



Grant Agreement N°: 101016673

Topic: ICT-40-2020



The European Cloud Computing Hub
to grow a sustainable and comprehensive ecosystem

D3.4: Recommendations for Cloud Computing business modelling, analysis and acceleration

Revision: v.1.0

Work package	WP3
Task	T3.2
Due date	30/06/2022
Submission date	01/07/2022
Deliverable lead	Tecnalia Ventures
Version	1.0

Abstract

After the first part in the series of recommendations for entrepreneurs in the field of cloud computing, this second part goes into detail in some specific areas: First, the analysis starts by focusing on the different segments within the cloud computing market in different geographical locations and in different sectors. Second, the study has a look at the European cloud computing markets, their characteristics, and specificities, to see where business opportunities may lie. Third, the analysis centres on open source within the cloud computing market to understand when and how open source can provide additional opportunities for cloud computing entrepreneurs. Fourth, entrepreneurial ecosystems are analysed from a European perspective, thus allowing the reader to identify opportunities and risks of developing entrepreneurship projects in cloud computing in Europe as compared to other parts of the world. Fifth, the study goes deep into the areas that are showing the biggest opportunities within cloud computing, as well as identifying some success stories in European start-ups. The document ends with final conclusions and recommendations for entrepreneurs.

Keywords: Cloud Computing, Business Model, Revenue Model, Pricing Mechanism, Cost Structure, Computing Paradigm, Service Delivery Model, Virtualisation, Internet-based Delivery Model, European entrepreneurs, European ecosystems, Open Source

Document Revision History

Version	Date	Description of change	List of contributor(s)
V0.1	15.03.2022	ToC	Tecnalia Ventures
V0.2	10/06/2022	First full draft completed	Tecnalia Ventures
V0.3	24/06/2022	Revision by partners	Tecnalia Ventures, Martel, Tecnalia
V1.0	01/07/2022	Submission	Martel

Disclaimer

The information, documentation and figures available in this deliverable, is written by the HUB4CLOUD (The European Cloud Computing Hub to grow a sustainable and comprehensive ecosystem) – project consortium under EC grant agreement 101016673 and does not necessarily reflect the views of the European Commission. The European Commission is not liable for any use that may be made of the information contained herein.

Copyright notice: © 2021 - 2022 HUB4CLOUD Consortium

Project co-funded by the European Commission under ICT-40-2020		
Nature of the deliverable:	R*	
Dissemination Level		
PU	Public, fully open, e.g. web	√
CI	Classified, information as referred to in Commission Decision 2001/844/EC	
CO	Confidential to HUB4CLOUD project and Commission Services	

* R: Document, report (excluding the periodic and final reports)

DEM: Demonstrator, pilot, prototype, plan designs

DEC: Websites, patents filing, press & media actions, videos, etc.

OTHER: Software, technical diagram, etc

EXECUTIVE SUMMARY

The present document is the second of a two-part report on “*Recommendations for Cloud Computing business modelling, analysis and acceleration*”. The first part focuses on identification and analysis of key business model patterns, existing value chains, and main business opportunities for entrepreneurs. This second and final part of the report focuses on recommendations for entrepreneurs.

The first instalment of the report had generally a worldwide view of entrepreneurship in cloud computing. In opposition to that, this second part of the study focuses on the European entrepreneurial ecosystem, the European cloud computing market, and the main areas of business in which entrepreneurs can find cloud-computing-related opportunities to develop their technologies successfully.

This report also has a look at open-source software, and analyses whether it makes sense to make it part of a cloud computing business strategy. Several OSS business models are analysed. Starting from the premise that OSS allows entrepreneurs to not have to develop software from scratch; and that developers can build on each other’s contributions by relying on a strong community, we reach the conclusion that recommendations regarding open source adoption vary from project to project.

The report identifies the main trends and opportunities in the industry, with special focus on European entrepreneurs. It is concluded that, although the big US players dominate the scene, there is plenty of room for European entrepreneurs to succeed. What is more, several European cloud computing success cases are presented, in the hope that they will serve as inspiration for new start-ups in cloud computing.

TABLE OF CONTENTS

EXECUTIVE SUMMARY	4
TABLE OF CONTENTS	5
LIST OF FIGURES	7
LIST OF TABLES	8
1 CLOUD COMPUTING MARKETS BY SEGMENT	9
1.1 Introduction	9
1.2 SaaS	12
1.3 IaaS.....	14
1.4 PaaS	16
2 CLOUD COMPUTING MARKETS IN EUROPE	18
2.1 Main CC service providers in Europe	18
2.2 CC usage by European enterprises.....	19
2.3 Specificities of the European CC market	23
3 OPEN SOURCE VS. PROPRIETARY SOLUTIONS IN CLOUD COMPUTING	27
3.1 Copyright protection.....	27
3.2 Patent protection.....	27
3.3 Other methods of software IPR protection.....	28
3.4 Free and Open-Source Software	28
3.5 Use of OSS licenses by for-profit firms	29
3.6 Business models involving open-source software	30
3.7 Ways to incorporate open source in cloud computing	31
3.8 From open source to source availability	32
3.9 Conclusions	34
4 ENTREPRENEURIAL ECOSYSTEMS IN THE EU	35
4.1 The global economy from a start-up perspective.....	35
4.2 Entrepreneurial ecosystems throughout the world.....	36
4.3 Public policies for global entrepreneurial ecosystems from around the world	40
4.4 European policies and initiatives.....	40
4.5 European initiatives to facilitate connectivity.....	42
4.6 Europe's entrepreneurial ecosystems.....	42
4.7 Summary and recommendations	47
5 IDENTIFICATION OF MAIN OPPORTUNITIES AND RISKS	49
5.1 Markets	49
5.2 Public sector	52
5.3 Risks	54
6 SUCCESS CASES IN CLOUD COMPUTING ENTREPRENEURSHIP IN EUROPE	55



7 CONCLUSIONS AND FINAL RECOMMENDATIONS 57



LIST OF FIGURES

Figure 1 Spending on cloud and data centres 2009-2021	9
Figure 2 Global cloud applications market size 2013-2025	10
Figure 3 Cloud Spending during COVID-19, by organizations	10
Figure 4 Global public IT cloud services revenue 2016-2020, by segment	11
Figure 5 Worldwide hybrid-cloud market size	12
Figure 6 Global Market for SaaS, by Organization Size	13
Figure 7 Global Market for SaaS, by Organization Size	13
Figure 8 Global software as a service market share forecast 2020-2025, by select country	14
Figure 9 Global Market for IaaS, by Organization Size.....	15
Figure 10 Public cloud PaaS market.....	16
Figure 11 Platform as a Service (PaaS) spending by segment worldwide 2016-2022	16
Figure 12 Spend per employee ranking in US\$ and revenue share in 2020	17
Figure 13 Cloud computing market size in Europe from 2016 to 2025, by segment.....	18
Figure 14 Use of cloud computing services in enterprises, 2020 and 2021 (% of enterprises)..	19
Figure 15 Use of cloud computing services, by economic activity.....	21
Figure 16 Use of cloud computing services, by size.....	21
Figure 17 Types of cloud computing services used, by service model.....	22
Figure 18 Level of sophistication of cloud computing services used, by size	23
Figure 19 EU: dependency on external actors in tech according to professionals	24
Figure 20 EU: dependency on external countries tech according to professionals	24
Figure 21 CIOs in Europe have stricter concerns about data security, governance, and regulatory compliance.....	26
Figure 22 Number of unicorns in Europe.....	35
Figure 23 Share of Top Global Ecosystems by Continent.....	36
Figure 24 Global Start-up Ecosystem Index: Top Countries	37
Figure 25 Global Start-up Ecosystem Ranking.....	38
Figure 26 Ecosystems with Billion-Dollar Club Start-ups.....	38
Figure 27 Emerging Ecosystems are Gaining Relevance	39
Figure 28 Share of Emerging Ecosystems by Region	39
Figure 29 Exits Value by Region for Top 100 Ecosystems.....	40
Figure 30 VC Funding in Europe evolution.....	43
Figure 31 VC Funding in Europe evolution.....	45
Figure 32 VC-backed start-ups vs. Unicorns	46
Figure 33 Distribution of start-ups in hubs - Europe vs. the USA	47
Figure 34 IoT devices worldwide (in billions)	52

LIST OF TABLES

Table 1 Global Market for IaaS, by Industry Vertical	15
Table 2 Use of cloud computing services in enterprises, 2021	20
Table 3 Types of business models including OSS	31

1 CLOUD COMPUTING MARKETS BY SEGMENT

1.1 Introduction

Cloud computing technologies have seen a tremendous increase in usage during the coronavirus pandemic. Individual users have used cloud computing tools for communication, shopping and entertainment purposes, among others. And companies have had a similar trend, as the amount they spent on cloud infrastructure grew by 37% from 2020 to 2021, to an astonishing US\$ 178 billion. The main cloud-computing-related areas in which companies invested were modern networking, storage, and databases solutions¹.

Overall, companies increased their spending on cloud computing during the pandemic:

Enterprise spending on cloud and data centers by segment from 2009 to 2021 (in billion U.S dollars)

Spending on cloud and data centers 2009-2021, by segment

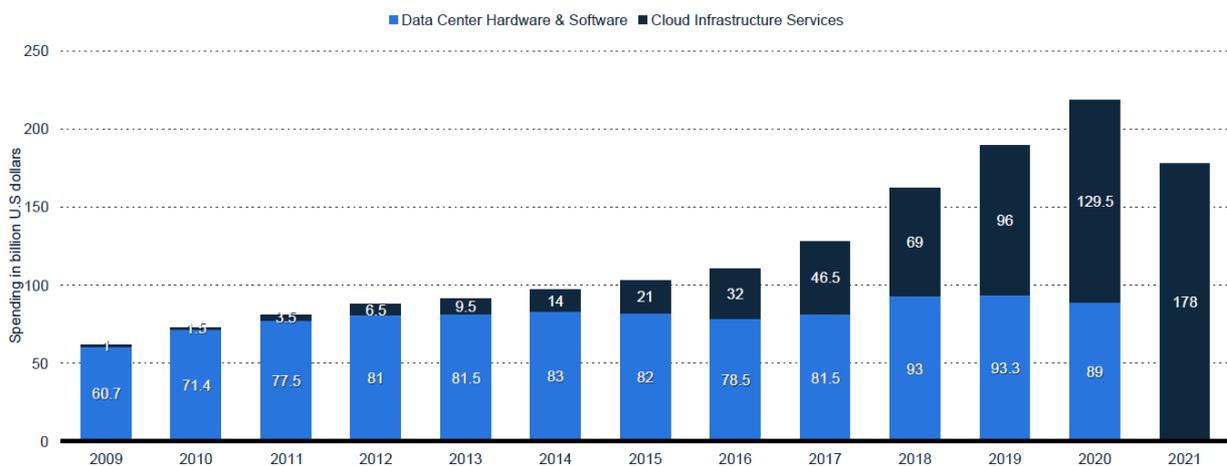


Figure 1 Spending on cloud and data centres 2009-2021²

This trend does not seem to have an end in the near future. In the case of cloud applications, its market was valued at US\$ 133.6 billion in 2020; and it is foreseen to grow up to US\$ 168.6 billion in 2025:

¹ Statista, Enterprise spending on cloud and data centers by segment (2022)

² Statista estimates; Synergy Research Group; ID 1114926 (2022)

Cloud applications market size worldwide from 2013 to 2025 (in billion U.S. dollars)

Global cloud applications market size 2013-2025

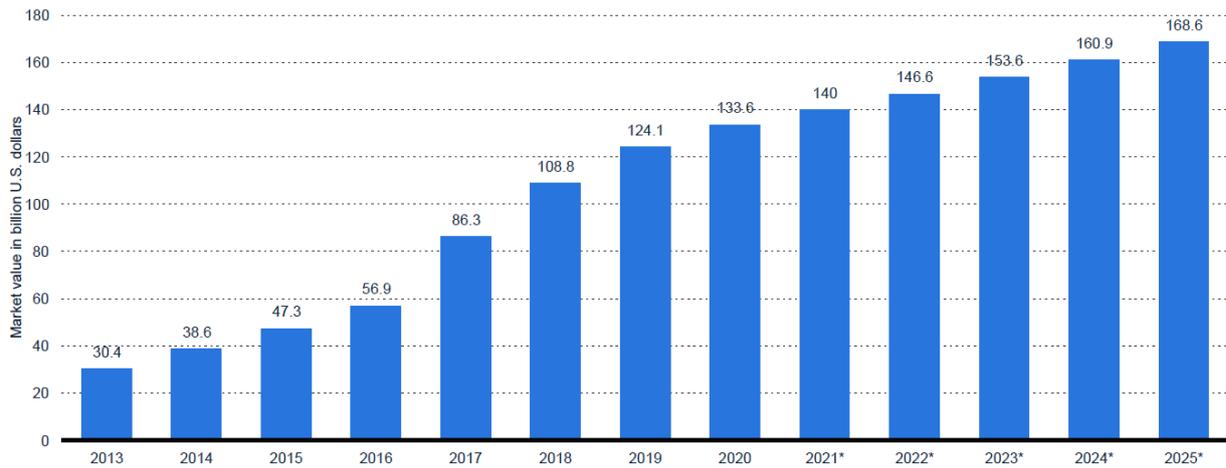


Figure 2 Global cloud applications market size 2013-2025³

What is more, we have seen a significant increase in the percentage of companies that spend the largest amounts of money:

Cloud Spending during COVID-19, by Organization, 2020 vs. 2021 (%)

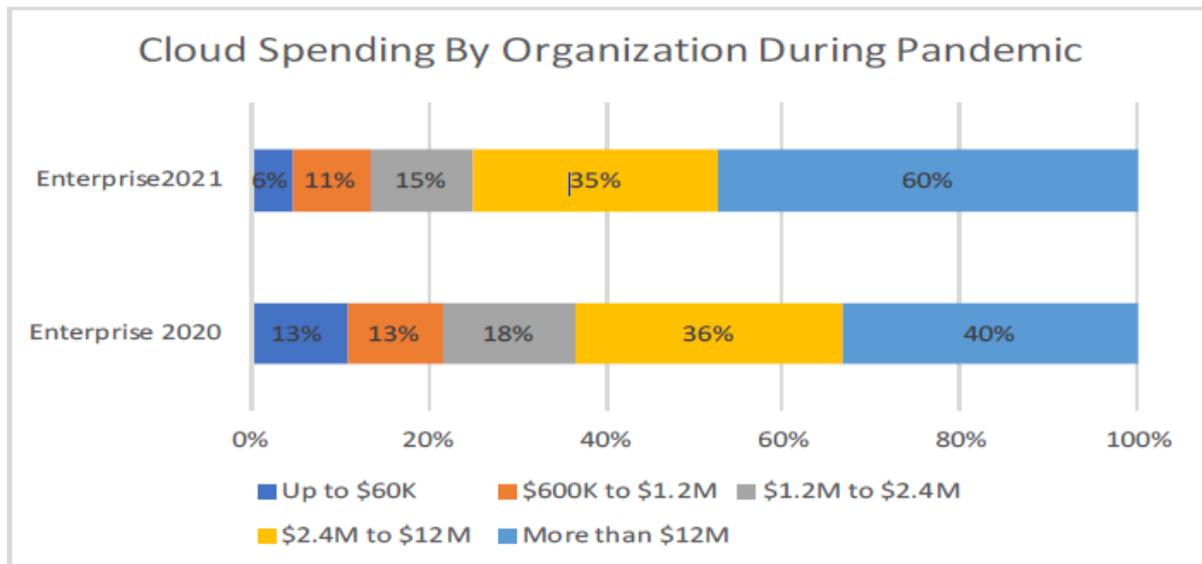


Figure 3 Cloud Spending during COVID-19, by organizations⁴

³ Apps Run The World; Statista (<https://www.statista.com/statistics/475670/cloud-applications-market-size-worldwide/>) (2021)

⁴ Various Analysts, "2021 Cloud Technology Research Review", BCC (2022)

Although all areas of cloud computing have grown in revenue in recent years, Platform as a Service (PaaS) was the field which grew the most in absolute terms (from US\$ 61.11 billion in 2016 to US\$ 197.6 billion in 2020). In relative terms, however, it was Infrastructure as a Service (IaaS) which grew the most (26,5%).

Public IT cloud services market revenue worldwide from 2016 to 2020, by segment (in billion U.S. dollars)

Global public IT cloud services revenue 2016-2020, by segment

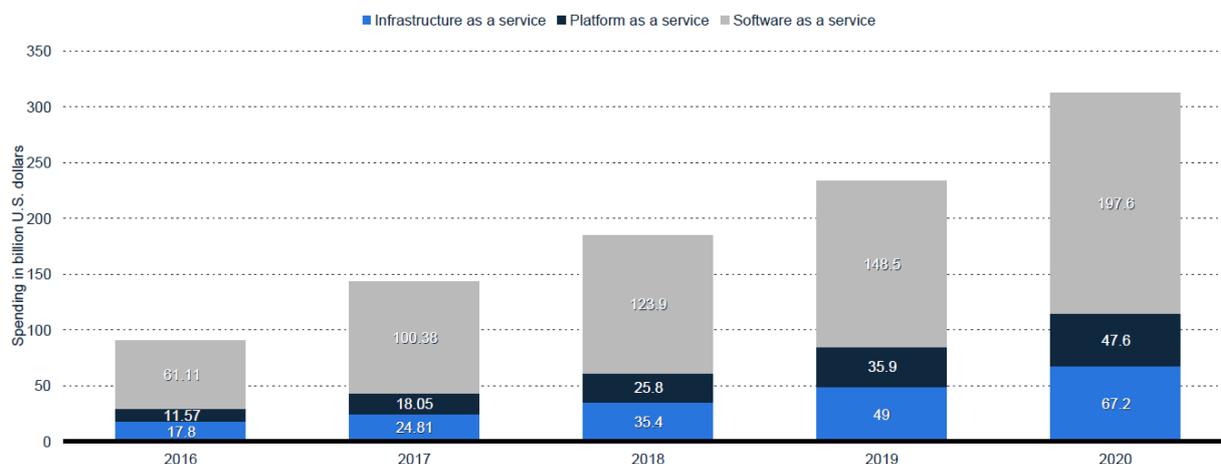


Figure 4 Global public IT cloud services revenue 2016-2020, by segment⁵

As presented by the white paper which was published by the EC-funded project H-Cloud⁶, companies often end up using neither fully cloud nor fully in-house solutions, but a combination of these types of solutions. This situation has led to different issues in the areas of interoperability, cybersecurity and an increase in costs. Multi-cloud and federated cloud are two ways in which these issues related to integration can be solved, either by the user (hybrid and multi-cloud) or by the service providers (federated cloud)⁷.

This situation has created many opportunities for business. As can be seen below, the hybrid-cloud market is expected to nearly triple from 2020 to 2026:

⁵ IDC; ID 370305 (2021)

⁶ <https://cordis.europa.eu/project/id/871920/es> (accessed 21/06/2022)

⁷ Arend, C., Calisti, M., Cattaneo, G., Claps, M., Fernández, E., Ferrari, T., Giuliano, A., Meadley, P., Robertshaw, S. (2022), "Cloud Computing in Europe: Landscape Analysis, Adoption Challenges and Future Research and Innovation Opportunities"

Hybrid cloud market size worldwide in 2020 and 2026

(in billion U.S. dollars)

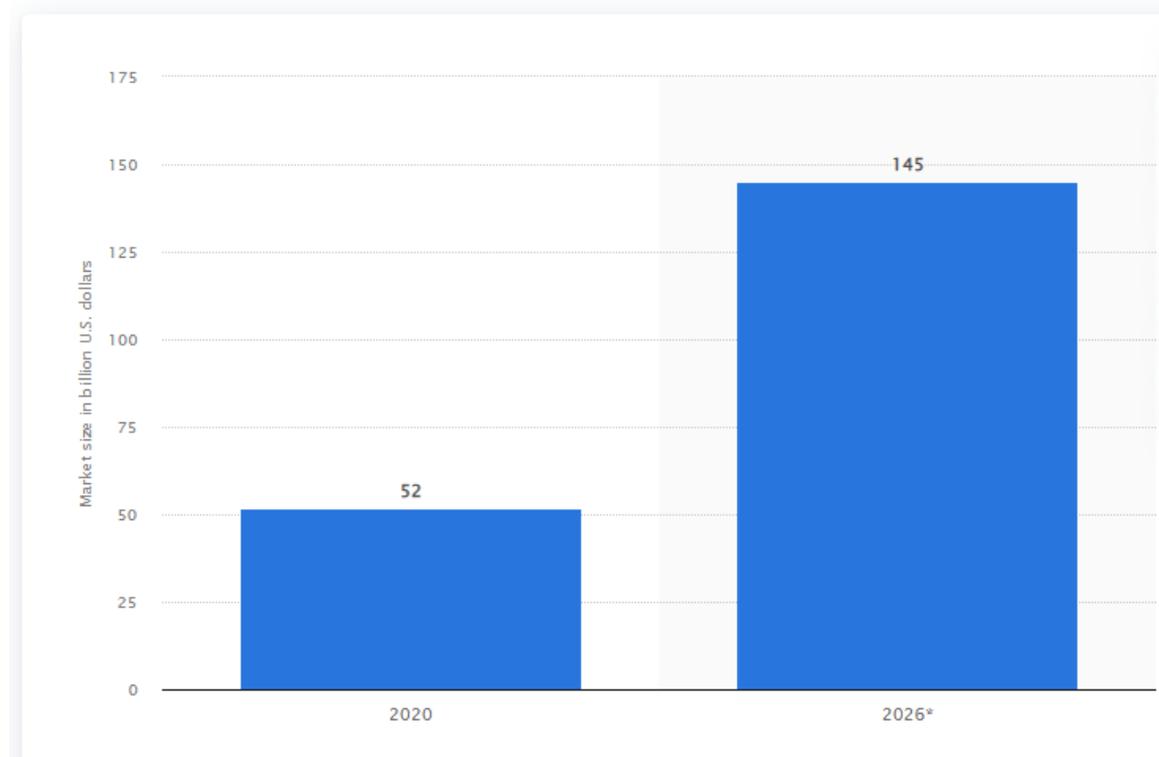


Figure 5 Worldwide hybrid-cloud market size⁸

1.2 SaaS

As we have just seen, SaaS has grown significantly in recent years, both for business and for personal use. As can be seen below, this growth has occurred in all sizes of organisations, from small to large enterprises.

⁸ <https://www.statista.com/statistics/1232355/hybrid-cloud-market-size/> (accessed 21/06/2022)

Global Market for SaaS, by Organization Size, 2018-2024 (\$ Millions)

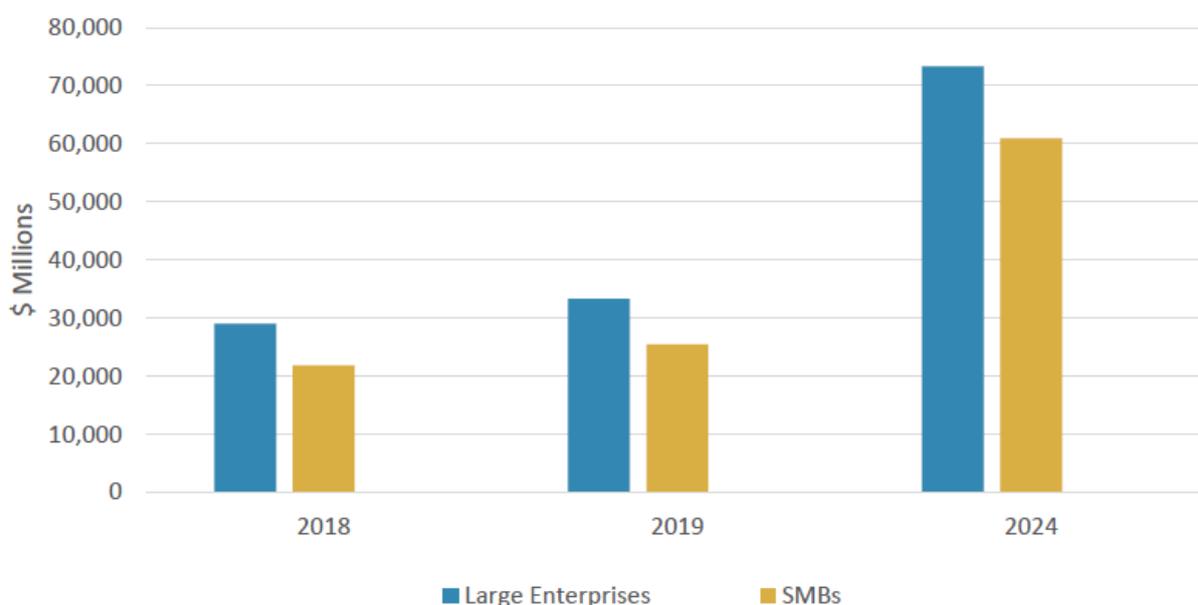


Figure 6 Global Market for SaaS, by Organization Size⁹

All sectors of activity, from e-commerce and retail to travel and hospitality have seen an increase in their SaaS markets in recent years. What is more, there is no sign that any of these markets will experience a deceleration any time soon.

Global Market for SaaS, by End-use Industry, Through 2024 (\$ Millions)

End-use Industry	2018	2019	2024	CAGR% 2019-2024
E-commerce and Retail	6,888.7	8,205.3	21,491.3	21.2
Manufacturing	9,456.6	10,665.7	21,491.3	15.0
BFSI	6,369.0	7,534.3	19,073.5	20.4
Media and Hi-tech	7,214.8	8,075.8	15,581.2	14.0
Healthcare and Life Sciences	4,738.5	5,591.8	14,103.6	20.3
Utilities	4,493.9	5,262.2	12,760.4	19.4
Travel and Hospitality	4,015.0	4,685.4	11,282.9	19.2
Others	7,775.2	8,841.0	18,536.2	16.0
Total	50,951.7	58,861.5	134,320.4	17.9

Figure 7 Global Market for SaaS, by Organization Size¹⁰

⁹ Cloud Components and Services: Global Markets (IFT187A), BCC (2019)

¹⁰ Cloud Components and Services: Global Markets (IFT187A), BCC (2019)

When comparing SaaS to other non-cloud alternatives, we are seeing that SaaS options are becoming more and more popular, replacing the latter in many parts of the world. By 2025, SaaS alternatives are expected to have a larger market share in countries such as the USA and the UK, even though the opposite was true in 2020.

Global software as a service (SaaS) market share 2020 and 2025, by select country (in million euros)

Global software as a service market share forecast 2020-2025, by select country

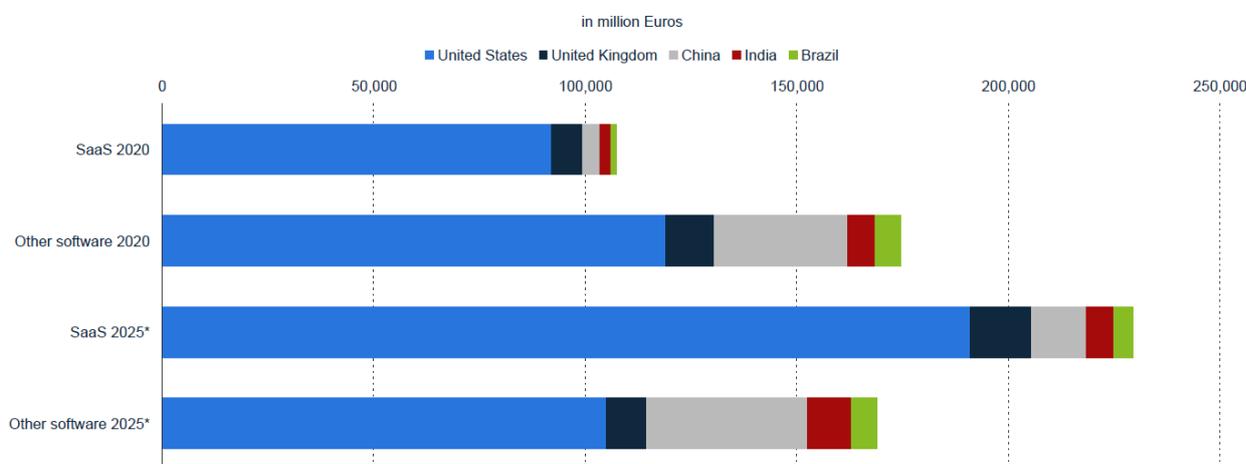


Figure 8 Global software as a service market share forecast 2020-2025, by select country¹¹

1.3 IaaS

The IaaS market has continued to grow in recent times, and it is expected to continue to grow in the near future at an average speed of 25% per year, at least for the next couple of years. What is quite remarkable is that, as can be seen in the figure below, IaaS is expected to grow at a similar rate across different sectors. The range of expected growth goes from 21.3% CAGR in IT and telecom, to 29% in healthcare. In absolute terms, media and entertainment, IT and telecom, BFSI, and retail and commerce are the industries with the biggest markets¹².

¹¹ Statista estimates; teknowlogy Group; ID 1219255 (2021)

¹² Cloud Components and Services: Global Markets (IFT187A), BCC (2019)

Global Market for IaaS, by Industry Vertical, Through 2024 (\$ Millions)

Industry Vertical	2018	2019	2024	CAGR% 2019-2024
Media and entertainment	5,160.6	7,479.5	24,480.4	26.8
IT and telecom	6,380.4	8,864.6	23,249.5	21.3
BFSI	4,972.9	7,157.8	22,702.5	26.0
Retail and e-commerce	4,722.7	6,728.9	20,377.5	24.8
Discrete manufacturing	2,877.4	4,146.3	13,265.9	26.2
Energy and utilities	2,533.4	3,663.8	11,898.3	26.6
Healthcare	2,064.2	3,065.1	10,941.0	29.0
Others	2,564.7	3,574.4	9,846.9	22.5
Total	31,276.3	44,680.3	1,36,761.9	25.1

Table 1 Global Market for IaaS, by Industry Vertical¹³

If we analyse the IaaS market size by size of organisation, we see that large companies had double the market as SMEs did in 2018. This difference diminished slightly in 2019, and the tendency is that it will continue to diminish in the coming years. Altogether, large companies' market is expected to grow at a rate of 22.6% per year, whereas SMEs are expected to grow at a rate of 29.2% per year until 2024¹⁴.

Global Market for IaaS, by Organization Size, 2018-2024 (\$ Millions)

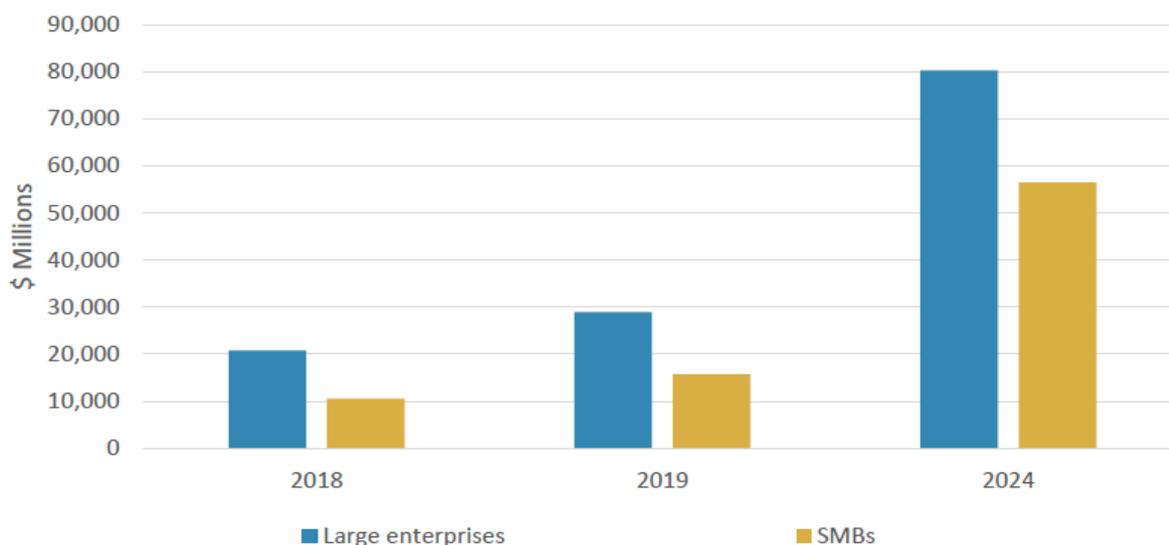


Figure 9 Global Market for IaaS, by Organization Size¹⁵

¹³ Cloud Components and Services: Global Markets (IFT187A), BCC (2019)

¹⁴ Cloud Components and Services: Global Markets (IFT187A), BCC (2019)

¹⁵ Cloud Components and Services: Global Markets (IFT187A), BCC (2019)

1.4 PaaS

By the end of 2022, the global PaaS market is expected to grow all the way up to US\$ 101 billion, compared to the US\$ 4 billion of 2015. That is 25 times what it was worth just 7 years before! This proves how potent the possibility to develop applications and services over cloud computing platforms really is.

Public cloud platform as a service (PaaS) end-user spending worldwide from 2015 to 2022 (in billion U.S. dollars)

Public cloud application infrastructure services market 2015-2022

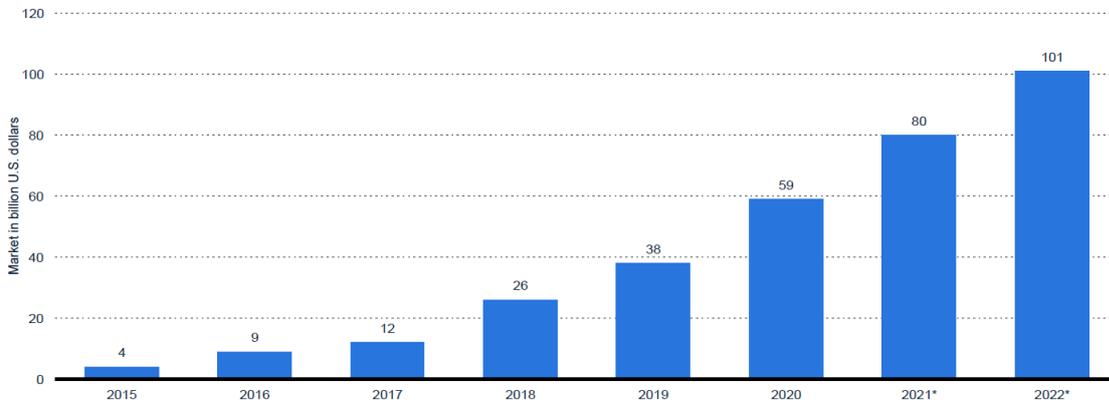


Figure 10 Public cloud PaaS market¹⁶

In the period between 2016 and the end of 2022, all segments of PaaS (iPaaS, adPaaS, baPaaS, aPaaS, dbPaaS, bpmPaaS and others) are expected to grow. Predictions for Database Platform as a Service (dbPaaS) in particular are especially positive, as this market foreseen to grow to US\$ 12.1 billion in 2022.

Global spending on Platform as a Service (PaaS) by segment from 2016 to 2022 (in billion U.S. dollars)

Platform as a Service (PaaS) spending by segment worldwide 2016-2022

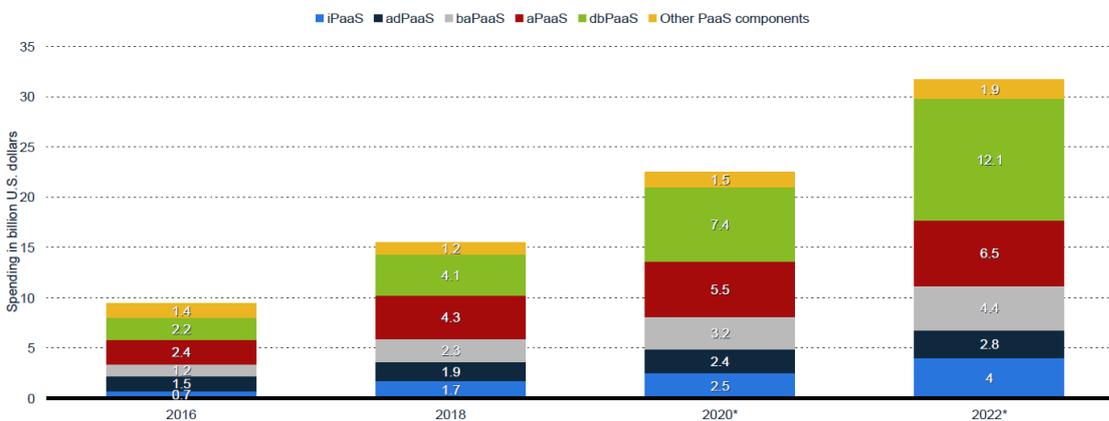


Figure 11 Platform as a Service (PaaS) spending by segment worldwide 2016-2022¹⁷

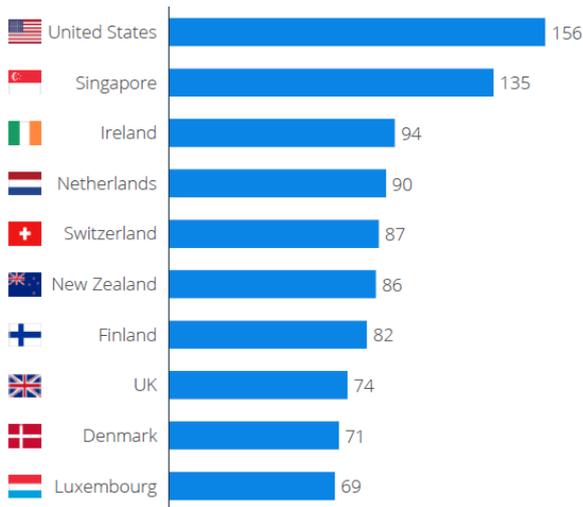
¹⁶ Statista Platform as a Service (PaaS) (2021)

¹⁷ Statista Platform as a Service (PaaS) (2021)

Below is a list of the countries with the highest levels of spending in PaaS per employee in 2020. We can see that the USA is on top of this list, followed by Singapore. Ireland, the Netherlands, Switzerland, Finland, Denmark and Luxembourg are the European countries that make this top-ten list.

When it comes to revenues generated by PaaS, we see that, as of 2020, the Americas were the world region with the highest share (62%). Europe followed at a distance (23%). If we look at the populations of both regions of the world, we see that the Americas (with a population of nearly one billion,) are well ahead of Europe (which has a population of around 750 million).

Spend per employee ranking in US\$ in 2020



Revenue share in 2020

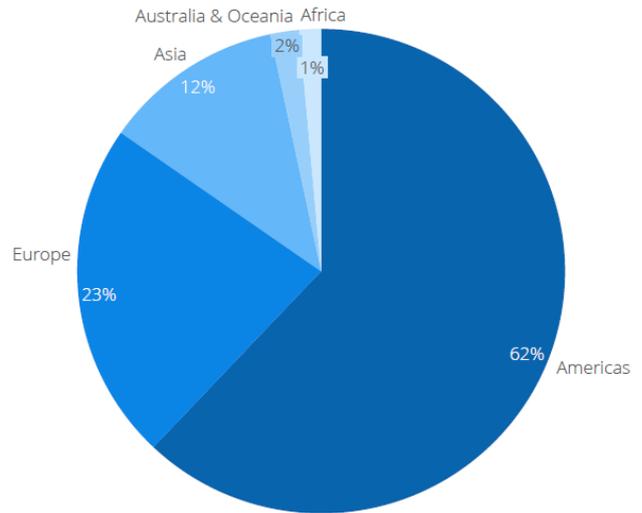


Figure 12 Spend per employee ranking in US\$ and revenue share in 2020¹⁸

¹⁸ Statista Platform as a Service (PaaS) (2021)

2 CLOUD COMPUTING MARKETS IN EUROPE

So far, we have analysed cloud computing markets from a global perspective. In this chapter we are going to concentrate on Europe and, more precisely, on the EU. We are going to look at the characteristics of the European cloud computing markets in order to be able to identify the most relevant opportunities for European entrepreneurs.

As of 2020, Europe had a cloud computing market of nearly €54 billion. SaaS was the main segment with CC, taking up around 63% of the total. IaaS and PaaS were at distant second and third places, with 20 and 17%, respectively. All segments are expected to grow year by year in the near future. SaaS and IaaS are expected to more than double by 2025; and PaaS is expected to be more than triple the size it was in 2020, as can be seen in the figure below. So, according to these predictions, it could be argued that the future of European CC markets look extremely bright.

Cloud computing market size in Europe from 2016 to 2025, by segment (in billion EUR)

European cloud computing market size 2016-2025, by segment

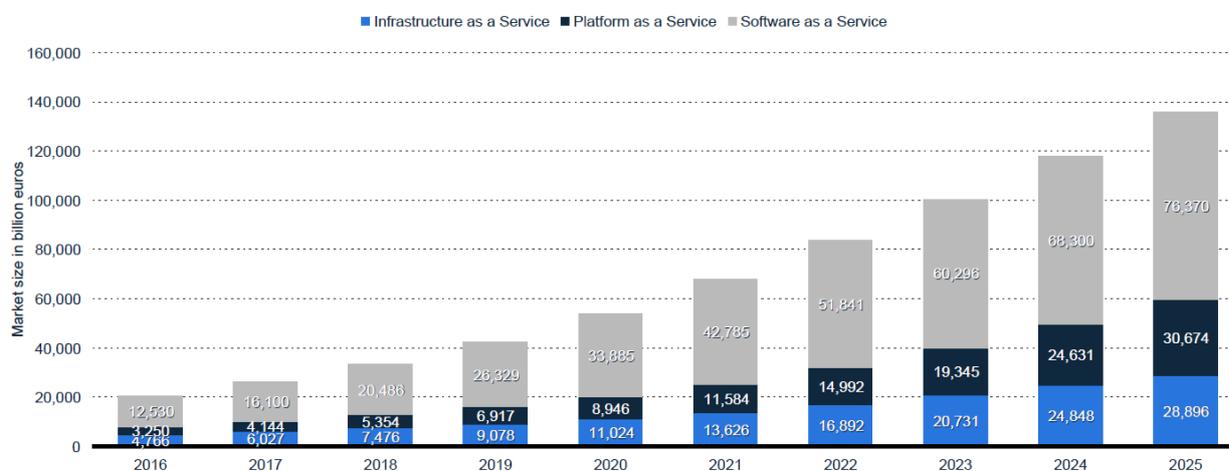


Figure 13 Cloud computing market size in Europe from 2016 to 2025, by segment¹⁹

2.1 Main CC service providers in Europe

It is no secret that US-based companies dominate the world (and European) cloud computing markets. Amazon Web Services (AWS), Microsoft Azure and Google Cloud have a more than a 65% share of the European market. The main European cloud computing service provider is the German Deutsche Telekom, yet this company only has a 2% share of the market. It is followed by the French OVH Cloud and a myriad of regional and national telcos. As of the first half of 2021, revenues from European CC markets kept growing. Even though total markets for European service providers kept growing, their share of the European market decreased to less than 16%²⁰.

¹⁹ Statista European cloud computing market size 2016-2025, by segment (2021)

²⁰ <https://www.statista.com/topics/8472/cloud-computing-in-europe/#dossierKeyfigures> (accessed 05/04/2022)

This situation has led the institutions of Europe, and especially those of the European Union, to develop initiatives to promote European cloud service providers. The main such initiative is GAIA-X, which aims to maintain data sovereignty within European cloud infrastructures²¹.

2.2 CC usage by European enterprises

Cloud computing requires access to the internet. Currently, almost all companies of 10 or more employees in the EU fulfil this requirement, as 98% of enterprises have access to the internet. It is noteworthy that access to the internet for these companies is similar across countries in the EU.

Around 2/5 of these companies use cloud computing services. And this ratio is increasing, as the number of companies using cloud computing services grew by 5% from 2020 to 2021. It should be noted, moreover, that nearly $\frac{3}{4}$ of the companies using cloud computing use sophisticated CC services in the fields of security, database hosting, application development platforms, etc.

Data related to the use of cloud computing services varies widely from country to country. Sweden and Finland quintuple the use of CC of Bulgaria, for instance. With the exception of Denmark, all EU countries' companies' use of CC has either grown or remained constant between 2020 and 2021²².

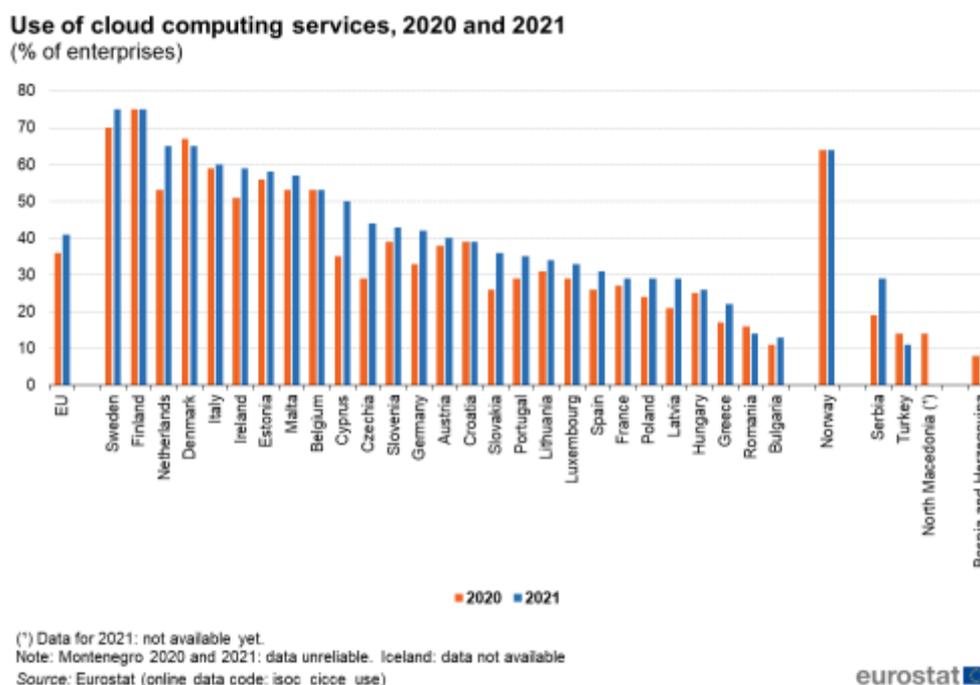


Figure 14 Use of cloud computing services in enterprises, 2020 and 2021 (% of enterprises)²³

²¹ Statista, Cloud Computing in Europe (2021)

²² https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Cloud_computing_statistics_on_the_use_by_enterprises (accessed 04/04/2022)

²³ https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Cloud_computing_statistics_on_the_use_by_enterprises (accessed 04/04/2022)

If we look at the CC applications that enterprises use, we see that e-mail is still the most popular one, followed by storage of data, office software and security software. E-mail in particular is used at a large scale in all European countries. Usage of office software is also quite consistent across different countries. Storage and security applications, on the other hand, are used to a large degree in countries such as Denmark; but not so much in countries such as Poland.

Platform for application development, testing or deployment was the least used type of CC. This is understandable, as only certain types of companies require these types of services. There are, nevertheless, significant differences between countries, from 7 and 8% in Czechia and Cyprus; to 40% in Denmark.

Use of cloud computing services in enterprises, 2021

	Use of cloud computing	E-mail	Storage of files	Office software	Security software applications	Financial or accounting software applications	Hosting the enterprise's database(s)	CRM software applications	Computing power for enterprise's own software	ERP software applications	Platform for application development, testing or deployment
	% enterprises	% enterprises using the cloud									
EU	41	79	66	61	58	47	46	27	24	24	21
Belgium	53	82	81	68	65	50	58	46	40	36	27
Bulgaria	13	80	68	60	44	32	55	21	21	24	21
Czechia	44	81	62	85	78	52	32	17	11	19	7
Denmark	65	86	83	73	80	65	72	38	43	35	40
Germany	42	65	61	55	48	40	33	21	25	18	23
Estonia	58	77	65	68	44	75	26	19	32	19	17
Ireland	59	80	69	73	54	54	40	24	12	13	16
Greece	22	84	67	73	50	34	41	28	36	28	36
Spain	31	82	80	63	62	40	69	38	35	33	28
France	29	67	76	54	51	44	59	30	22	31	25
Croatia	39	88	72	61	65	52	54	20	23	18	22
Italy	60	96	58	58	70	52	39	19	14	20	10
Cyprus	50	83	60	68	71	43	23	20	12	17	8
Latvia	29	79	54	57	41	36	49	17	22	15	17
Lithuania	34	80	58	51	52	46	42	17	33	13	22
Luxembourg	33	81	67	68	61	41	65	33	27	23	29
Hungary	26	72	61	61	45	41	44	21	32	18	17
Malta	57	89	83	80	55	51	55	33	41	22	26
Netherlands	65	82	81	72	64	66	78	49	28	35	30
Austria	40	70	71	52	49	27	26	23	24	16	28
Poland	29	79	41	64	41	30	27	17	10	22	14
Portugal	35	89	71	61	66	41	46	26	35	34	25
Romania	14	80	58	58	52	44	50	27	22	30	22
Slovenia	43	73	66	66	72	38	43	21	28	25	23
Slovakia	36	88	60	65	68	52	39	28	25	16	18
Finland	75	85	76	75	65	64	49	41	20	37	17
Sweden	75	87	84	71	64	73	60	38	43	21	27
Norway	64	88	83	78	67	69	67	38	39	33	32
Serbia	29	77	52	46	34	42	37	14	17	19	14
Turkey	11	72	71	57	46	57	37	27	35	56	29
Bosnia and Herzegovina	9	84	65	62	58	49	55	27	33	28	31

Note: Iceland: 2021 data not available. North Macedonia: 2021 data not available. Montenegro: 2021 data unreliable.
Source: Eurostat (online data code: isoc_cicce_use)



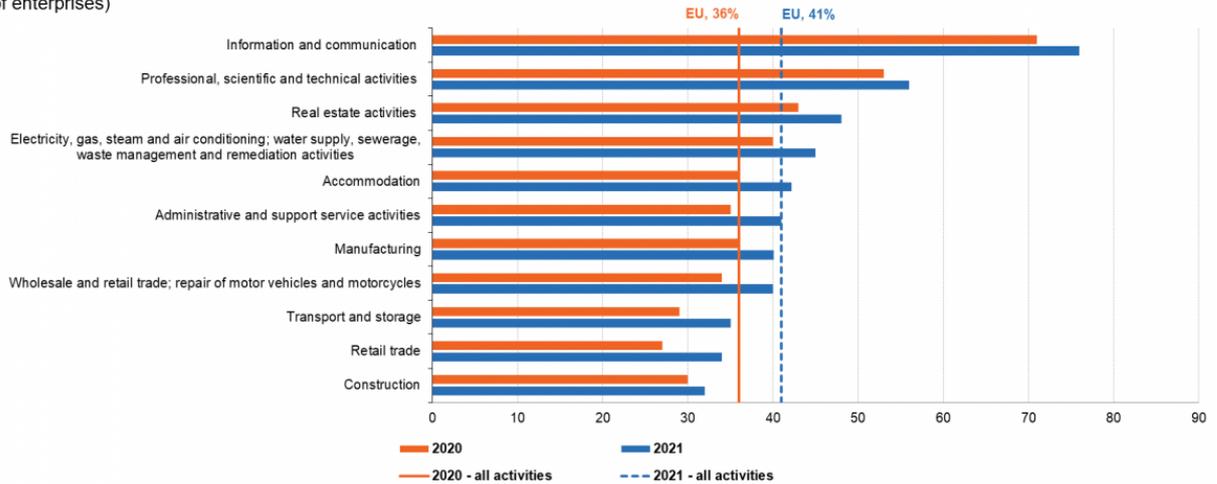
Table 2 Use of cloud computing services in enterprises, 2021²⁴

CC is on the rise regardless of type of economic activity. As we can see in the graph below, all the different types of activity which were analysed experienced growth in CC usage from 2020 to 2021. However, not all sectors share the same level of CC usage. While nearly 80% of ICT companies use CC tools, these tools are not nearly as widespread in construction, retail trade or transport and storage, where they do not even reach the 40% mark. It should be pointed out that, from 2020 to 2021, the highest relative increase in CC usage took place in retail trade, which grew by 7%.

24

https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Cloud_computing_statistics_on_the_use_by_enterprises (accessed 04/04/2022)

Use of cloud computing services, by economic activity, EU, 2020 and 2021
(% of enterprises)



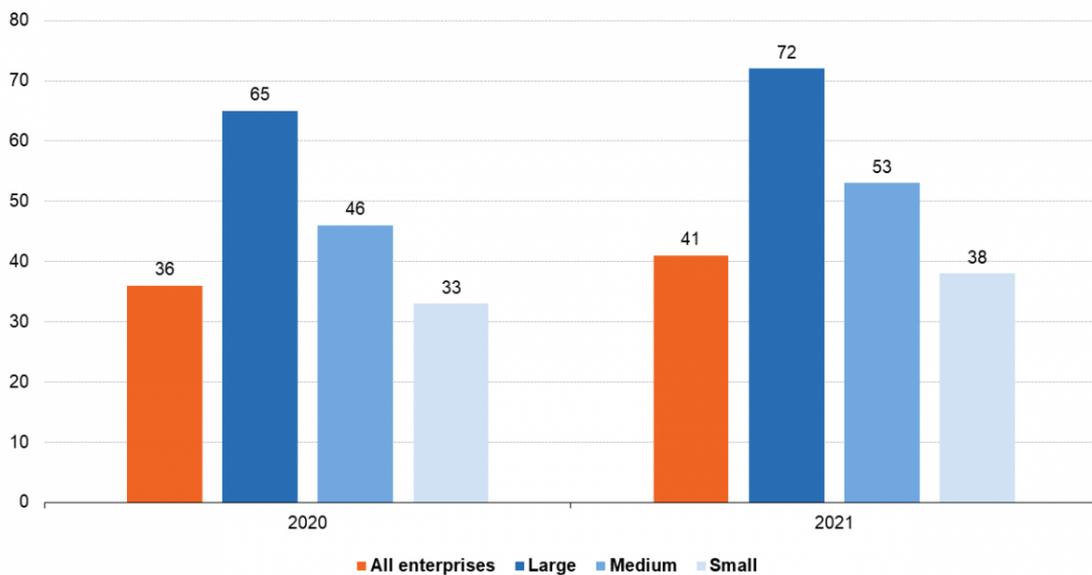
Source: Eurostat (online data code: isoc_cicce_use)

eurostat

Figure 15 Use of cloud computing services, by economic activity²⁵

In terms of company size, we see that, the larger the company, the more cloud computing is used. Another observation that can be made is that cloud computing is growing in companies of all sizes. And the gap between larger and smaller companies is decreasing slightly: whereas in 2020 almost double the large enterprises used cloud computing compared to small enterprises (1.97 times), in 2021 this ratio decreased moderately (1.89 times).

Use of cloud computing services, by size, EU, 2020 and 2021
(% of enterprises)



Source: Eurostat (online data code: isoc_cicce_use)

eurostat

Figure 16 Use of cloud computing services, by size²⁶

²⁵ https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Cloud_computing_statistics_on_the_use_by_enterprises (accessed 04/04/2022)

²⁶ https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Cloud_computing_statistics_on_the_use_by_enterprises (accessed 04/04/2022)

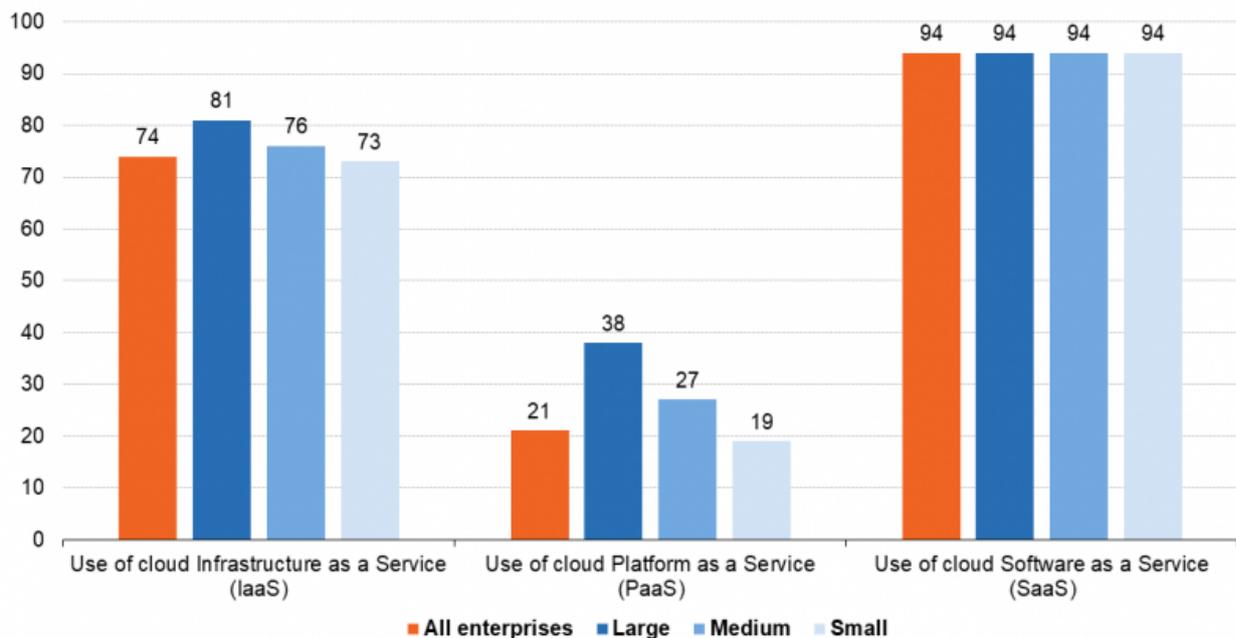
If we analyse the use of cloud computing in companies by service model, we see that 94% of companies of all sizes use Software as a Service. Therefore, we could conclude that SaaS is commonplace in nearly the totality of companies that use CC.

The percentage of companies using Infrastructure as a Service does not differ too significantly by company size, from 73% in small companies to 81% in large companies.

The big difference comes when analysing the use of Platform as a Service, as large companies using PaaS represent double (38%) the amount of small companies using PaaS (19%) as part of their daily activities.

Types of cloud computing services used, by service model, EU, 2021

(% of enterprises using the cloud)



Source: Eurostat (online data code: isoc_cicce_use)

eurostat 

Figure 17 Types of cloud computing services used, by service model²⁷

In terms of sophistication of CC services employed by enterprises, three levels are differentiated:

1. Basic level includes: e-mail, office software, storage, etc.
2. Intermediate includes basic-level options and: software for finance or accounting, ERP, CRM, etc.
3. Sophisticated includes basic-and-intermediate-level options and: security software, database hosting, computing platform for software development, etc.

As we can see below, the percentage of companies using CC at a basic or intermediate level of sophistication does not exceed 17%. What is more, more than 70% of companies using CC use

²⁷

https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Cloud_computing_-_statistics_on_the_use_by_enterprises (accessed 04/04/2022)

sophisticated CC services.

There are no significant deviations in terms of sophistication by size of organisation, as the range of adoption for each type varies in less than 5% for small, medium or large enterprises.

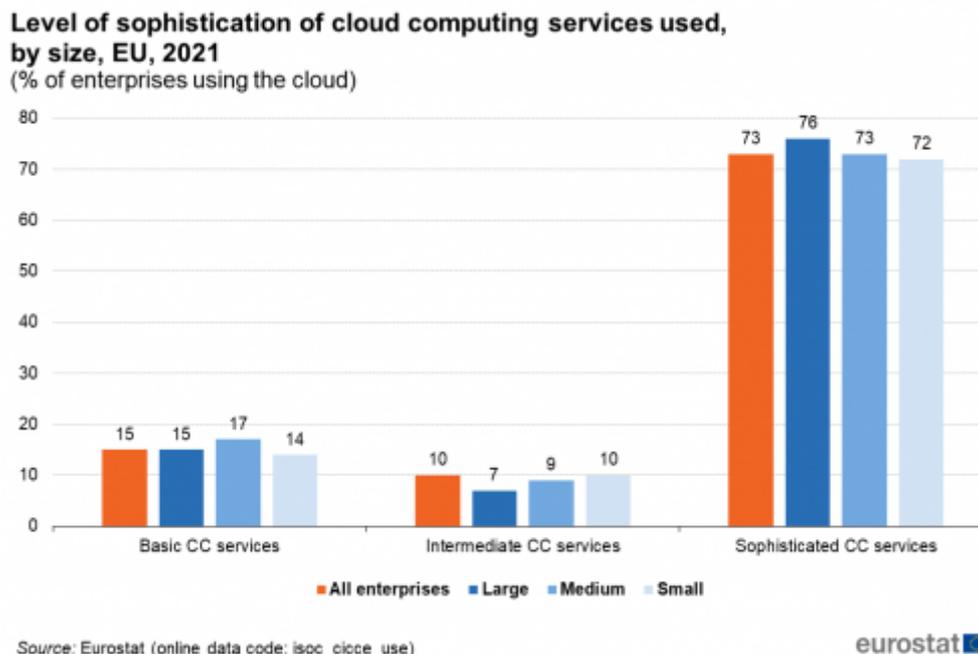


Figure 18 Level of sophistication of cloud computing services used, by size²⁸

2.3 Specificities of the European CC market

In general, it is believed that Europe is not only lagging behind in terms of control of the technology market, but that Europe is way too dependent on the technologies provided by foreign actors. This is particularly true for cloud computing, where more than 75% of tech professionals believe that the EU is too dependent on external actors²⁹.

²⁸ https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Cloud_computing_statistics_on_the_use_by_enterprises (accessed 04/04/2022)

²⁹ Statista, Cloud computing in Europe (2022)

Tech professionals believe the European Union is too dependent on external actors 2021, by technology

EU: dependency on external actors in tech according to professionals 2021

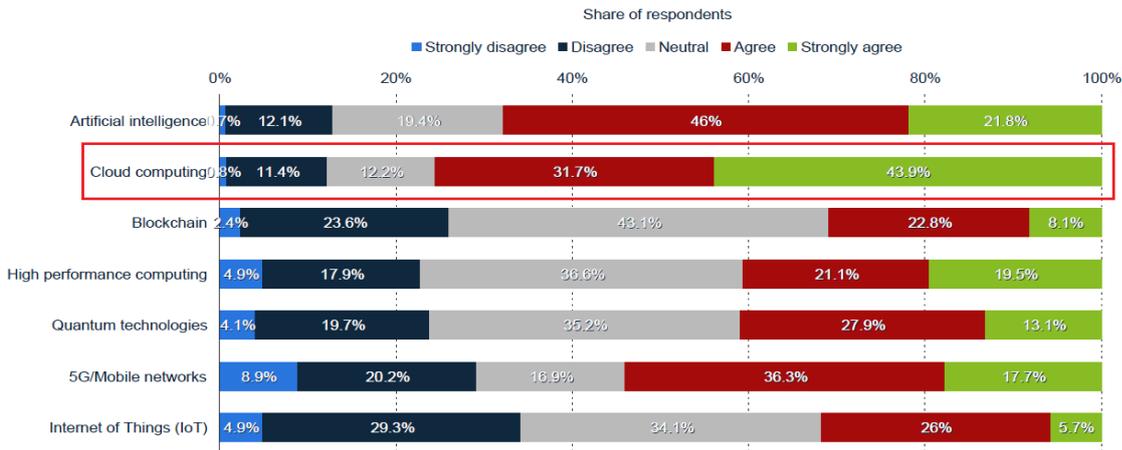


Figure 19 EU: dependency on external actors in tech according to professionals³⁰

If we take a look at which country leads the cloud computing market, it is obvious that the US is the one country that controls what is by far the highest share of the market. Companies like Amazon Web Services (AWS), Microsoft Azure, or Google Cloud barely have any competitors in Europe. This is a widely held belief in the tech professionals' community, as 92.7% of tech professionals believe that the EU is too dependent on external countries when it comes to cloud computing, with special emphasis on the US³¹.

Tech professionals believe the European Union is too dependent on external countries 2021, by technology

EU: dependency on external countries tech according to professionals 2021

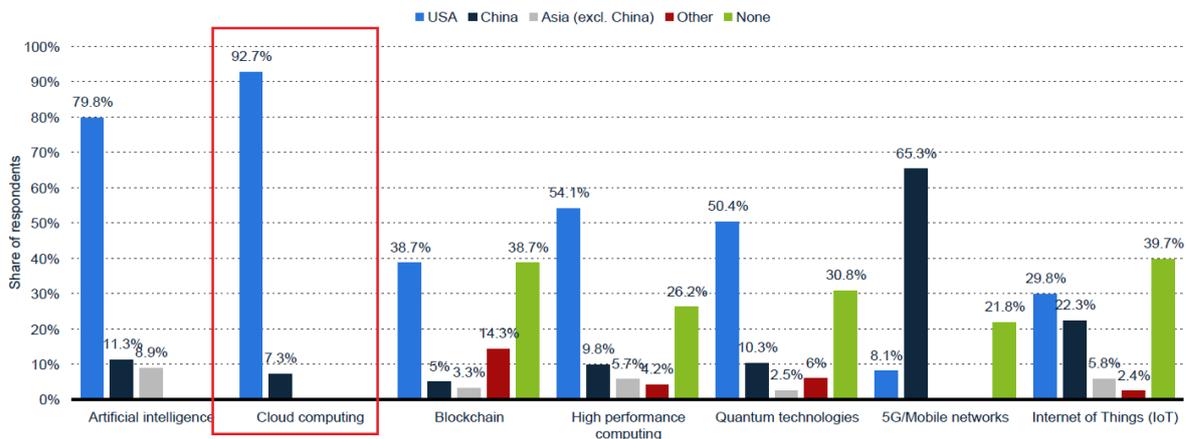


Figure 20 EU: dependency on external countries tech according to professionals³²

³⁰ Statista, EU: dependency on external actors in tech according to professionals (2021)

³¹ Statista, Cloud computing in Europe (2022)

³² Statista, EU: dependency on external countries tech according to professionals (2021)

Having the current market situation in mind, we will now explore the characteristics of the European CC market. It is crucial for entrepreneurs to understand the specific conditions which affect the market that they are going to try to approach.

We will begin by stating that the European CC market is like no other in the world. Europe represents around a quarter of the global IT market, and cloud computing is turning into one of the highest priorities for European CIOs. Moreover, the cloud computing market is expected to grow at a rate of 20% per year and reach €44 billion by 2024³³.

Europe is singular in that there are numerous official languages; differences in technological and economic development across regions; specific local, regional and national regulations, etc. This makes Europe a very diverse continent in many respects. This leads European companies to have very different sets of priorities compared to those of other parts of the world. As can be seen in the figure below, the reasons why European companies would keep their data offline are different to those of other countries. For instance, European enterprises focus more on regulatory compliance, control and governance and data security than in other countries. In North America and Asia, for instance, the cost of the technology plays a much more relevant role in the decision-making process³⁴.

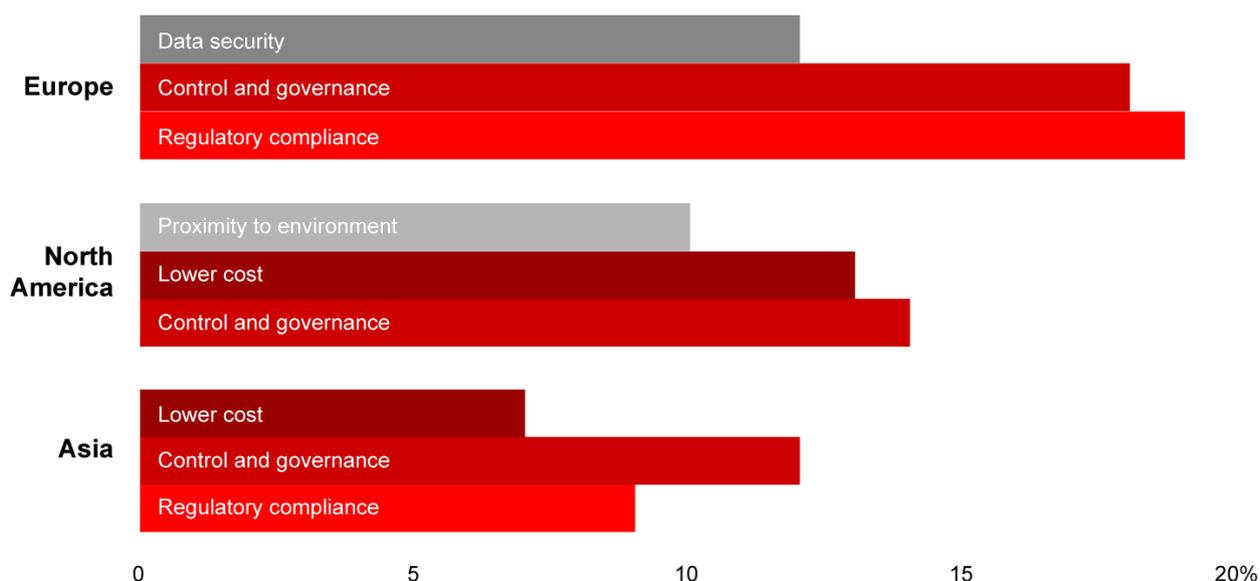
The appearance of Europe-wide regulations such as the General Data Protection Regulation (GDPR) have made it crucial for European enterprises to make sure that they comply with such regulations, thus affecting their CC offering and acquisition. The Digital Markets Act (DMA) and Digital Services Act (DSA), which have been proposed by the European Commission, aim to develop a safer digital space³⁵. Such regulatory schemes may represent barriers for newcomers and established service providers, as they have to adapt their services to satisfy them. But they may also represent an opportunity for CC entrepreneurs who can make these conditions work to their advantage.

³³ <https://www.bain.com/insights/how-cloud-companies-can-win-in-europe-tech-report-2021/> (accessed 12/04/2022)

³⁴ <https://www.bain.com/insights/how-cloud-companies-can-win-in-europe-tech-report-2021/> (accessed 12/04/2022)

³⁵ <https://digital-strategy.ec.europa.eu/en/policies/digital-services-act-package> (accessed 12/04/2022)

Top three reasons for keeping data on-premise



Source: 2021 Bain cloud survey (n=EU 204, North America 365, Asia 69)

Figure 21 CIOs in Europe have stricter concerns about data security, governance, and regulatory compliance³⁶

Regulatory frameworks not only affect the requirements that cloud computing providers and customers must comply with, but also the types of economic activities in which cloud computing is more likely to be employed.

More security-affected sectors like healthcare, for instance, are less prone to use cloud-based solutions, due to the difficulty to share patient data across companies and countries. This needs to be taken into account by CC entrepreneurs, who must work extra hard to be able to provide satisfactory solutions to their customers. Beyond regulations, the costs of successful migration to the cloud and customisation represent the biggest problems for companies in the utility sector; and the same can be said for scalability and reaction time to customer requests in the telecom industry.

As a result of this situation in the CC market, service providers are going to have to come up with industry-specific solutions. And, in some cases, customer-specific solutions. It is estimated that, by the end of 2022, 20% of all CC spending by companies will be directed towards solutions that are specific to their industries³⁷.

The big international players have a considerable advantage over the European cloud computing market, as they have the economic power to adapt to the specificities of the European market. Therefore, European entrepreneurs must use whatever weapons they may have at their disposal. These may include teaming up with security-based IT companies to provide CC-based solutions; focusing on needs of the micro niches which are not being covered by the big companies; or taking advantage of initiatives such as Gaia-X to accommodate public or private customers which demand that the services which are being offered comply with such frameworks.

³⁶ <https://www.bain.com/insights/how-cloud-companies-can-win-in-europe-tech-report-2021/> (accessed 22/03/2022)

³⁷ <https://www.bain.com/insights/how-cloud-companies-can-win-in-europe-tech-report-2021/> (accessed 22/03/2022)

3 OPEN SOURCE VS. PROPRIETARY SOLUTIONS IN CLOUD COMPUTING

There is an open debate in software and hardware over intellectual property rights, and the implications that they have in reference to business models and innovation results. Economists have often argued that IPR allows for innovation to occur, as entrepreneurs are motivated to seek the benefits derived from the exclusive commercial exploitation of their inventions³⁸. Moreover, IPR protection in the software industry can be a useful tool for the licencing of products and services, as it allows entrepreneurs to package and commercialise the results of their inventions.

3.1 Copyright protection

The European Commission published the Council Directive 2009/24/EC of 23 April 2009 regarding the legal protection of computer programmes. Article 1 of said Directive states that *“Member States shall protect computer programs, by copyright, as literary works within the meaning of the Berne Convention for the Protection of Literary and Artistic Works”*³⁹.

The WIPO Copyright Treaty establishes that *“Computer programs are protected as literary works within the meaning of Article 2 of the Berne Convention. Such protection applies to computer programs, whatever may be the mode or form of their expression”*⁴⁰.

It must be noted, however, that copyright protects the source code of computer programmes. This copyright protection does not cover their functionalities, programming languages, data formats or architectural features⁴¹. Copyright protection is viewed as an effective tool to prevent copying of software at a large scale, but it is not considered to avoid the copying of existing algorithms by using alternative expressions⁴². What is more, a factor that must be considered is that, before, SaaS, binary code was used to release computer programmes. This made it more difficult for competitors to copy the non-protected functionalities of these programmes⁴³.

3.2 Patent protection

Patents can be used for different reasons, but often they are used as a defence mechanism rather than to promote innovation. Moreover, patents are often used in the software industry as a way to better negotiate licensing of products and services; and as way to retaliate against infringement of intellectual property rights⁴⁴. Finally, those organisations using EPO patents to

³⁸ Scotchmer, S. (2004). Innovation and incentives. MIT press.

³⁹ <https://eur-lex.europa.eu/legal-content/GA/TXT/?uri=CELEX%3A31991L0250> (accessed 19/04/2022)

⁴⁰ <https://www.jus.uio.no/lm/en/html/wipo.copyright.treaty.1996/4.html> (accessed 19/04/2022)

⁴¹ Judgment of 2 May 2012, SAS Institute Inc. v World Programming, Ltd., C-406/10. World Programming Ltd., paragraph 46.

⁴² Martinez Catalina (2018), Expanding Patents in the Digital World: The Example of Patents in Software in In X. Seuba, C. Geiger, & J. Pénin (Eds.), Intellectual Property and Digital Trade in the Age of Artificial Intelligence and Big Data. Centre d'études internationales de la propriété intellectuelle (CEIPI). CEIPI / ICTSD Publication Series on Global Perspectives and Challenges for the Intellectual Property System, No. 5

⁴³ Kazimierczak, Michał, Breckwoldt Jurado, Altair, & Wajsman, Nathan (2020, June) Open Source Software in the European Union, EUIPO

⁴⁴ Graham, S. J., Merges, R. P., Samuelson, P., & Sichelman, T. (2009). High technology entrepreneurs and the patent system: Results of the 2008 Berkeley patent survey. Berkeley Technology Law Journal, 24(4), 1255.

protect their IPR in the software industry cited Freedom to operate as one of the main reasons for them to patent their inventions⁴⁵.

3.3 Other methods of software IPR protection

Another form of IPR protection which is common in the software industry is trade secrets. Article 30 of the Agreement on Trade-Related aspects of Intellectual Property Rights (TRIPS) states that the conditions that a trade must fulfil include⁴⁶:

1. The information which is meant to be kept secret must not be publicly known or readily available to people who are knowledgeable in the field in question.
2. The information which is meant to be kept secret has commercial value because it is secret.
3. The information which is meant to be kept secret is actively being kept secret by those who have produced it.

Within the software industry, trade secrets can serve to protect content representation, algorithms and data structures. Cloud computing, and especially SaaS, has given rise to this type of protection, as there is no need to provide access to the code while using this kind of products.

Finally, although not specifically relevant to the features of the products themselves, software products can be protected by trademark. The reason for the use of trademarks is that one may prevent a competitor from using a similar name or logo, thus making our product unique in the market⁴⁷.

3.4 Free and Open-Source Software

As an alternative to IPR protection in the software industry, we have Free and Open Source Software (OSS). As IPR protection developed, some viewed that these developments went against the more open and sharing nature of the community of software developers, thus restricting creativity and cooperation⁴⁸. As this OSS movement grew, it developed into a structured establishment.

In 1985, the Free Software Foundation (FSF) published what became known as the “Four freedoms” of software⁴⁹:

- *“the freedom to run the software for any purpose;*
- *the freedom to study how the program works, and change it so it does your computing as you wish;*
- *the freedom to redistribute copies so you can help others;*
- *the freedom to distribute copies of your modified versions to others”.*

These four freedoms do not necessarily mean that one should not make charge a price for

⁴⁵ Frietsch, R., Neuhäusler, P., Melullis, K. J., Rothengatter, O., & Conchi, S. (2015). The economic impacts of computer-implemented inventions at the European Patent Office. Fraunhofer Institute for Systems and Innovation Research.

⁴⁶ https://www.wto.org/english/docs_e/legal_e/27-trips_04d_e.htm (accessed 19/04/2022)

⁴⁷ Kazimierczak, Michał, Breckwoldt Jurado, Altair, & Wajzman, Nathan (2020, June) Open Source Software in the European Union, EUIPO

⁴⁸ Williams, S. (2002). Free as in Freedom: Richard Stallman's Crusade for Free Software. O'Reilly Media, Inc..

⁴⁹ <https://www.gnu.org/philosophy/free-sw.html> (accessed 12/04/2022)

providing software products or services. What they do mean is that one should not charge royalties for the software that is distributed.

Prior to the publication of the four freedoms, Richard Stallman founded the GNU project in 1983 as a response to the proprietary UNIX operating system⁵⁰.

OSS licences can be divided into two different types⁵¹:

1. Copyleft licences: these include GNU GPL, and demand that any changes made to the original OSS software be made available under the same licencing conditions as the original.
2. Permissive licences: these include Apache, Berkeley Software Distribution (BSD) and MIT. This type of licences does not require that the distribution of the changes in the code be carried out under the same terms as the original code. Therefore, we are talking about a hybrid between OSS and proprietary licences.

The main difference between these two types of licences is represented by the fourth freedom of the FSF: the freedom to distribute copies of your modified versions to others. With permissive licences, one is allowed to distribute modified versions of the software using whichever licence one may choose, even proprietary licences⁵².

Modern networking technologies have allowed the OSS ecosystem of companies to flourish, thus facilitating the growth of the OSS movement and people's awareness of it. This had led to a wide variety of new licensing schemes and business models to emerge.

3.5 Use of OSS licenses by for-profit firms

Open knowledge dissemination is one of the main objectives of the OSS community. This allows entrepreneurs to take advantage of the situation and have access to knowledge which may not otherwise be available to them. Moreover, evidence shows that benefits of OSS are switching from considerations dealing with low-cost operations to those dealing with strategic objectives⁵³.

By employing OSS, entrepreneurs can generate products and services as part of a strategy to compete with bigger players in the market⁵⁴. This is particularly true whenever this bigger player exercises a product or service that acts as a 'bottleneck' product, thus allowing the OSS entrepreneurs to compete against said giants⁵⁵.

It has been argued that open-source software results in not only faster adoption rates, but also larger numbers of users. This generates a complementary market for related products and services. Therefore, going the OSS route allows entrepreneurs to explore new applications for existing solutions, which in turn results in new jobs being created. By competing against a giant

⁵⁰ Haff, G. (2018). *How Open Source Ate Software. Understand the Open-Source Movement and So Much More*. Apress.

⁵¹ <https://www.whitesourcesoftware.com/resources/blog/open-source-licenses-explained/> (accessed 19/04/2022)

⁵² Phillips, D. E. (2009). *The software license unveiled: how legislation by license controls software access*. Oxford University Press.

⁵³ Morgan, L., & Finnegan, P. (2014). Beyond free software: An exploration of the business value of strategic open source. *The Journal of Strategic Information Systems*, 23(3), 226-238.

⁵⁴ Merges, R. P. (2004). A new dynamism in the public domain. *The University of Chicago Law Review*, 183-203.

⁵⁵ Teece, D. J. (2018). Profiting from innovation in the digital economy: Enabling technologies, standards, and licensing models in the wireless world. *Research Policy*, 47(8), 1367-1387.

in the market, OSS entrepreneurs have the advantage of being perceived as the David vs. Goliath, thus receiving sympathy from potential customers⁵⁶.

Proprietary business models pose restraints on those who lack the IPR over the products and services. According to a study conducted by Morgan & Finnegan across 11 companies from Europe in 2014, inability to satisfy the demand from clients because of restrictions caused by proprietary software was one of the main reasons for these companies to develop commercial OSS projects⁵⁷.

There are, however, some risks that must be addressed when considering entrepreneurship in OSS. According to respondents to a survey, companies involved in OSS often lacked high-quality technical support, as well as proper documentation. Moreover, companies using software must make a culture change when switching from well-known and well-established proprietary software solutions to their OSS equivalents⁵⁸.

3.6 Business models involving open-source software

When entrepreneurs consider commercialising their software solutions, they must not only consider their innovative technologies and the available markets, but also the business models that they are going to use. Frequent and successful OSS business models include providing complements to existing solutions, e.g. providing support services or customising existing solutions to accommodate the specific needs of customers. It is argued that entrepreneurs must analyse the specific market they are targeting in order to find the right combination of proprietary and open products and services⁵⁹.

Open-source software can be incorporated in entrepreneurs' business models in different ways: by modality of offering, specific or mass market targeting, orientation of product vs. service, etc.⁶⁰ Furthermore, entrepreneurs can mix traditional business models with OSS by using a proprietary licence for commercial users and a free licence for general distribution⁶¹. Paid services can encompass software installation, migration, support, provision of specific features, training, consulting and the marketing of software.

The table below shows a series of business models that incorporate OSS in some way or another. The table was developed by R. Rajala, J. Nissilä and M. Westerlund in 2006.

⁵⁶ Merges, R. P. (2004). A new dynamism in the public domain. *The University of Chicago Law Review*, 183-203.

⁵⁷ Morgan, L., & Finnegan, P. (2014). Beyond free software: An exploration of the business value of strategic open source. *The Journal of Strategic Information Systems*, 23(3), 226-238.

⁵⁸ Morgan, L., & Finnegan, P. (2014). Beyond free software: An exploration of the business value of strategic open source. *The Journal of Strategic Information Systems*, 23(3), 226-238.

⁵⁹ Anderson, C. (2013). *Free: How today's smartest businesses profit by giving something for nothing*. Random House.

⁶⁰ Rajala, R., Nissilä, J., & Westerlund, M. (2006, June). Determinants of OSS revenue model choices. In *ECIS* (pp. 1839-1850).

⁶¹ Välimäki, M. (2005). The rise of open source licensing: a challenge to the use of intellectual property in the software industry. Turre publishing.

Revenue Model	Description	Licence Types	Revenue Sources
Support selling	A for-profit company provides support for software that is distributed free of charge.	Any	Revenue comes from media distribution, branding, training, consulting, custom development, and post-sales support for physical goods and services.
Loss-leader	A no-charge open-source product is used as a loss-leader for traditional commercial software, i.e. the software is made free with a hope that this will stimulate demand for a related offering the company has.	Varies	Complementary offerings, e.g. other software products.
Widget-frosting	Companies that are in business primarily to sell hardware can use this model for enabling software such as driver and interface code. By making the needed drivers open, the vendor can ensure that they are debugged and kept up to date.	Any	The company's main business is hardware. This is quite similar to the loss-leader model.
Accessorising	Companies which distribute books, computer hardware and other physical items associated with and supportive of OSS.	Any	Supplementary offerings.
Service enable	OSS is created and distributed primarily to support access to generating revenue from consulting services and online services.	Any	Service fees.
Brand licensing	A company charges other companies for the right to use its brand names and trade marks in creating derivative products.	Strong reciprocity	Copyright compensations.
Sell it free it	A company's software products start out their product life cycle as traditional commercial products and then are converted to open-source products when appropriate.	Alteration of licence type	Initial revenue from software product offerings converted into other models, e.g. the loss-leader model.
Software franchising	A combination of several of the preceding models (in particular 'Brand licensing' and 'Support selling') in which a company authorises others to use its brand names and trade marks in creating associated organisations doing custom software development, in particular geographic areas or vertical markets.	Strong reciprocity	The franchiser supplies franchisees with training and related services in exchange for franchising fees of some sort.

Table 3 Types of business models including OSS⁶²

Other business model possibilities include partnering with funding organisations; advertising; pre-selling code; pre-order or crowdfunding; dual licensing or open core; commercialisation of certificates, proprietary extensions; obfuscation of open source; delayed open-sourcing; open sourcing of end-of-life; etc⁶³.

3.7 Ways to incorporate open source in cloud computing

One must choose the right strategy if we are to succeed in CC by using OSS, as we must be aware that cloud services as a whole are predominantly not open source. In fact, when cloud computing emerged, Richard Stallman warned that *"on the Internet, proprietary software isn't the only way to lose your computing freedom. Service as a Software Substitute, or SaaS, is another way to give someone else power over your computing"*⁶⁴. This is taken to mean that, in a SaaS and cloud-native application, a service is called through an API that includes the URL/endpoint of where the service is deployed: therefore, a certain open-source component provided by a large corporation will be much more visible (and generate more vendor lock-in) than the very same software deployed by a smaller company. That is why we must know when and how to use open source when approaching a CC entrepreneurial project. We will now look at some possibilities for OSS in cloud computing.

⁶² Rajala, R., Nissilä, J., & Westerlund, M. (2006, June). Determinants of OSS revenue model choices. In ECIS (pp. 1839-1850).

⁶³ https://www.wikiwand.com/en/Business_models_for_open-source_software (accessed 22/06/2022)

⁶⁴ <https://www.gnu.org/philosophy/who-does-that-server-really-serve.en.html> (accessed 20/04/2022)

3.7.1 Private clouds

A way in which open source can be applied to the cloud is by creating private clouds which use an open-source platform such as OpenStack or CloudStack. In order to do so, however, entrepreneurs must have the necessary resources and manage a CC environment, as well as having one's own hosting infrastructure. Moreover, by not using the public cloud, one may lack convenience, scalability and the ability of the operate without capital expenditure. And it does require extensively more work⁶⁵.

3.7.2 Public clouds

Another option is to run open-source applications under public clouds. This allows entrepreneurs to have control over the applications, while relinquishing control over the infrastructure it is running under. This means that entrepreneurs will not have as much privacy as they would under a private server, as the public cloud provider can collect data from its servers.

On the other hand, using a public cloud allows entrepreneurs to scale their infrastructure up and down as they see fit. Moreover, public clouds don't require one to pay for hosting resources, and they don't require the acquisition of servers in order to run software.

3.7.3 Managed service

Entrepreneurs can opt for running OSS in the cloud by using a managed service provided by a cloud vendor. As an example, one could use AWS EKS to run Kubernetes; or use AWS OpenSearch as a substitute for Elasticsearch⁶⁶. This makes the process simpler, since one does not need to worry about infrastructure or provide one's own OSS.

There are, however, some drawbacks to this proposition: first, it is less flexible than directly using open source, as one can only use one's own software in manners that the vendor would allow. Second, the software can rarely be modified, and the source code is definitely out of reach. Which leads to the situation that Richard Stallman denounced.

Using a managed service in the public cloud can have positive effects, however, as it can be a step in the direction of using open source platforms to allow users to have more freedom to operate.

3.8 From open source to source availability

According to a report entitled *"The Changing Face of Open Source"*, produced by Percona, the current debate on open source in the context of the cloud is complicated. This report states that IT decision makers responded to a survey by saying that OSS companies are facing several challenges, one of which being that many CC companies use OSS tools, but they do not contribute to the open-source community⁶⁷. This, they argued, does not contribute to developers and entrepreneurs wanting to utilise OSS in cloud computing.

The figure below shows that, of all the problems being faced by open-source companies, *"competition from public cloud companies who use open source projects but don't contribute*

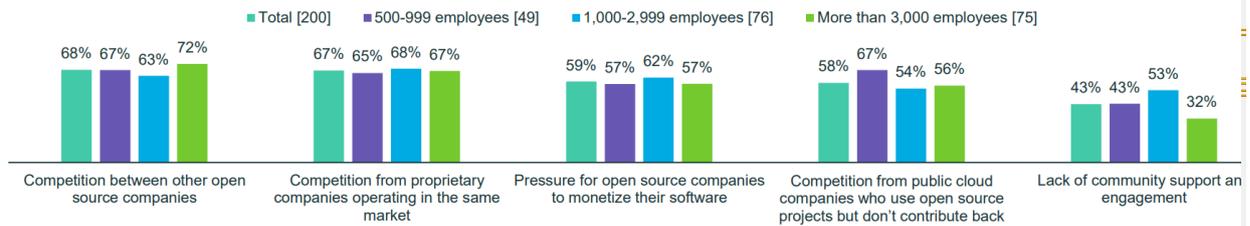
⁶⁵ <https://www.itprotoday.com/performance-management/3-ways-leverage-open-source-cloud> (accessed 20/04/2022)

⁶⁶ <https://www.itprotoday.com/performance-management/3-ways-leverage-open-source-cloud> (accessed 22/04/2022)

⁶⁷ <https://www.percona.com/blog/2021/05/12/new-survey-shows-enterprises-increasing-their-reliance-on-open-source-software/> (accessed 21/04/2022)

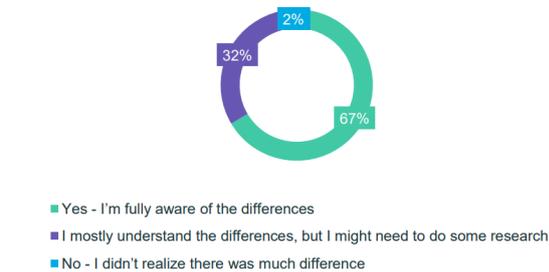
back” is fourth on the list. This statement is backed by 58% of all OS companies. One could argue that (large) cloud computing companies are viewed as unreliable competitors, and thus not contributing to a mutual climate of trust.

Open source companies are currently facing various challenges

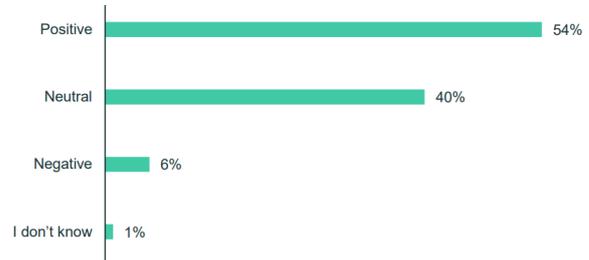


Open Source Challenges⁶⁸

Source-available software differs from open-source software in that, while the latter allows for the modification of the source code, the former only allows for its viewing. More than two thirds of respondents knew the difference between the two types; and more than half of respondents said that they viewed switching from OSS to source-available software in a positive light if it meant that this would deter CC service providers from offering SaaS for free.



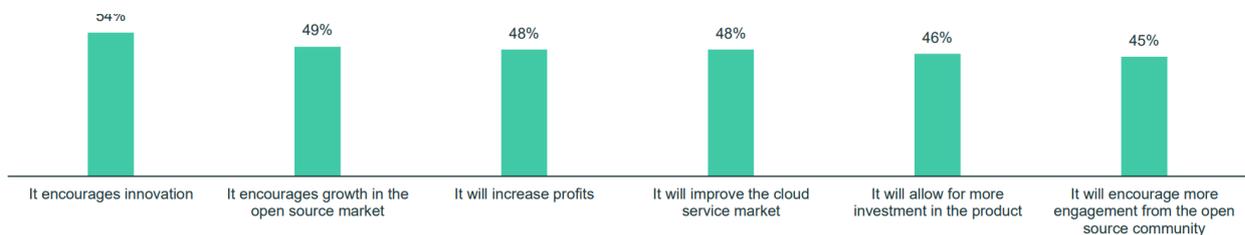
Do you understand the difference between open source licenses (like MIT, BSD and Apache, GPL) and source available licenses (like BSL and SSPL)? [200]



How do you feel about open source companies switching to source available licenses to deter cloud service providers from offering their software as a service for free (for example Elastic's move to an SSPL license)? [200]

Source Available Licenses⁶⁹

In addition to the conclusions from the previous graph, nearly half of the respondents from the open-source community said that source-available licences will improve the cloud-service market.



What are the benefits for the open source community if open source companies switch to source available licenses (such as BSL and SSPL)? [200], respondents that think organizations introducing source available licenses is positive or neutral, omitting some answer options

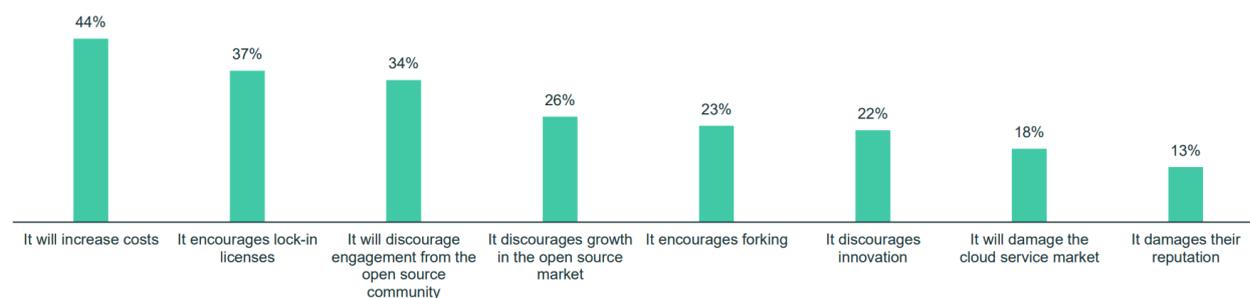
Benefits of Source Available Licenses⁷⁰

⁶⁸ <https://virtualizationreview.com/articles/2021/06/22/cloud-open-source.aspx> (accessed 12/04/2022)

⁶⁹ <https://virtualizationreview.com/articles/2021/06/22/cloud-open-source.aspx> (accessed 12/04/2022)

⁷⁰ <https://virtualizationreview.com/articles/2021/06/22/cloud-open-source.aspx> (accessed 12/04/2022)

Moreover, only 18% of respondents believed that source-available licences will damage the cloud-service market.



*Drawbacks of Source Available Licenses*⁷¹

3.9 Conclusions

Some, like Evan Weaver, founder of FaunaDB, argue that “people aren’t interested in ownership of the code. They’re happy with a cloud solution”⁷². The reasoning behind this statement is that the cloud has made running software simpler. Charity Majors, founder of Honeycomb, on the other hand, argues that open source is more relevant than ever, since it allows developers to maintain control over their creations, even under public cloud providers⁷³.

As we have seen, it is all about balance between proprietary solutions and open source and deciding on the right strategy for each particular entrepreneur’s case.

One advantage of open-source software is that there are repositories of open source solutions. Moreover, there are websites such as <https://www.opensourcealternative.to/> which specifically provide open-source alternatives to proprietary software. Moreover, the European Commission published a report which connected OSS to GDP growth entitled “Study about the impact of open-source software and hardware on technological independence, competitiveness and innovation in the EU economy”⁷⁴, and the EC-funded project H-Cloud⁷⁵ published an event report entitled “Digital autonomy in the computing continuum: From cloud to edge to IoT for European data”, which analyses open-source as a way to achieve digital autonomy⁷⁶.

⁷¹ <https://virtualizationreview.com/articles/2021/06/22/cloud-open-source.aspx> (accessed 12/04/2022)

⁷² <https://www.techrepublic.com/article/this-early-twitter-engineer-has-a-suggestion-for-your-next-database/> (accessed 22/04/2022)

⁷³ <https://udinachmany.me/> (accessed 22/04/2022)

⁷⁴ <https://digital-strategy.ec.europa.eu/en/library/study-about-impact-open-source-software-and-hardware-technological-independence-competitiveness-and> (accessed 22/06/2022)

⁷⁵ <https://cordis.europa.eu/project/id/871920> (accessed 22/06/2022)

⁷⁶ Rimassa, G., Facca, F.M. (2021). “Digital autonomy in the computing continuum: From cloud to edge to IoT for European data”. Accessible at <https://www.h-cloud.eu/?wpdmdl=1897&ind=1643279452674>

4 ENTREPRENEURIAL ECOSYSTEMS IN THE EU

4.1 The global economy from a start-up perspective

When the pandemic took the world by storm in 2020, travel ceased, consumer demand decreased, and venture capital spending plummeted. It did not look like good times for entrepreneurs.

However, the same pandemic has allowed for new ways to connect, and new ways to get things done. Among these novelties, meetings and other types of events do not necessarily have to take place face to face. Moreover, due to remote work and digitisation of customer and supply-chain operations, internet use and e-commerce have grown significantly, making many of us in society early adopters of new ideas⁷⁷. The current situation has created the perfect scenario for entrepreneurs, especially within the realm of cloud computing, to revitalise the economy.

This situation has pushed investors to increase investments in new opportunities. Venture funding worldwide amounted to \$148 billion in the first half of 2020; in the same period of 2021, this amount rose to \$288 billion. What is more, investment surged in all stages of start-up development⁷⁸.

The term “unicorn”, which describes start-ups worth \$1 billion or more, has become commonplace throughout the world. So much so that the number of unicorns grew by 43% from October 2020 to June 2021. The USA led the ranking of unicorns in the world, followed by China, Canada and India. Germany, the UK and France were the first European countries on this list⁷⁹.

Number of unicorns in Europe as of April 2021, by country

Number of European unicorns in 2021, by country

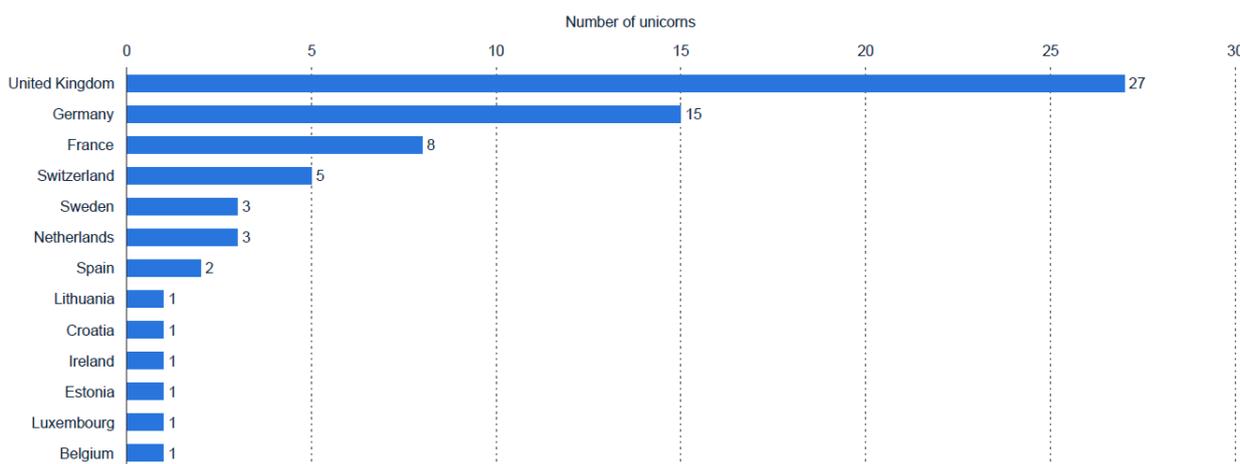


Figure 22 Number of unicorns in Europe⁸⁰

⁷⁷ <https://www.mckinsey.com/business-functions/strategy-and-corporate-finance/our-insights/how-covid-19-has-pushed-companies-over-the-technology-tipping-point-and-transformed-business-forever> (accessed 05/05/2022)

⁷⁸ <https://news.crunchbase.com/news/global-vc-funding-h1-2021-monthly-recap/> (accessed 05/05/2022)

⁷⁹ <https://start-upgenome.com/article/state-of-the-global-start-up-economy-2021> (accessed 05/05/2022)

⁸⁰ Statista, Number of European unicorns in 2021, by country (2021)

4.2 Entrepreneurial ecosystems throughout the world

The term “entrepreneurial ecosystem” is understood as “a set of interdependent actors and factors coordinated in such a way that they enable productive entrepreneurship”⁸¹.

This increase in global investment and in entrepreneurship is due to a large extent to entrepreneurial ecosystems. Moreover, the situation has created the need to strengthen existing ecosystems and to create new ones.

As we can see in the figure below, North America leads the way in terms of entrepreneurial ecosystems; and Asia-Pacific has surpassed Europe as the second continent on the list.

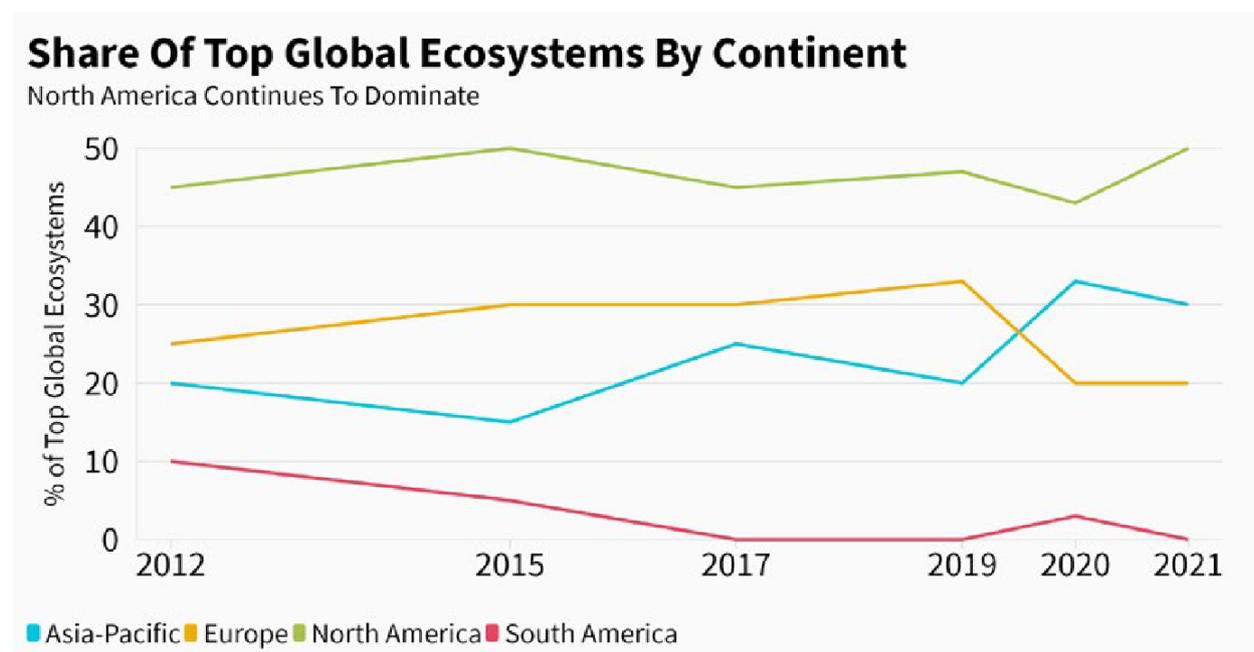


Figure 23 Share of Top Global Ecosystems by Continent⁸²

The USA leads Start-up Blink’s Global Start-up Ecosystem Index by far, both from a quantitative and qualitative perspective. The UK, Israel and Canada follow at a distance. Germany and Sweden are the only two EU countries on the top-10 list (#5 and #6, respectively).

⁸¹ Stam, E. 2015. Entrepreneurial ecosystems and regional policy: A sympathetic critique. *European Planning Studies*, 23(9): 1759-1769.

⁸² Start-up Genome, “*The Global Start-up Ecosystem Report GSER 2021*” (2021)

Rank	Country	Rank Change (from 2020)	Quantity Score	Quality Score	Business Score	Total Score
1	<u>United States</u>	–	19.45	101.17	3.80	124.420
2	<u>United Kingdom</u>	–	8.16	16.86	3.70	28.719
3	<u>Israel</u>	–	5.48	19.14	3.13	27.741
4	<u>Canada</u>	–	6.58	9.75	3.55	19.876
5	<u>Germany</u>	–	3.64	9.92	3.49	17.053
6	<u>Sweden</u>	+4	2.40	9.24	3.78	15.423
7	<u>China</u>	+7	1.33	11.46	2.34	15.128
8	<u>Switzerland</u>	–	3.82	7.58	3.54	14.943
9	<u>Australia</u>	–2	4.46	5.87	3.50	13.835
10	<u>Singapore</u>	+6	3.22	7.69	2.84	13.745

Figure 24 Global Start-up Ecosystem Index: Top Countries⁸³

When it comes to the main ecosystems in the world, Silicon Valley is the main hub for start-ups, followed by New York. London comes third; and Paris, the first EU hub on this list, comes in at number 12. Other European ecosystems in the top-30 list include Amsterdam-Delta (#13), Stockholm (#17) and Berlin (22).

⁸³ Start-up Blink, “Global Start-up Ecosystem Index 2021” (2021)

Global Startup Ecosystem Ranking (Top 30 + Runners-Up)

Factors are tiered from 10-1

Ranking	Performance	Funding	Connectedness	Market Reach	Knowledge	Talent
Silicon Valley #1	10	10	10	10	10	10
New York City #2 (tie)	10	10	10	10	5	10
London #2 (tie)	9	10	10	10	7	9
Beijing #4	10	9	5	9	10	10
Boston #5	9	9	9	9	5	10
Los Angeles #6	9	10	3	9	7	9
Tel Aviv #7	8	9	8	10	4	8
Shanghai #8	10	7	1	9	10	9
Tokyo #9	8	9	1	8	9	9
Seattle #10	9	7	7	8	7	8
Washington DC #11	7	7	6	8	1	8
Paris #12	6	8	9	6	1	8
Amsterdam-Delta #13	6	6	9	7	1	7
Toronto-Waterloo #14 (tie)	5	8	7	3	2	6
Chicago #14 (tie)	5	6	6	6	1	7
Seoul #16	6	5	9	5	10	5
Stockholm #17 (tie)	7	6	5	7	3	6
Singapore #17 (tie)	4	8	6	6	1	5
Shenzhen #19	8	5	1	1	9	7
Austin #20	4	5	7	5	7	6
San Diego #21	5	3	1	7	6	7
Berlin #22	2	7	10	1	1	5
Bangalore-Karnataka #23	5	7	4	1	8	3
Sydney #24	4	4	8	5	1	4
Hangzhou #25	8	1	1	3	9	6
Atlanta #26	3	2	2	5	1	5
Denver-Boulder #27	1	4	5	3	4	4
Philadelphia #28	3	3	1	6	1	4
Vancouver #29	6	3	4	1	2	3
Salt Lake-Provo #30	7	1	1	7	1	1
Dallas #31 (tie)	2	1	1	4	3	2
Hong Kong #31 (tie)	1	2	1	8	1	2
Montreal #31 (tie)	3	1	1	1	1	2
Munich #31 (tie)	1	3	7	1	3	1
Sao Paulo #31 (tie)	3	4	4	1	1	3
Bern-Geneva #36 (tie)	1	1	5	1	1	1
Delhi #36 (tie)	2	6	1	1	1	1
Dublin #36 (tie)	1	1	3	1	1	3
Melbourne #36 (tie)	1	1	4	2	1	2
Research Triangle #36 (tie)	1	1	1	1	1	4

31-35 and 36-40 are in alphabetical order

Figure 25 Global Start-up Ecosystem Ranking⁸⁴

It is interesting to note that the number of ecosystems producing unicorns has been growing year after year, with a total of 91 such ecosystems in 2020. This high number of entrepreneurial ecosystems means that, while US-based ecosystems are still very powerful, successful entrepreneurship takes place in various parts of the world.

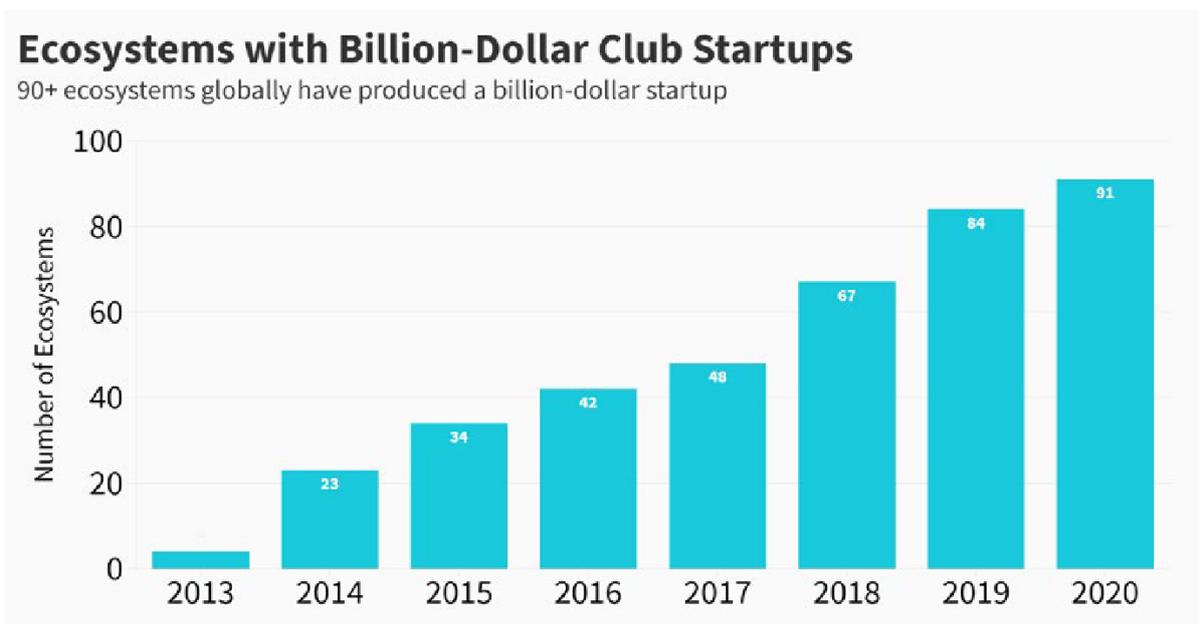


Figure 26 Ecosystems with Billion-Dollar Club Start-ups⁸⁵

⁸⁴ Start-up Genome, “The Global Start-up Ecosystem Report GSER 2021” (2021)

⁸⁵ Start-up Genome, “The Global Start-up Ecosystem Report GSER 2021” (2021)



This reality is reinforced by the growing importance of emerging ecosystems throughout the world, which account for over \$500 billion.

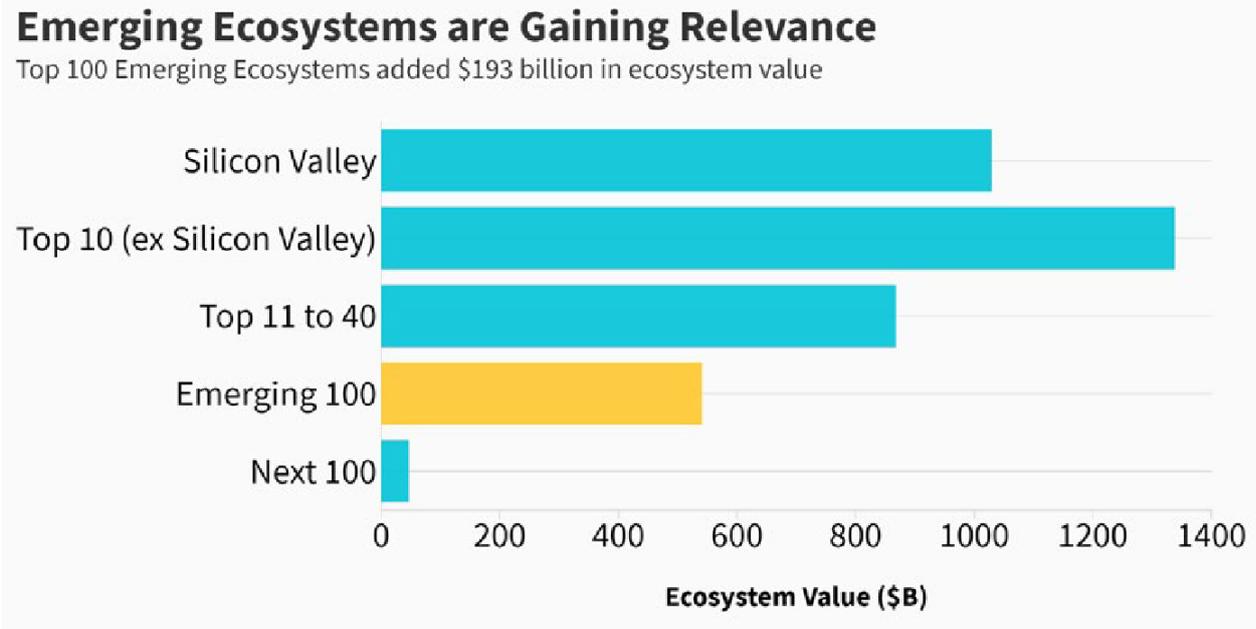


Figure 27 Emerging Ecosystems are Gaining Relevance⁸⁶

And this is where the future looks brightest for Europe: Europe has the highest share of emerging ecosystems in the world (37%), followed by North America (30%) and Asia (19%).

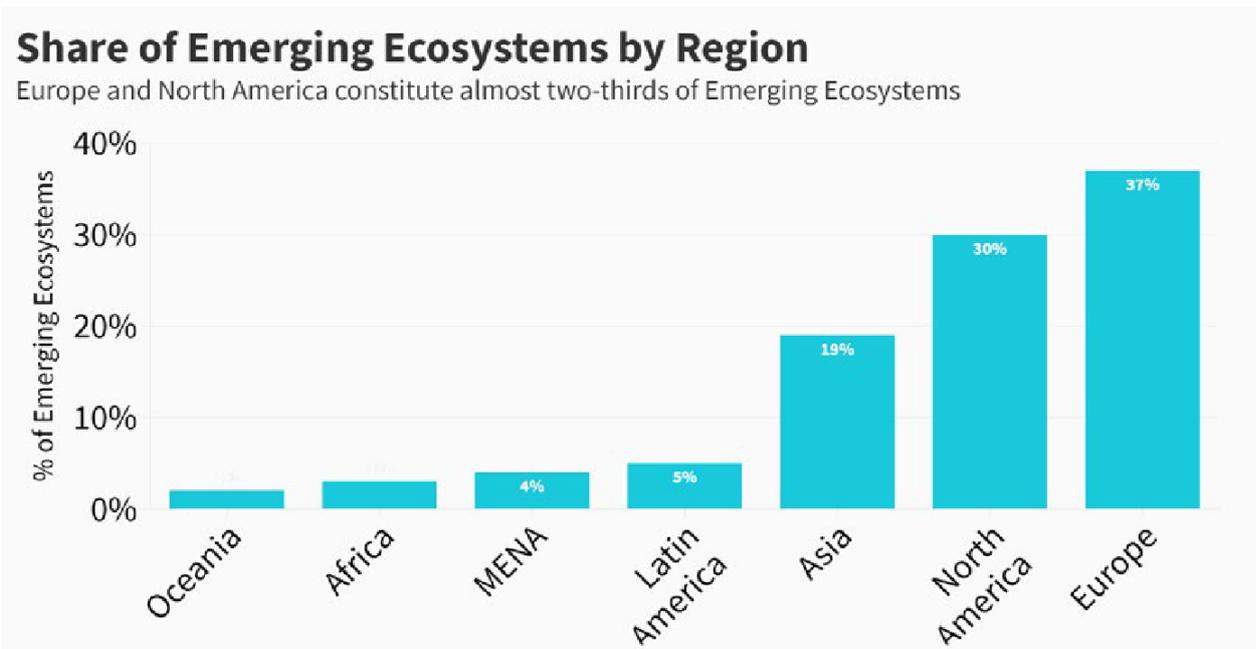


Figure 28 Share of Emerging Ecosystems by Region⁸⁷

⁸⁶ Start-up Genome, “The Global Start-up Ecosystem Report GSER 2021” (2021)

⁸⁷ Start-up Genome, “The Global Start-up Ecosystem Report GSER 2021” (2021)

When it comes to the value of exit operations, North America still leads the ranking by far, as can be seen in the figure below. Europe is the third strongest region, preceded by Asia.

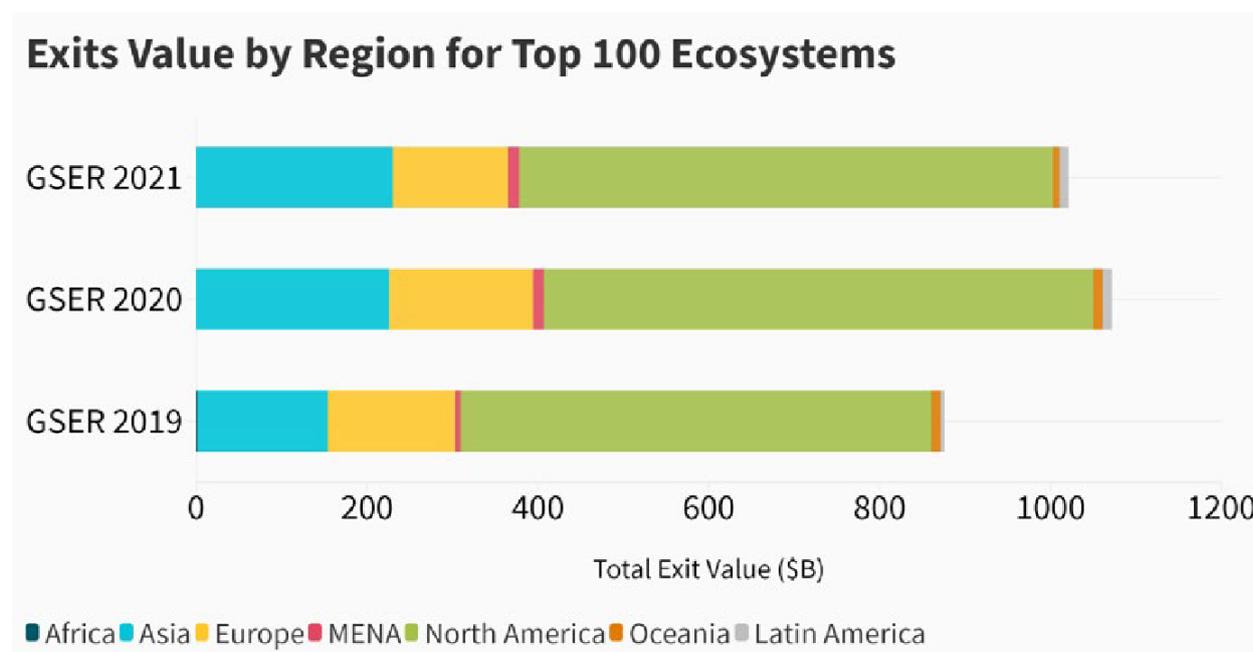


Figure 29 Exits Value by Region for Top 100 Ecosystems⁸⁸

4.3 Public policies for global entrepreneurial ecosystems from around the world

Governments can and do introduce different types of measures to facilitate entrepreneurial growth.

In Africa, for instance, governments have introduced policies, grants and tax breaks to benefit start-ups in their initial stages. One such example is a bill which was introduced in Kenya to implement the National Innovation Agency to generate relationships between investors and entrepreneurs, while facilitating the process through incubators. Ethiopia covers the expenses of protecting IP for entrepreneurs, while making big efforts to attract foreign investment.

Moreover, countries like Brazil are introducing legislature to minimise the process of creating a business. India is relying on accelerators to provide 300 early-stage start-ups with the necessary tools to become entrepreneurs (funds, mentors, etc.). Victoria, in Australia, is dedicating \$2 billion to promote start-ups in several technology-related fields.

In sum, governments throughout the world are implementing measures to try to generate the right environments for start-ups to flourish⁸⁹.

4.4 European policies and initiatives

The EU has also dedicated significant efforts to promote entrepreneurship, as well as facilitating ecosystems which lead to innovation and entrepreneurship. Below are the main initiatives which entrepreneurs can find as far as the EU is concerned:

⁸⁸ Start-up Genome, "The Global Start-up Ecosystem Report GSER 2021" (2021)

⁸⁹ <https://start-upgenome.com/article/europes-booming-start-up-ecosystems> (accessed 05/05/2022)

4.4.1 Policy

- The **COSME** programme “aims to make it easier for small and medium-sized enterprises (SMEs) to access finance in all phases of their lifecycle – creation, expansion, or business transfer. Thanks to EU support, businesses have easier access to guarantees, loans and equity capital. EU financial instruments are channelled through local financial institutions in EU countries.” Relevant financial institutions in each EU country can be found on the COSME website⁹⁰.
- The **Entrepreneurship 2020 Action Plan** aims at “re-igniting the entrepreneurial spirit in Europe” through education⁹¹.
- The **Start-up and Scale-up Initiative** “is a 6-month accelerator program, enabling accepted start-ups to receive mentorship and support from the brightest IOT people in the World”⁹².
- **Erasmus for Young Entrepreneurs** “helps provide aspiring European entrepreneurs with the skills necessary to start and/or successfully run a small business in Europe. New entrepreneurs gather and exchange knowledge and business ideas with an experienced entrepreneur, with whom they stay and collaborate for a period of 1 to 6 months. The stay is partly financed by the European Commission”⁹³.
- **Start-up Europe** “strengthens networking opportunities for deep tech scaleups and ecosystem builders to accelerate the growth of the European start-up scene”⁹⁴.
- **Start-up Europe Week** is a “movement that focuses on local stories and access to resources to help budding entrepreneurs. More than 300 cities in 50 countries”⁹⁵.

4.4.2 Initiatives

- **The European Institute of Innovation and Technology (EIT)**. “Together with leading partners, the EIT Community offers a wide range of innovation and entrepreneurship activities: education courses that combine technical and entrepreneurial skills, tailored business creation and acceleration services and innovation driven research projects. This brings new ideas and solutions to the market, turns students into entrepreneurs and, most importantly, delivers innovation”⁹⁶.
- **The European Innovation Council (EIC)** “aims to identify and support breakthrough technologies and game changing innovations to create new markets and scale up internationally”. It includes the EIC Accelerator, which provides funds “for individual start-ups and small companies to develop and scale up game changing innovations”⁹⁷. The EIC also has “EIC Transition”, a programme that helps entrepreneurial projects mature

⁹⁰ https://ec.europa.eu/growth/smes/cosme_en (accessed 05/05/2022)

⁹¹ <https://www.eesc.europa.eu/en/our-work/opinions-information-reports/opinions/entrepreneurship-2020-action-plan> (accessed 05/05/2022)

⁹² <http://start-up-scaleup.eu/> (accessed 05/05/2022)

⁹³ <https://www.erasmus-entrepreneurs.eu/page.php?cid=20> (accessed 05/05/2022)

⁹⁴ <https://digital-strategy.ec.europa.eu/en/policies/start-up-europe#:~:text=Start-up%20Europe%20coordinates%20EU%20work,innovation%20agencies%20and%20other%20stakeholders>. (accessed 05/05/2022)

⁹⁵ <https://www.start-upblink.com/blog/a-start-up-ecosystem-guide-europe/> (accessed 05/05/2022)

⁹⁶ <https://eit.europa.eu/who-we-are/eit-glance> (accessed 05/05/2022)

⁹⁷ https://eic.ec.europa.eu/index_en (accessed 05/05/2022)

and validate novel technologies and the development of their business cases⁹⁸.

4.5 European initiatives to facilitate connectivity

European research organisations, in collaboration with other organisations such as technology transfer offices (TTOs) have taken action to breach the gap between research and entrepreneurship by developing initiatives to bring managerial talent to research projects; and to provide visibility to newly formed technology-based businesses. Below are some examples of such initiatives.

4.5.1 Initiatives to connect managerial talent with researchers:

- Building bridges with business schools (Tecnalia, CEA, Fraunhofer Venture, CERN): business schools are approached by RTOs in order to find potential candidates to manage business opportunities developed by researchers.
- Speed dating events (Tecnalia): These are specific meetings to put in contact potential managerial personnel with start-ups coming from Tecnalia.
- Boot camps (Fraunhofer Venture): Start-ups' members are invited to test their abilities. At the end of the bootcamp, participants come out with recommendations regarding the best-suited roles for them within the start-ups. Each bootcamp accommodates between 25 and 30 participants.
- Alumni groups (CERN): The aim of the initiative is to allow previous CERN staff members in entrepreneurship opportunities⁹⁹.

4.5.2 Initiatives to improve the visibility of technology-based business opportunities:

- Entrepreneurship Club (Tecnalia): The aim of the initiative is to provide visibility to Tecnalia's start-ups within the local entrepreneurial ecosystem. The initiative includes informal networking events, coaching sessions, and speed dating events.
- Talent for Ventures (Tecnalia): In collaboration with the Basque government, Tecnalia Ventures and Mondragon University develop a series of activities to provide students with tools to create a start-up.
- Lille ecosystem (CEA): A showroom is organised with the aim of finding business cases for technologies developed by CEA researchers. Moreover, entrepreneurs are invited to participate in the business projects.
- Entrepreneurship Student Programme (CERN): It consists of a 5-week entrepreneurship programme where students discuss specific technologies with experts in different fields, including business representatives¹⁰⁰.

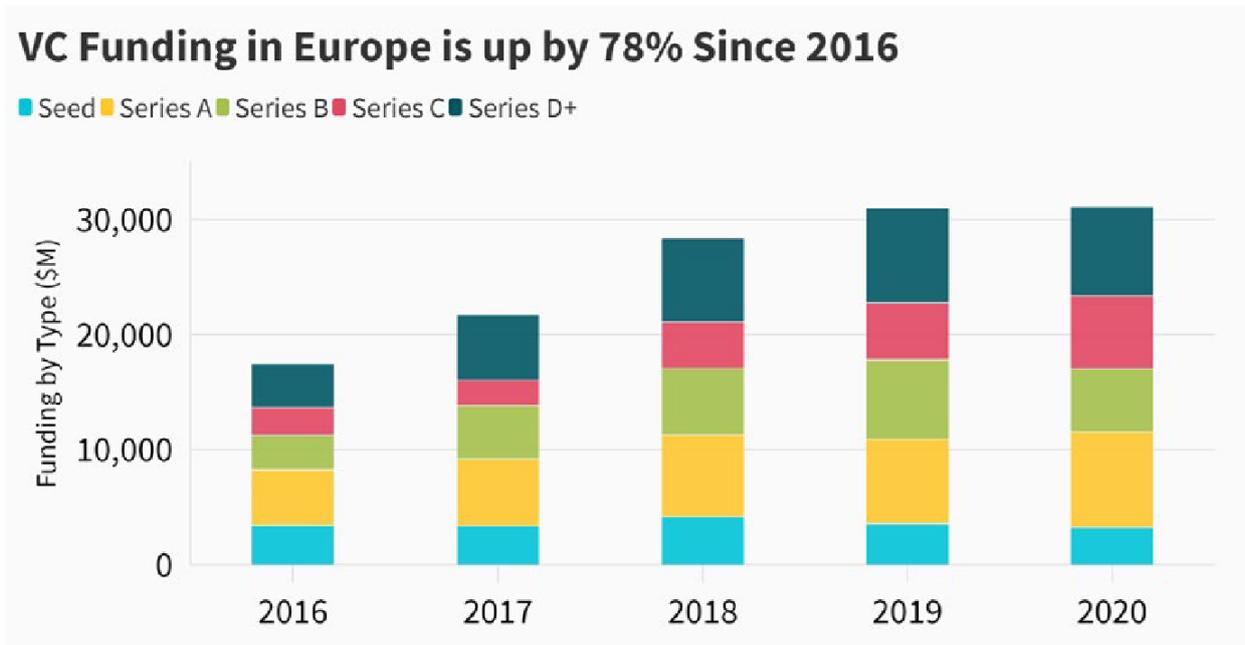
4.6 Europe's entrepreneurial ecosystems

As can be seen in the figure below, VC funding has increased significantly in the last few years. This has been made possible by the entrepreneurial ecosystems surrounding the start-ups.

⁹⁸ https://eic.ec.europa.eu/eic-funding-opportunities/eic-transition_en (accessed 22/06/2022)

⁹⁹ Martiarena, A, "Connecting with the Entrepreneurial Ecosystem - TTO Circle Workshop Report" (2019)

¹⁰⁰ Martiarena, A, "Connecting with the Entrepreneurial Ecosystem - TTO Circle Workshop Report" (2019)

Figure 30 VC Funding in Europe evolution¹⁰¹

There are numerous entrepreneurial ecosystems in Europe, which vary in size, target sectors, scope, etc. The main ecosystems by country are:

1. United Kingdom: London is the main hub in the country. Furthermore, London is the epicentre of European VCs. This is due to a well-established support system, government support and the fact that many of the key players and entrepreneurs move to the city to find success¹⁰².
2. Germany: Germany is the biggest player in the EU, offers affordable living conditions for entrepreneurs and attracts international talent. Together with growing government support, Germany has all it takes to become an alternative to other powerful global entrepreneurial ecosystems¹⁰³.
3. Switzerland: Swiss start-ups raised \$3.1 billion in 2021. Altogether, the entire start-up ecosystem is estimated to be worth \$149 billion, which triple what it was worth in 2016. It should be noted that 50% of all VC activity since 2015 was related to healthtech start-ups¹⁰⁴.
4. The Netherlands: The secret behind the Dutch entrepreneurial ecosystem lies within the network of actors which has been established over the years: a business-oriented education, a network of support agents, relevant investors, a series of facilitators and effective policy implementation¹⁰⁵.

¹⁰¹ Start-up Genome, "The Global Start-up Ecosystem Report GSER 2021" (2021)

¹⁰² <https://www.start-upblink.com/blog/a-start-up-ecosystem-guide-europe/> (accessed 05/05/2022)

¹⁰³ <https://www.start-upblink.com/blog/a-start-up-ecosystem-guide-europe/> (accessed 05/05/2022)

¹⁰⁴ <https://dealroom.co/blog/the-swiss-start-up-ecosystem-in-numbers> (accessed 05/05/2022)

¹⁰⁵ <https://getinthering.co/country/the-netherlands/> (accessed 05/05/2022)

Top 5 Performers in Europe¹⁰⁶:

1. London
2. Paris
3. Amsterdam-Delta
4. Stockholm
5. Berlin

Top Regional Challengers:

1. Copenhagen
2. Barcelona
3. Estonia
4. Madrid
5. Zurich

Although, overall, the European entrepreneurial ecosystem is thought to be booming, it does have its weaknesses, especially when compared to other regions of the world such as the USA. We will now look at Europe's strengths and limitations with the objective of concluding what areas Europe needs to promote and which areas Europe needs to work on in order to improve.

4.6.1 Strengths of the European ecosystem

The entrepreneurial ecosystem in Europe has several strong points:

First, it is well established, and there are plenty of organisations that take part in the different ecosystems throughout Europe. As part of the ecosystem, there are wide networks of investors at different levels and in different areas of activity. Therefore, entrepreneurs can have easy access to TTOs, accelerators, investors and potential customers.

Second, the players of the ecosystem are well connected amongst themselves. Regional and national governments, as well as the European Commission, support the entrepreneurial ecosystem by providing the necessary resources for it to prosper.

Third, start-ups in Europe are particularly successful in providing business to business products and services. This has been made evident during the pandemic, as the digital economy has been increasingly relevant.

Fourth, funding in tech start-ups has grown significantly in recent times:

¹⁰⁶ Start-up Genome, "The Global Start-up Ecosystem Report GSER 2021" (2021)

The Top Performers are identified by applying our Global Ranking methodology within a specific region, while the Regional Challengers are identified using the Emerging Ecosystems methodology.

VC Funding in Europe is up by 78% Since 2016

■ Seed ■ Series A ■ Series B ■ Series C ■ Series D+



Figure 31 VC Funding in Europe evolution¹⁰⁷

We are therefore at a good time to create a tech start-up in Europe, as investors are actively looking for opportunities in which to invest.

Fifth, English acts as a common language throughout Europe, especially in the tech community. This allows for mobility to occur both for entrepreneurs and investors, thus increasing the chances of finding a match between the business opportunity and the investor that may provide the economic resources to develop it.

Finally, in order to facilitate mobility, there is a tendency to facilitate residency and provide e-visas for entrepreneurs. Estonia has been a pioneer in this regard, and several other European countries have followed suit¹⁰⁸.

4.6.2 Limitations of the European ecosystem

On the other hand, Europe has room to improve in several areas when it comes to its entrepreneurial ecosystem:

First, Europe has not managed to generate large tech companies such as the ones that dominate the market from the US. This is particularly relevant for entrepreneurs, as these large companies act as tractors for start-ups to flourish.

Second, when compared to the USA, Europe still has to strengthen its entrepreneurial ecosystem. Venture capital firms have a long tradition in the USA going back to the 1940s, while the European ones began their activities in the 1990s. There is, therefore, some catching up to do.

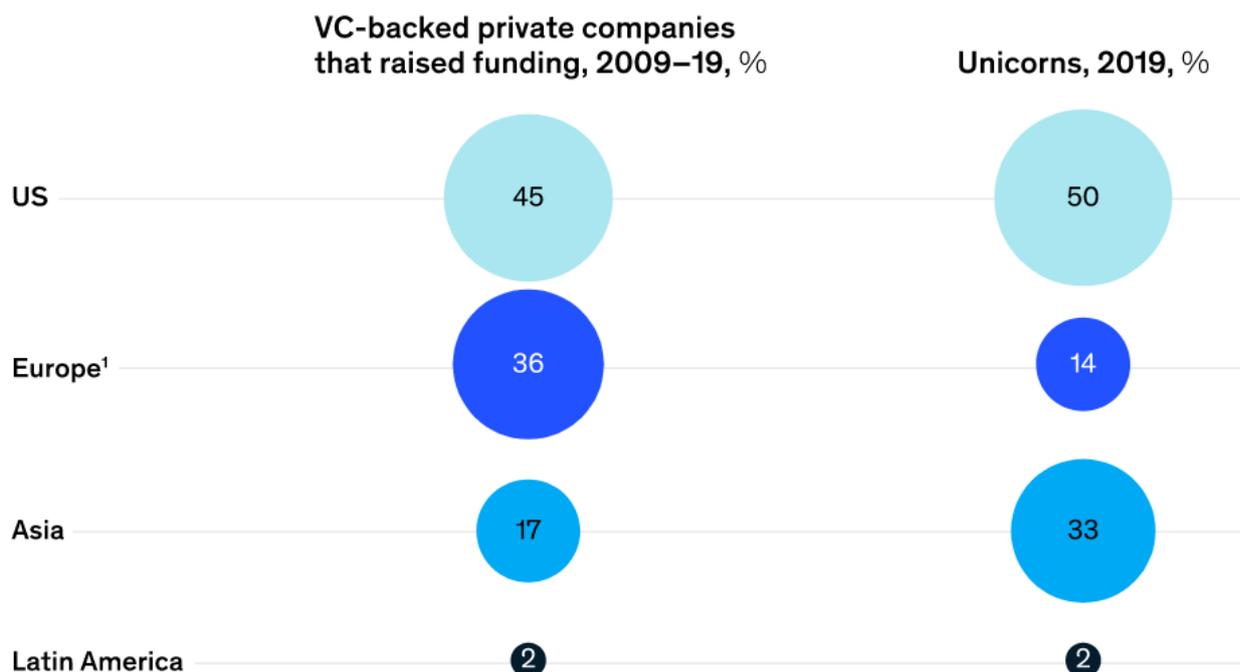
Third, Europe is still characterised by its bureaucratic red tape. This is particularly relevant in southern states, and it is a deterrent for individuals to start-up their own businesses. This is

¹⁰⁷ Start-up Genome, "The Global Start-up Ecosystem Report GSER 2021" (2021)

¹⁰⁸ <https://www.start-upblink.com/blog/a-start-up-ecosystem-guide-europe/> (accessed 16.05.2022)

particularly true in EU countries, as it is not so much the case in others such as Norway, Switzerland and the UK¹⁰⁹.

Fourth, even though there is a significant number of start-ups, and investment levels in general increasing in Europe, investment in later stages of start-ups is still low. It should be noted that, while generating 36% of all funded start-ups, only 14% of the unicorns in the world come from Europe. There are several reasons for European start-ups to face difficulties to grow: first, Europe is fragmented in terms of business cultures and bureaucratic barriers, resulting in start-ups having difficulty in reaching foreign markets; second, studies show that European start-ups do not reach unicorn status using only European resources, thus having to face the phase of internationalisation at an earlier stage; third, European start-ups generally receive lower amounts of funding if compared to US start-ups at similar stages of development¹¹⁰.



Note: Figures may not sum to 100%, because of rounding.
¹Data from Europe, the Middle East, and Africa used as a proxy for Europe.
 Source: PitchBook; McKinsey analysis

Figure 32 VC-backed start-ups vs. Unicorns¹¹¹

Fifth, Europeans are said to be culturally more risk-averse than in other parts of the world. Fear of failure often stops Europeans from either embracing entrepreneurship altogether or from continuing when start-ups do not evolve as planned.

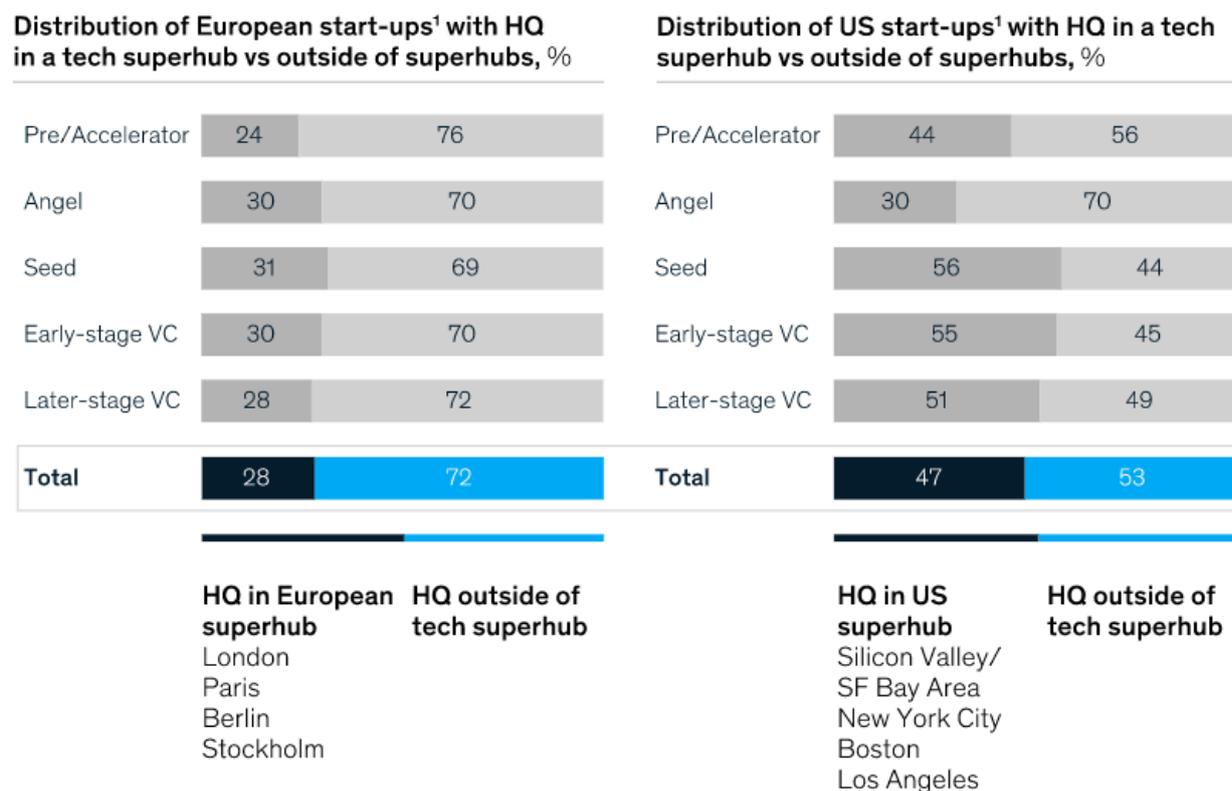
Finally, Europe does not have entrepreneurship hubs the size of those in the USA. There are no places such as Silicon Valley or New York City in Europe, with such a large concentration of entrepreneurs, tech experts and investors. As a result, only about 30% of start-ups have located

¹⁰⁹ <https://www.start-upblink.com/blog/a-start-up-ecosystem-guide-europe/> (accessed 16.05.2022)

¹¹⁰ <https://www.mckinsey.com/industries/technology-media-and-telecommunications/our-insights/europes-start-up-ecosystem-heating-up-but-still-facing-challenges> (accessed 16.05.2022)

¹¹¹ <https://www.mckinsey.com/industries/technology-media-and-telecommunications/our-insights/europes-start-up-ecosystem-heating-up-but-still-facing-challenges> (accessed 16.05.2022)

their businesses in such hubs, whereas this figure is close to 50% in the USA, as can be seen in the figure below.



¹Active VC-backed companies that raised any VC round in last 3 years (since January 1, 2017).
 Source: PitchBook; McKinsey analysis

Figure 33 Distribution of start-ups in hubs - Europe vs. the USA¹¹²

4.7 Summary and recommendations

The state of the European start-up ecosystem is improving. However, Europe is far from reaching the USA in terms of creating the right conditions for entrepreneurship to flourish. From a political perspective, there are several steps that should be taken in order to accelerate the process: First, entrepreneurs could benefit from simplified and standardised regulatory frameworks throughout Europe. Second, European public institutions could help the ecosystem grow by contracting start-ups and those actors around them. This is particularly relevant in Europe, given the B2B nature of a large portion of the start-ups in Europe. Third, European budgets could be directed towards investing in start-ups; and by designing policies that favour collaboration between researchers, entrepreneurs, industry and investors.

The European TTO Circle has made some further suggestions as to how the European entrepreneurial ecosystem could be improved:

1. Existing ecosystems should be prioritised, instead of creating new ones. Moreover, making existing ones bigger would create superhubs, thus creating more opportunities for entrepreneurs.

¹¹² <https://www.mckinsey.com/industries/technology-media-and-telecommunications/our-insights/europes-start-up-ecosystem-heating-up-but-still-facing-challenges> (accessed 17/05/2022)

2. There should be more cooperation among the existing European ecosystems, for the benefit of a truly European network of actors working together to improve everyone's chances of success.
3. In order to come up with the best possible scenario, local, regional and national ecosystems should be mapped and analysed. This would lead to conclusions and actions regarding what modifications should be made.
4. There is still a big disconnect between academia and business when it comes to entrepreneurship. Researchers should be made aware of the need to solve problems within the business world; and business people should be aware of what is happening with new ideas coming from the scientific and technological world. This would lead to greater cooperation and more business opportunities¹¹³.

¹¹³ Martiarena, A, "Connecting with the Entrepreneurial Ecosystem - TTO Circle Workshop Report" (2019)

5 IDENTIFICATION OF MAIN OPPORTUNITIES AND RISKS

5.1 Markets

From a market perspective, cloud computing is not only the backbone of well-established digital services, but also of emerging technologies such as virtual reality, artificial intelligence, the internet of things and quantum computing. This is why CC providers are also addressing these new markets. The main trends in CC could be categorised as follows¹¹⁴:

- Edge computing and distributed cloud
- Cloud strategy & transformation: hybrid and multi-cloud, the connection of public clouds amongst themselves and on-site workloads.
- Cognitive & intelligence cloud: Artificial Intelligence as a Service is resulting in the emergence of related services such as marketing intelligence, customer service, robotic process automation, and analytics to a wider audience.
- High-performance computing & big data cloud
- Cloud-native technology stack: CC automation, cloud containers, and serverless computing.
- Industry-specific applications and solutions

We will now have a look at the main business opportunities within these general tendencies.

5.1.1 Edge Computing & Distributed Cloud

Edge computing is expected to grow significantly in the next few years. According to information published by the European Commission, by 2025, 80% of all data is expected to be processed through edge computing¹¹⁵. The highest growth within Europe is expected to take place in Germany, 28% from 2020 to 2025¹¹⁶. The main opportunities for entrepreneurs are within the following areas¹¹⁷:

Connected vehicles and smart transport. As part of Internet of Things, connected vehicles can connect to external devices via wireless networks, thus allowing for communication with other vehicles, mobile devices, and traffic signals¹¹⁸. Edge computing and distributed cloud opportunities lie in the fields of service chains, driver assistance and autonomous vehicles. Moreover, transport infrastructure offers further business opportunities.

Digital factory: We use this term to describe a series of digital models which serve to simulate a physical factory. Services offered through the digital factory should result in improved quality of planning and economic efficacy, shorter go-to market time, clear communication, uniform planning standards and capable knowledge management¹¹⁹. The objective here is therefore to plan more efficiently, evaluate accordingly and overall improvement of the customer company.

¹¹⁴ From Cloud To Edge, Reply (<https://www.reply.com/en/Shared%20Documents/from-cloud-to-edge-EN.pdf>) (2020)

¹¹⁵ <https://ati.ec.europa.eu/news/future-cloud-computing-europe> (accessed 22/06/2022)

¹¹⁶ <https://www.reply.com/en/topics/cloud-computing/from-cloud-to-edge> (accessed 19/05/2022)

¹¹⁷ From Cloud To Edge, Reply (<https://www.reply.com/en/Shared%20Documents/from-cloud-to-edge-EN.pdf>) (2020)

¹¹⁸ <https://www.digi.com/blog/post/what-is-connected-vehicle-technology-and-use-cases> (accessed 19/05/2022)

¹¹⁹ <https://www.tibco.com/reference-center/what-is-a-digital-factory> (accessed 19/05/2022)

Specific areas which represent current and near-future opportunities include connected workers, digital twins, predictive maintenance, digital quality control, and smart intra-logistics.

Smart cities: Smart cities are defined as places “*where traditional networks and services are made more efficient with the use of digital solutions for the benefit of its inhabitants and business.*”¹²⁰ Governments of all sizes are making efforts to make use of the possibilities of technological advances related to smart cities to improve the services offered to citizens in terms of safety, parking, urban infrastructure, environmental solutions, and traffic management.

Digital healthcare: Healthcare is a sector that offers plenty of opportunities for technological start-ups in general. Cloud computing is no exception, as CC-related technologies can be used for predictive maintenance of medical devices; and vehicle fleet management.

Smart home and buildings: Again, predictive maintenance of buildings can be carried out through cloud computing, as well as managing facilities, security and energy resources.

Smart retail and consumer packaged goods (CPG): Advancements in online shopping, as well as the possibility to acquire products that are replaced on a regular basis (often referred to as CPGs) allow customers to self-service and smart tracking and tracing. There are plenty of opportunities within this field for start-ups to grow, as this type of services is booming.

Smart energy: Using technology to increase energy efficiency is one of the biggest priorities globally. In conjunction with energy-related products and services, there is a huge market for CC-related start-ups provide services to consumers, as well as to companies of different sizes.

5.1.2 Vertical Applications

Companies commercialising cloud computing services have typically sold these services to organisations across all industries, regardless of the sectors they belonged to. However, more and more companies are requesting sector-specific solutions to their problems. Therefore, IT providers are having to provide specific solutions to specific problems. These are often sector-specific, but they can even be company-specific. This is particularly relevant for SaaS providers, where entrepreneurs have a wide range of possibilities depending of the target market they are addressing.

5.1.3 Artificial Intelligence and Machine Learning

Artificial intelligence is being introduced more and more as part of major IT providers' service catalogue. Apple and Amazon pioneered this trend in the consumer market with Siri and Alexa, respectively. This tendency is proving to be popular, with major IT companies investing heavily on developing such technologies; and purchasing innovative start-ups which provide services in the field. This is particularly relevant in the SaaS market, as such technologies allow customer companies to save time in categorising and analysing data. The results of this process are then used to enhance the services which are being provided, to be more efficient as a company, etc. Furthermore, machine learning and AI allow companies to make predictions regarding customer needs and preferences, among other aspects.

¹²⁰ https://ec.europa.eu/info/eu-regional-and-urban-development/topics/cities-and-urban-development/city-initiatives/smart-cities_en (accessed 19/05/2022)

5.1.4 Containers

“A container is a standard unit of software that packages up code and all its dependencies so the application runs quickly and reliably from one computing environment to another.”¹²¹

Although the term has been used for a while now, it is becoming more and more relevant, as it is proving to be an alternative to virtual machines. This is so because containers do not require the use of the whole operating system, whereas VMs do.

The use of containers has led to the emergence of the term “containers as a service” (CaaS), a type of IaaS. Although containers were first introduced as part of open source operating systems, it is foreseen that the use of containers in Windows and MacOS will grow significantly in the near future.

5.1.5 Serverless Computing

In serverless computing, also known as Function as a Service (FaaS), it is the CC provider that acts as the server and allocates computing resources in the most efficient way possible. This makes it possible for companies to run software without having to worry about onsite computing infrastructures, which takes up a lot of the companies’ time. CSPs invoice on the number of resources which are actually used.

5.1.6 Smart Cities

Until recently, Internet of Things (IoT) has generally been associated with buildings and the interactions within them. Technological advances have made it possible to extend the uses of IoT to devices that people carry, such as smartphones and smartwatches. This allows for these machines to interact with devices which are located throughout our cities. This results in smart city technologies to be booming at the present time. According to Statista, by 2025, there will be more than 75 billion connected devices in the world.

¹²¹ <https://www.docker.com/resources/what-container/> (accessed 19/05/2022)

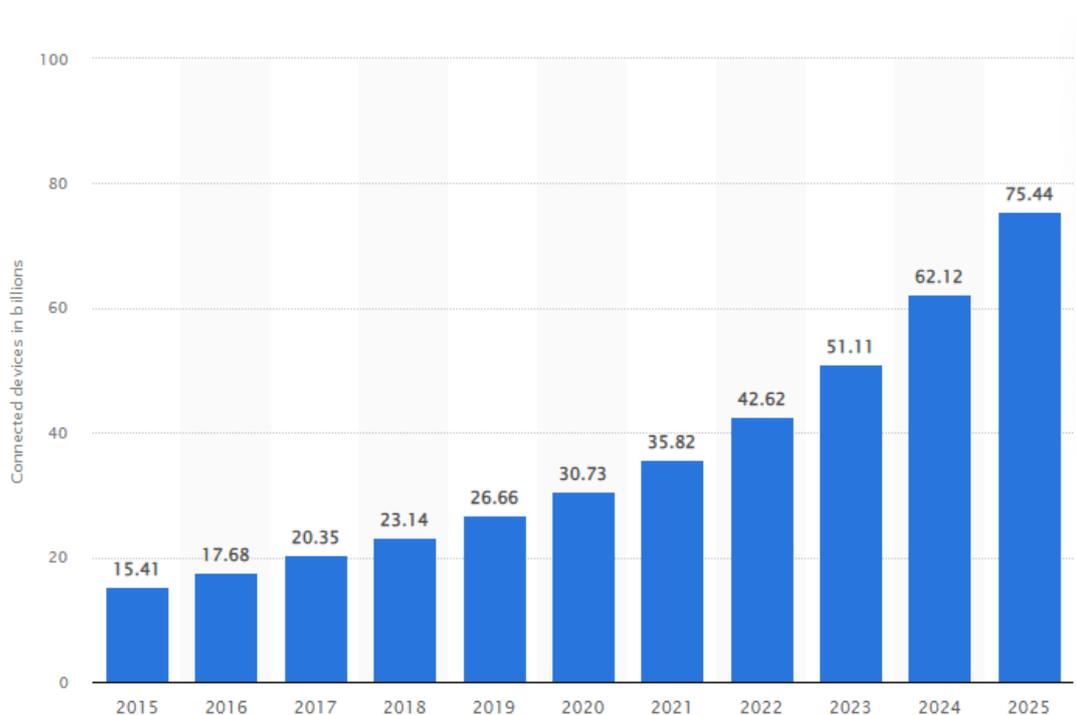


Figure 34 IoT devices worldwide (in billions)¹²²

This means that there will be plenty of opportunities for CC entrepreneurs to provide services in smart cities in various fields, such as SaaS, CaaS, HPCaaS, NaaS and IaaS¹²³.

5.2 Public sector

The public sector, with its policy-making and purchasing power, offers plenty of opportunities for CC start-ups. We will now look at the main areas of opportunities, as well as some examples of policy making that give us an idea of where the main opportunities will lie in the foreseeable future.

5.2.1 Opportunities

We should begin by saying that, although cloud computing has existed for a while now, the public sector has not begun to adopt it until quite recently. Mainly for security reasons, policy makers have tended to rely heavily on onsite data centres, as opposed to cloud computing solutions. This situation has resulted in a challenge for cloud computing entrepreneurship related to the public sector. On the other hand, there is so much to be done in this arena that the opportunities are endless.

a) Security

Governments need to make sure that their applications, and the information contained within them, are secure. They need to guarantee data sovereignty and privacy. This provides

¹²² <https://www.statista.com/statistics/471264/iot-number-of-connected-devices-worldwide/> (accessed 20/05/2022)

¹²³ From Cloud To Edge, Reply (<https://www.reply.com/en/Shared%20Documents/from-cloud-to-edge-EN.pdf>) (2020)

opportunities related to cybersecurity. More precisely, encryption and authentication are some areas that entrepreneurs targeting public administrations as customers will have to keep in mind when designing the types of products and services that they offer them.

b) Training

One of the reasons for low adoption of cloud computing solutions within the public sector is that their personnel is not well-equipped to handle CC solutions. Providing training to enhance the capabilities and skills of public administration workers may be a way for entrepreneurs to work with public institutions. Plus, it may be a way to open doors and establish a relationship with them for future sale of products and services. Moreover, entrepreneurs should keep in mind that a combination of sale of a tool, combined with training on how to use the tool, could be the most efficient way to approach working with public administrations.

c) Procurement

According to recent studies, public administrations often consider cloud computing services, or the move to said services, too expensive. Moreover, accounting is often given as a reason not to switch to CC, as existing infrastructures have not yet reached their so-called “end of life”. This makes it difficult for CC entrepreneurs to convince public administrations that they should move to the cloud. However, as time passes, “end of life” for said infrastructures is nearer, and CC prices are becoming lower and lower. It is the job of CC entrepreneurs to convince potential customers that investing in the cloud is worthwhile from an economic and policy standpoint. And people in charge of public procurement should open their ears to listen to what these entrepreneurs have to say¹²⁴.

5.2.2 Cloud related policy examples

There is hope that public administrations will incorporate CC solutions to their infrastructures. In fact, we will now see how some governments around the world have incorporated cloud computing in some form or another.

We will begin by analysing different cases in Europe: as far back as 2013, the British government introduced a Cloud First Policy, meaning that CC options should be evaluated before any other type of onsite alternative; France adopted a similar initiative a year later; the Norwegian public sector and its enterprises must at least consider the cloud as a possibility when procuring products and services; and Germany has the ‘Bundescloud’, which basically consists of a cloud infrastructure to host government data.

Other parts of the world also provide us with examples of a positive evolution in CC adoption in the public sector: Canada now prioritises the cloud over other types of alternatives, the US government actively looks to migrate its infrastructure to the cloud; Nigeria is aiming to have at least 30% of its services being offered through the cloud; the “Kasumigaseki Cloud” initiative in Japan has intention to develop a private cloud to host all government computing services; and countries such as Egypt, Israel, the Philippines, Australia, New Zealand, Singapore and India are also making efforts to improve their services through the cloud¹²⁵.

5.2.3 Applicable funds for CC entrepreneurs in the EU:

The EU offers several sources of financing for entrepreneurs in the field of cloud computing.

¹²⁴ Deloitte, Digital Government: How the EU cannot miss the cloud opportunity (2021)

¹²⁵ Deloitte, Digital Government: How the EU cannot miss the cloud opportunity (2021)

Moreover, the following programmes not only offer funding, but what may be more important, they give an idea of what the EU's institutions consider to be the main trends in cloud computing:

- a) The Next Generation EU programme includes the Recovery and Resilience Facility, which aims at mitigating the effects of the coronavirus pandemic. An important part of this initiative is the transition to digital solutions; and more precisely, cloud computing.
- b) The Digital Europe Programme (2021-2027) aims at funding projects that bring digital technology to businesses, citizens and public administration.
- c) The Digital programme within the Connecting Europe Facility funds trans-European networks and infrastructure, with the ultimate aim of favouring digital connectivity in Europe.
- d) Technological and industrial aspects related to the European defence sector are promoted through the European Defence Fund (EDF)¹²⁶.

Some country-specific programmes include:

- a) The Plan to support the French cloud sector, with a budget of €1.8 billion over 4 years.
- b) The Supply of Central Cloud Computing Infrastructure and Service, and the Upgrade of Cloud-computing infrastructure and services of the National Infrastructures for Research and Technology (GRNET) in Greece, with budgets of €95 million and €63 million, respectively.
- c) A significant programme for Enabling and facilitating Cloud migration in Italy, with a budget of €1 billion¹²⁷.

5.3 Risks

Although other difficulties associated with cloud computing business development include a wide gap in terms of skills, unclear contract conditions and limited offer of services, the main challenge for cloud computing entrepreneurs to succeed, beside their ability to identify the right business opportunities, is security. Data confidentiality and privacy are still great concerns for many would-be customers and consumers. Despite these issues, cloud computing continues to rise thanks to the flexibility, cost-effectiveness and scalability of cloud computing. Nevertheless, security concerns should not be underestimated. Furthermore, entrepreneurs should not only think of security as a technical issue, but they should also incorporate this topic in their business models.

¹²⁶ Deloitte, Digital Government: How the EU cannot miss the cloud opportunity (2021)

¹²⁷ Deloitte, Digital Government: How the EU cannot miss the cloud opportunity (2021)

6 SUCCESS CASES IN CLOUD COMPUTING ENTREPRENEURSHIP IN EUROPE

It is common knowledge that the pandemic has accelerated cloud computing service adoption. Companies such as Netflix, Zoom and AWS have seen their revenues rise significantly in recent times. And although the USA dominates the cloud computing market, there are some cases of European start-ups which are thriving in today's climate of CC adoption. We will now look at a few examples of successful European start-ups which are not so well known^{128,129}:

1. **Aiven (Finland):** Funded in 2015, Aiven has developed an automated operations platform that allows users to set up cloud databases¹³⁰. Thus far, they have raised €46.4 million in funding.
2. **Altostratus (Spain):** Altostratus provide personalised solutions for storage, data processing and security. It was bought by Telefónica Tech in 2021¹³¹, they have offices in Madrid and Barcelona, and they employ over 75 people.
3. **Atlas Cloud (UK):** funded in 2010, Atlas Cloud have raised €4.9 million in funding. They provide public cloud technologies in association with Microsoft¹³².
4. **Cloudalize (Belgium):** The company was founded in 2018, and they have already raised €7.9 million. They offer a series of GPU-powered cloud solutions while guaranteeing online security¹³³.
5. **Cloudar (Belgium):** Founded in 2014, Cloudar combine reselling, consultancy, staffing, and managed services for different types of companies, while concentrating on AWS solutions¹³⁴.
6. **Contentful (Germany):** Founded in 2013, Contentful have developed an “API-first content management platform to create, manage and publish content on any digital channel”. They claim to have over 2,000 customers, 10,000 websites in production, 400,000 engaged users and 300 application integrations with technology partners¹³⁵. They have raised over €70 million.
7. **Dixa (Denmark):** Created in 2015, Dixa have developed a cloud-based platform for customer relations. They have raised nearly €50 million as of May 2020¹³⁶.
8. **Konsolidator (Denmark):** Founded in 2016, Konsolidator provides software to automate and standardise financial consolidation and reporting¹³⁷. With offices in Denmark, Sweden and the UK, they currently employ over 50 people¹³⁸.

¹²⁸ <https://siliconcanals.com/news/cloud-tech-start-ups-in-europe-to-survive-corona-crisis/> (accessed 24.05.2022)

¹²⁹ <https://jackmathew.medium.com/top-cloud-start-ups-in-europe-457be826d26d> (accessed 24.05.2022)

¹³⁰ <https://aiven.io/> (accessed 24.05.2022)

¹³¹ <https://www.telefonica.com/es/sala-comunicacion/telefonica-tech-adquiere-altostratus-y-consolida-su-liderazgo-en-cloud/> (accessed 24.05.2022)

¹³² <https://www.linkedin.com/company/atlas-cloud/about/> (accessed 24.05.2022)

¹³³ <https://www.cloudalize.com/> (accessed 24.05.2022)

¹³⁴ <https://cloudar.be/> (accessed 24.05.2022)

¹³⁵ <https://www.contentful.com/> (accessed 24.05.2022)

¹³⁶ <https://siliconcanals.com/news/cloud-tech-start-ups-in-europe-to-survive-corona-crisis/> (accessed 24.05.2022)

¹³⁷ <https://konsolidator.com/> (accessed 24.05.2022)

¹³⁸ <https://www.linkedin.com/company/konsolidator/?originalSubdomain=dk> (accessed 24.05.2022)

9. **Oodrive (France):** Founded in the year 2000, Oodrive manage sensitive data. Their target customer is companies of over 500 employees, as they help them incorporate electronic signatures within the company. So far, they have raised €68 million¹³⁹.
10. **Scaleway (France):** Founded in 1999, Scaleway are a multi-cloud service provider for newly formed and cloud-native companies. They operate in 160 countries, and have Adobe and Dailymotion among their customers¹⁴⁰.
11. **Tresorit (Switzerland):** The company was founded in 2011, and they claim to be *“the ultra-secure place in the cloud to store, sync, and share files”*¹⁴¹. They have raised €30 million thus far.
12. **Veeam (Switzerland):** Founded in 2006, Veeam is the most successful start-up on this list, as they have raised a whopping €455 million in funding with their intelligent data management service for enterprises¹⁴².
13. **WeTransfer (The Netherlands):** Probably one of the best known European cloud companies, WeTransfer was founded in 2009. Their aim is to offer a simple yet effective way to share large files around the world. Their business strategy has allowed them to raise €57.7 million.
14. **OpenNebula Systems (Spain):** Founded in 2010 as C12G Labs, OpenNebula Systems has developed and maintains the cloud and edge computing platform OpenNebula [<https://opennebula.io>], the only European open source alternative for building private, hybrid, and edge clouds. With around 5,000 cloud deployments worldwide, OpenNebula is being used by organizations such as AlmaLinux, Akamai, Blackberry, Booking.com, Dustin, Growens, Harvard University, Hitachi, Ludia, Nasdaq Dubai, Qt, and Telefónica.
15. **Qarnot (France):** Founded in 2010, Qarnot offers budget cloud high-performance computing (HPC) that is environmentally friendly. The company has raised €10.6 million in four investment rounds.

As we have seen, not all successful CC start-ups come from the USA. There are plenty of success cases in Europe which show that, when one addressed the market in the right way, there are endless possibilities to succeed.

¹³⁹ <https://siliconcanals.com/news/cloud-tech-start-ups-in-europe-to-survive-corona-crisis/> (accessed 24.05.2022)

¹⁴⁰ <https://www.scaleway.com/en/about-us/> (accessed 24.05.2022)

¹⁴¹

https://tresorit.com/business?dnc&utm_term=tresorit&gclid=Cj0KCQjwhLKUBhDiARIsAMaTLnFUkyic6WOa1X4o1K8xZtVXxbLw0ICmLiYhI5M-4NEunYAljESeTV0aAmaLEALw_wcB (accessed 24.05.2022)

¹⁴² <https://siliconcanals.com/news/cloud-tech-start-ups-in-europe-to-survive-corona-crisis/> (accessed 24.05.2022)

7 CONCLUSIONS AND FINAL RECOMMENDATIONS

In this second part of the “*Recommendations for Cloud Computing business modelling, analysis and acceleration*” report, we began by analysing the worldwide market trends in cloud computing by segment. We saw that cloud computing is virtually pulverising data centre hardware and software implementation; that spending in cloud computing is growing in companies of all sizes; that all segments of cloud computing (IaaS, PaaS and SaaS) are growing rapidly; and that SaaS represents the largest share of revenue.

We then went on to concentrate on the characteristics of the European markets in order to find out what differentiates Europe from other parts of the world. Again, we saw that the markets for all segments of cloud computing are growing in Europe, where revenues from SaaS represent more than those of IaaS and PaaS combined. US-based cloud computing service providers still have a big advantage over their European counterparts. However, steps are being taken by European institutions to reverse the situation. These institutions should continue to develop policies that facilitate entrepreneurship, reduce red tape and make Europe more competitive in cloud computing.

There are numerous people advocating for open-source solutions in IT in general, and cloud computing is no exception. We analysed the opportunities and risks of OSS in cloud computing and came to the conclusion that open source allows entrepreneurs to be able to take advantage of previous software developments; and allows them to compete more easily with big players in the market. Furthermore, the report looked at different business models that incorporate open source in cloud computing and ways to incorporate open-source solutions in cloud computing. We came to the conclusion that there are plenty of opportunities being facilitated by open source. However, we also saw that each case is different, and each entrepreneur will have to evaluate the best alternative for them. Entrepreneurs should identify those areas in which open source can represent a competitive advantage by looking at previous examples and analysing market trends.

The report analysed different entrepreneurial ecosystems around the world, to go on to focus on the European ones. We saw that European ecosystems lack in size when compared to those of places such as the USA, China or Israel. The same can be said in terms of the number of unicorns generated in Europe. Moreover, there is still some work that needs to be done in connecting the academic world with the business world to produce research results that will end in products and services in the market. However, the public institutions in Europe are working hard by developing infrastructures and policies to build sustainable ecosystems that will generate growth at continental, country and regional level. These efforts should not stop, as having the right environment is crucial for entrepreneurs to achieve commercial success.

Opportunities for cloud computing entrepreneurs were analysed from the point of view of the market, and also from the point of view of the public sector. We saw that the market offers plenty of opportunities from different angles; and there is a trend for the public sector to consume more and more cloud computing services, thus generating plenty of opportunities for entrepreneurs. The main challenge (and opportunity) that cloud computing entrepreneurs face is guaranteeing security and confidentiality of the services provided. Cloud-computing entrepreneurs should keep this in mind at all times when designing their products and services.

We ended the report by showcasing some examples of success cases in European cloud computing entrepreneurship. These examples should serve as inspiration and motivation for entrepreneurs throughout Europe to make their best efforts to succeed in the market.