore, as they "only" interact with devices, giving the impression that the system is fully realised in hardware, such as for washing machines, coffee makers, etc. There are however important reasons why in general IT development shifted from proprietary to general-purpose hardware and moved the logic completely into the software level: functionality, adaptability and reusability. Software is way more flexible than hardware and the functionality offered by modern software could not be made available through dedicated hardware. In particular in the embedded domain there are plenty of processors easily accessible and available that at least meet the performance of ASICs and are not considerably more expensive, yet allow reuse in multiple application domains through corresponding software adaptation.

Software thus has become a substantial part of our modern economy/industry — way more than we may be consciously aware of. However, one may rightfully ask, if software has become thus pervasive and "omnipresent", what further development is needed in this context? One might misguidedly argue that current software and software engineering principles and practice are fully sufficient for the day-to-day purposes of our modern society. It turns out that significant investment in software engineering research is required to help Europe stay on top and even lead a world that is increasingly defined and shaped by software. The need for targeted research in software engineering is prompted by developments in three broad areas.

First, the computing landscape is changing from top to bottom. Technology influences the way we develop software both through the affordances it provides (for example ample directly addressable main memory and multiple computing cores) and through the requirements it imposes (for instance the ability to analyse mountains of data). Specifically, cloud computing and infrastructure as code allow the radical rethinking of computing systems; universal memory obsoletes current memory hierarchies; multicore architectures change how energy efficiency and performance are to be obtained; while big data, machine learning, and natural user interfaces open new possibilities for computing applications. Software lies at the heart of all these changes.

Second, eight software-driven vertical application domains are reshaping entire industries and society as a whole. Some of these domains are currently emerging through the evolution of computing technology, while others are long-established ones redefined through the use of software. The domains are autonomous vehicles, massive open online courses, open intellectual property, the Internet of Things, life sciences, 3D printing, financial technology, and Industry 4.0. Research in software technologies is an enabler and a driver for these application domains.

Third, the computing landscape’s technological trends and the changes in the vertical application domains give rise to several critical crosscutting software

engineering challenges. These come about through the changes in the computing landscape and the software-driven vertical application domains, together with the convergence of cloud, big data, and software-defined infrastructures. The challenges involve the taming of the immense scale and complexity of the required software through suitable tools and abstractions, data analytics, novel processes and collaboration mechanisms, as well as the integration of software development with operations. On top of these return with a vengeance known challenges regarding security, privacy, reliability, and environmental sustainability.

One major, recurring comment in this respect arising during the meeting is that the dependency on functioning software is a crucial aspect that needs to be kept in mind. Even if software engineering processes were sufficient (but they are not, see below), code failures (be that due to bugs, bad programming, changes in the hardware etc.) are costly and have a massive economic impact, be that on small but costly scale, such as losing satellites, or on large but (individually) low-cost scale, such as recalling an embedded device or leaking personal data. Though software can be easily adapted, it does not mean that errors cannot be fatal, such as in the Tesla incident.

More **reliability, provability and tools for testing** code was therefore one commonly agreed concern that still prevails in modern software engineering and continues to cause tremendous economic impact. Failures occur in principle due to inappropriate matching of the process to the different usage contexts (platform, application domain) as the scope is too large and dynamic.

However, the degree to which platforms (devices), usage areas (application domains) and user types change means that testing and code adaptation needs to be way faster than can be currently done. As will be elaborated below, this is an implicit demand for **portability** of code across different platforms, i.e. without losing its non-functional and functional properties (retain reliability etc.).

It was (and can be) generally observed that the software development and maintenance cycle is getting shorter and shorter – this is not only due to the increased competition on the market to meet the ever-rising demands, but also due to the fast pace in which conditions change: new types of processors and devices are being constantly pushed onto the market and are being taken up. Most software companies already have major problems to keep up with the pace and are just simply struggling with all the bugs arising even after the product has hit the market. This development is notably not likely to change – just the opposite: shorter development cycles hit every type of (IT) product and with software being pervasive to all, this puts additional stress on software development.

It is therefore crucial to provide the right means and mechanisms to support short product development cycles, faster code adaptation and maintenance without, as noted, losing reliability or other functional and non-functional properties – at the moment, no tools allow or support such maintenance, but necessitate the developer to reassess and painstakingly code such behaviour manually. This could equally mean tools, more clear engineering and development processes, lifecycle models, encoding of non-functional properties into self-adaptable code etc. (see below). Current standard mechanisms, including DevOps are insufficient to this end.

Software **development and testing tools may thereby have to be extended with big data and artificial intelligence mechanisms** themselves to identify and understand not only typical code patterns, but also typical usage and potentially typical coding behaviour, thus supporting the developer beyond traditional intelliSense, as well as mining contextual information regarding software usage in broader infrastructure environments, resulting in novel requirements on engineering methods.

In general it was clearly stated that software development needs to be more and more supported and become better structured to meet the development cycles, as well as to improve code properties, ranging from scale to reliability and security. Such **software engineering patterns may give rise to new usage fields and market areas**, much in the same way as e.g. Hadoop did. But patterns alone are insufficient if **better methods and processes are not put into place and followed more strictly**. There is still a strong tendency to "hack" solutions rather than to methodically develop them. This requires a general rethinking of software development processes and the according education. Digital nativity in the sense of usage is insufficient, if not complemented by programmability and development.

Better software design patterns need to be complemented and supported by ubiquitous requirement engineering principles and clearly defined and used standards, description and metadata conventions, increased flexibility of code and data etc.

At the moment, developers and users are too often treated separately, so that user requirements and feedback are frequently disregarded or considered too late, when the software is already on the market. In general, the community drive as in open source software development should pervade the software industry more thoroughly, ranging from design to market deployment. By involving users through the provision of domain-specific programming platforms, or users with coding capabilities into development, coding cycles may furthermore be decreased, as is e.g. visible in Linux. Furthermore, existing software engineering approaches can be profitably extended to apply to other fields that are rapidly becoming dominated by software and data [1].

Though better coding strategies and new patterns would generally improve the status of software and help with the development cycles, it is obvious that software itself needs to become more intelligent and more adaptable in order to cope with the degree of heterogeneity and the dynamicity of the environments. It was uniformly agreed that the effort for code adaptation to new environments (processors, devices, frameworks) is too high to be sustainable and that such effort should be removed from the developer as much as possible. This could mean that the **software itself, or the executing framework needs to be able to adapt to context and requirements at *run time***. This necessitates an appropriate representation of the context, i.e. the complete usage environment, including types of devices, usage and data, so that the software process gets the right information for adaptation.

It was also generally remarked that open source software development and innovation is vital for the European (and potentially global) software industry. Only

with open source software can the otherwise oppressive "dictatorship" of the large software vendors be disrupted, who so far still are the only industry large enough to deal with the complexity of modern software. **Future software must be easily developed from components and freely available software and its maintenance must be supported by a wide community**. This includes a reuse and evolution of existing software and modules: rather than developing from scratch, existing software must become more easily retrievable, interoperable and usable. Maintenance and evolution to new usage contexts requires, next to interest in supporting such an endeavour, in particular again digital nativity in the sense of development capabilities.

All in all, there was common agreement that future software engineering needs to cater for:

- Easier and more context-focused development and maintenance (including development by non-programmer domain experts) with shorter time-to-market cycles.
- Higher interoperability to improve composability and reusability.
- Adaptability of functional and non-functional requirements as well as portability to allow for the fast-moving hardware market.
- Improved internal, external, and in-use software quality.

Along these lines, the concepts developed and promoted as I3 (Information, Incentive and Intention) [2][3] were discussed as a possible "end goal". According to these concepts, software engineering needs to move away from the traditional Turing/von Neumann principles towards a generally more abstract view on algorithms and the data used. Specifically, principles should move towards:

Information instead of data – almost all processing happens to generate information, even if so far we can only encode it in data. Information, however, is interoperable and applicable in many circumstances, can be communicated in different fashions and interpreted according to need. The base technologies for this capability are standards, metadata and semantics.

Incentive describes how a code should perform, i.e. which non-functional properties it should fulfil. Currently this requires exact code specifications such as in SLAs per code segment, which binds the execution, deployment and configuration and thus hinders adaptability and portability. The incentive must thus be decoupled from the actual code to be decomposable and distributable. Such knowledge can only be gained domain-specifically.

Intention of the code describes the actual behaviour or rather what the code should achieve. Standard methods define the operations individually, thus again fixing the code to platform, configuration, distribution and runtime behaviour. To reduce development effort and to ensure adaptability, portability and dynamicity a higher abstraction level than ever needs to be reached. Care must be taken that all incentives are still maintained and performance is not lost to interpretation. First approaches consist in patterns, workflows and semantic/metadata descriptions.

These principles seem to be in line with the core statements from all participants. A more concrete realisation plan including technical details was discussed and should be developed further.

Software engineering research must be funded as a specific priority, so that it can act as a foundation for the robust evolution of computing and its applications. The findings of such research, whether empirical, such as the effect of code size, testing, or reviews on software quality, or technological, such as static program analysis tools and model checkers, increase the IT industry's efficiency and benefit society through more and higher-quality software. In contrast, restricting software engineering research to the incidental support that takes place within the development of applications is like trying to build a national highway network by patching together cobblestone paths of small villages. Such an approach is ineffective and drags down the economy.

In the coming decade software will affect crucial aspects of modern society: jobs, production, and the nature of work; security, privacy, transparency, and trust in the physical and cyber domains; government and social structures; as well as the ownership of tangible and virtual goods. Investing in the software engineering research required to progress in these areas can help Europe lead in the corresponding changes, while failure to commit resources may severely limit its say and options. Given the breadth of the upcoming changes, the proposed investment can spur a stronger economy, higher-quality jobs, increased security, better governance, and greener living.

Europe can build on its world-class pockets of excellence in specific areas of economic activity. Thus focused, significant, and effective research funding in the area of software engineering will enable the development of new methods, tools, architectures, systems, business models, processes, and applications that can be instrumental in the establishment of Europe as the centre of the rising software-run economy.

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14. Annex 5: List of Abbreviations

Abbreviation	Description
APAC	Asia-Pacific
BERD	business enterprise expenditure on R&D
BI	business intelligence
C&SI	consulting & system integration
CAGR	compound annual growth rate
CPG	consumer packaged goods
CRM	customer relationship management
CxO	Chief x Officer, a generic term for any corporate officer
GRC	governance, risk, compliance
ECM	enterprise content management
ERP	enterprise resource planning
EU	European Union
FLOSS	free/libre open source software
FP	framework program
Fraunhofer ISI	Fraunhofer Institute for Systems and Innovation Research
FTSE100	Financial Times Stock Exchange 100 Index, a share index of the 100 companies with the highest market capitalization listed on the London Stock Exchange
GDP	gross domestic product
HCM	human capital management
I/O concept	input/output concept
IaaS	infrastructure as a service
IAM	identity and access management
iOS	mobile operating system created and developed by Apple
IoT	Internet of things
IPR	intellectual property rights
ISV	independent software vendor
LOB	line of business
M2M	machine-to-machine
MDM	mobile device management
MES	manufacturing execution system
MINT	Mathematik, Informatik, Naturwissenschaft, Technik (German equivalent to STEM (see below))
NACE	industry standard classification system used in the European Union

Abbreviation	Description
OECD	Organization for Economic Cooperation and Development
OEM	original equipment manufacturer
OSS	open source software
p.a.	per annum
PaaS	platform as a service
PAC	Pierre Audoin Consultants
PLM	product lifecycle management
PPP	public-private partnership
PWB	paid web-based
R&D	research & development
RFID	radio frequency identification
SaaS	software as a service
SBIS	software-based Internet services
SC	social collaboration
SCADA	supervisory control and data acquisition
SCM	supply chain management
SIS	systems infrastructure software
SITSI®	Software and IT Services Industry; PAC's global research methodology and program on IT markets and vendors
SMACS	social, mobility, analytics, cloud and security
SME	small and medium-sized enterprise
SSBS	software and software-based services
STEM	science, technology, engineering and mathematics
T&M	time & material
TFP	total factor productivity
UCC	unified communication and collaboration
UK	United Kingdom
US/USA	United States of America
VA	value added
VAT	value added tax
VC	venture capital
VR	virtual reality

15. Annex 6: Literature

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