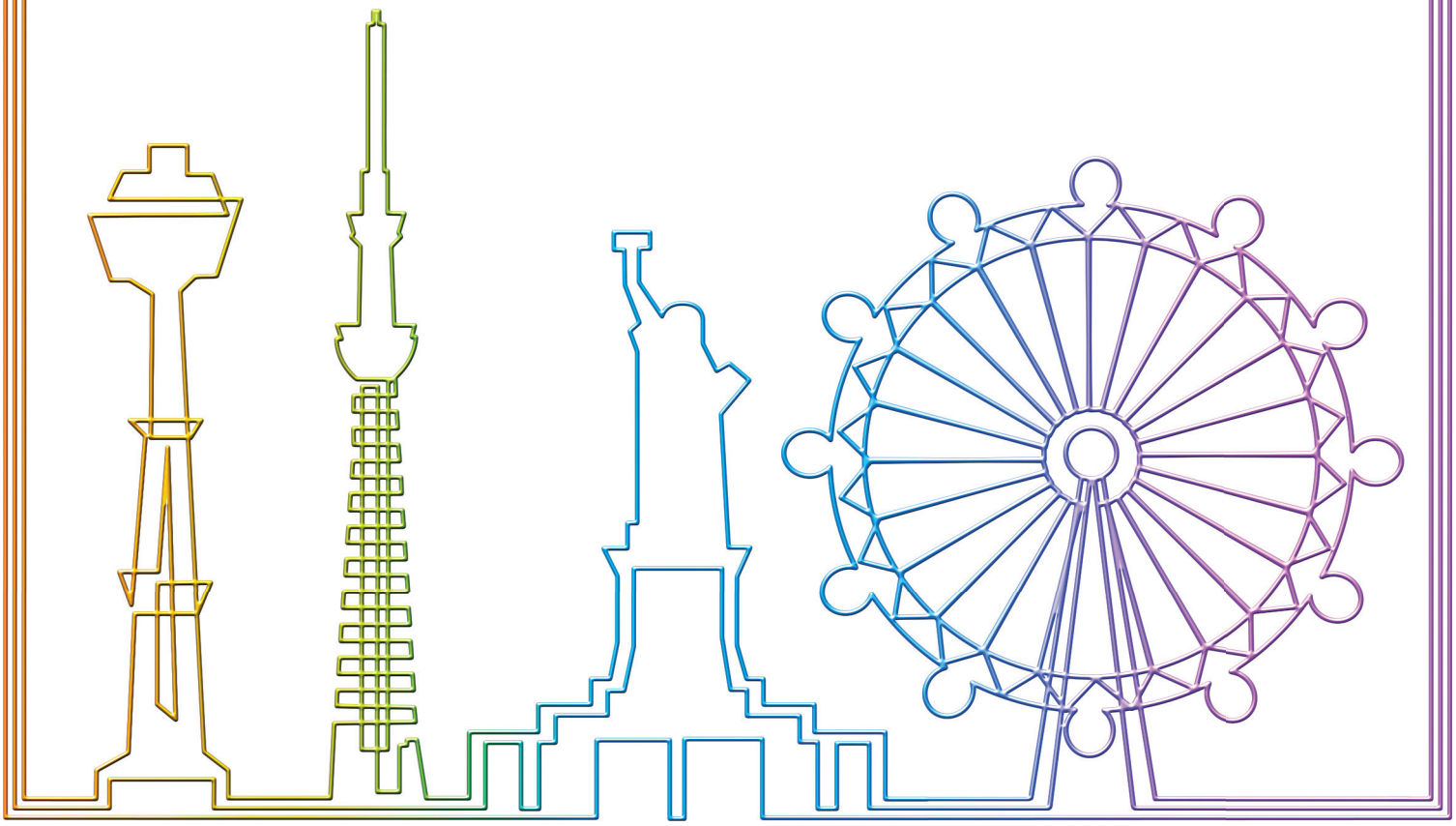
DIGITAL REALTY

Powering your digital ambitions

DIGITAL CAPITALS INDEX

NOVEMBER 2019



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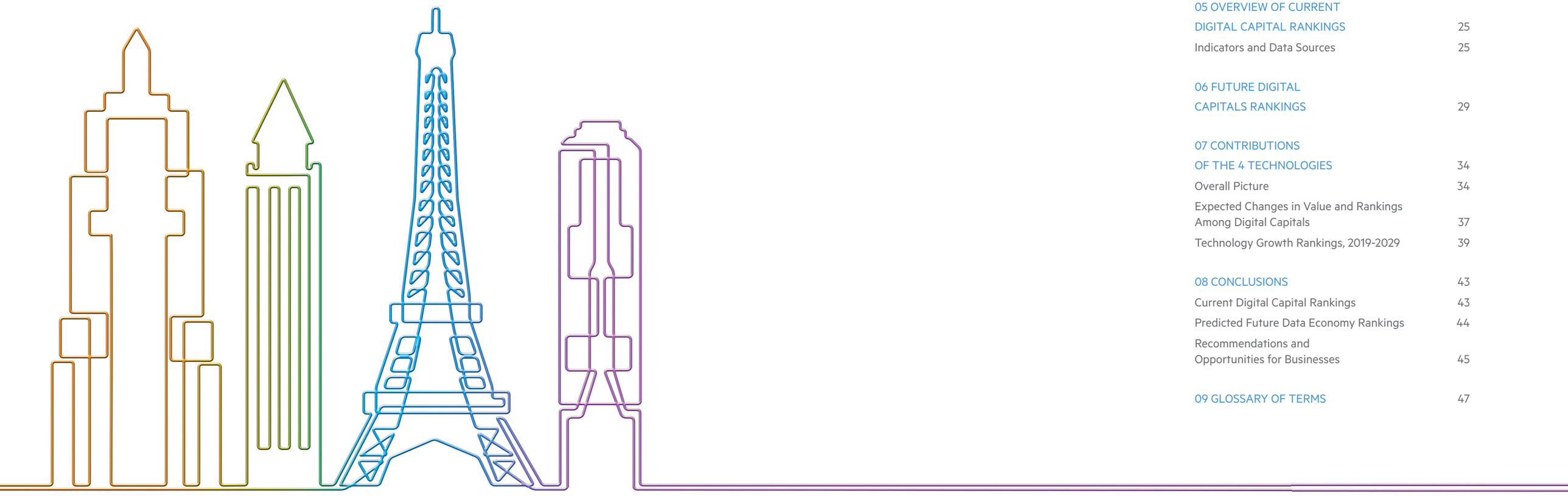
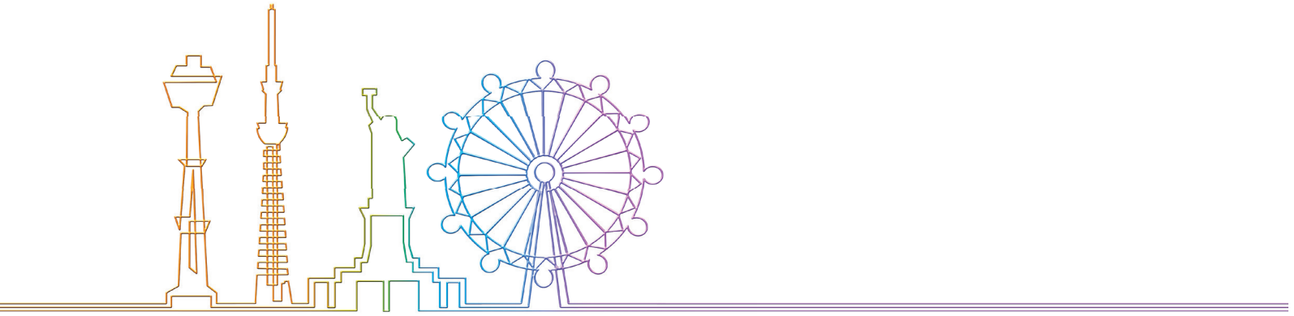


01

Executive Summary



The creation and sharing of information is central to both economic and social activity. However, in recent decades there has been an enormous increase in the rate at which information, increasingly in the form of digital data, is created, stored and used for commercial purposes, and for other uses such as in healthcare and entertainment.

The rate at which data is being created continues to grow at astounding rates. According to recent estimates, growth in data generation is expected to increase at over 60% per annum over the next 5 to 6 years, driven by data-intensive technologies in every aspect of life from business to the home. The growth in data is also expected to be further stimulated by new or evolving data-intensive applications such as artificial intelligence (AI) and 5G networks.

The economic contribution of digital information has previously been termed the data economy[1]: this is the financial and economic value generated by the creation, storage, retrieval and use of highly-detailed business and organizational data at high speeds. The economic contribution of the data economy to national economies has been previously examined in an earlier study also commissioned by Digital Realty dating from 2018, which focused on the current and potential future size and value of the data economy in a number of European countries.

In this new report the focus has shifted from the contribution of data to the economy of a small number of European countries to that of a much larger group of leading international cities. This is because cities – especially major conurbations such as New York City, Tokyo and London – are hubs for the highest density of digital commercial activity, digitally-skilled workforces and the creation of new digital technologies and applications. Major cities also usually possess the fastest and densest concentrations of digital, transportation and other infrastructures that make it easier for talented people to meet, share ideas, collaborate and develop new forms of technology and applications.

Major cities are also increasingly important as hubs for many globally-important technology-led clusters (such as information technology, life sciences, media and financial services). This is because of the high density of business networks, the availability of talent and the presence of key infrastructure usually found in larger cities, the advantages of which more than offset the higher property and other costs involved in operating there.

Specifically, this new report assesses the current and potential future rankings of 60 major global cities in terms of their contribution to the world's data economy. The objective of the research is to provide evidence on the scale of opportunities that cities and businesses could miss out on if they do not invest in the infrastructure, skilled workforces, commercial environment and other factors that allow businesses located there to compete with others in the modern, global digital economy.

In addition to the focus on these cities' data economies, the study also focuses on 4 specific digital technologies that are rapidly evolving and expected to become increasingly important contributors to the annual value of the data economy in each urban area. These technologies are: artificial intelligence (AI); internet of things (IoT); Blockchain; and 5G connectivity. Specifically, the study estimates both the current and potential future annual contribution to wealth creation in each of the 60 digital capitals from each specific digital technology and which cities will lead in each technology, the next decade's 'digital capitals'.

The report has been undertaken by Development Economics, an independent UK-based consultancy. Although the study has been commissioned by Digital Realty, all analysis and findings are the responsibility of Development Economics.

Current Data Economy Rankings

A key task of the study was to gather and analyze information that enabled the ranking of 60 leading world cities as locations for digital knowledge creation and commercial activity. The shortlisting of 60 digital hubs – known as digital capitals – was established through interrogation of business, economic, demographic and labor market datasets.

To establish and rank scores for each city, data was assembled and assessed across 10 families of indicators. The data covered: the size and structure of the city economy; the extent of consumer demand for data; the availability and quality of higher education teaching and research & development (R&D) capabilities; the capacity and reliability of data infrastructure; the availability of human capital resources, including advanced digital skills and entrepreneurship; the quality of city-level infrastructure and governance; an assessment of health, education, environment and other quality of life factors; and the quality and reliability of the environment for data sharing and doing business.

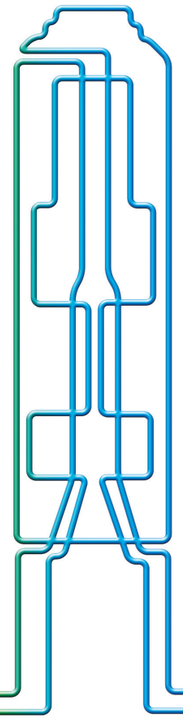
Based on these indicators, and the scoring, a ranked list of the world's top 60 locations for digital economy activity was established. Of these, the 10 most innovative and technology focused locations in 2019 were:

1. New York City
2. Tokyo
3. Los Angeles
4. London
5. San Francisco
6. Singapore
7. Chicago
8. Hong Kong
9. Paris
10. Toronto

Amongst the determinants of current position in the rankings, probably the most important is the scale and complexity of digital business and commercial activity taking place in the leading digital capitals. For example, nearly all of the top 10 are top global locations for data-intensive industries, such as financial services, information technology, media and entertainment, and professional services. These industries were also among those identified as being principal engines for the annual value of the contribution from the digital economy in the 2018 Data Economy Report.

The top 10 list is dominated by long-established cities in leading advanced economies such as the United States, United Kingdom, France and Japan, as well as the leading Asian trading centers of Hong Kong and Singapore.

Moreover, if the list is expanded to include the world's top 20 digital capitals, then additional cities located in developed countries – such as Amsterdam, Berlin, Houston, Munich, Seoul and Sydney – are encompassed. On the other hand, the highest currently ranked city located outside the Organization for Economic Cooperation and Development (OECD) grouping[2] is Beijing, at 29.



[1] Digital Realty: The Data Economy Report, 2018

[2] Organization for Economic Cooperation and Development

Predicted Future Digital Capital Rankings

As well as current rankings of digital capitals, the study also examines forecast data for business and demographic growth and technology trends to produce predicted data economy rankings for the next decade.

By 2029 the world's leading digital capitals are predicted to be:

1. New York City
2. Los Angeles
3. Tokyo
4. San Francisco
5. Singapore
6. London
7. Chicago
8. Toronto
9. Paris
10. Hong Kong

Essentially, the research finds that within the current top 10 digital capitals, it is London and Hong Kong which are perceived to be at greatest risk of losing ranked places between 2019 and 2029, with Toronto having the greatest potential to improve its current (2019) relative position.

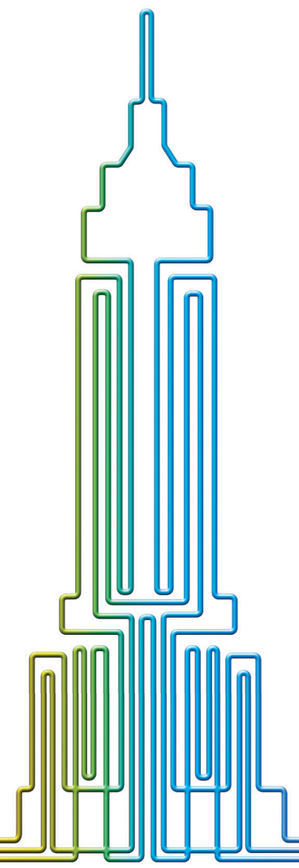
However, more significant changes are expected outside the current top 10 list. Among the cities that have the greatest potential to improve their position between 2019 and 2029 are:

- Shanghai: with a predicted increase of 8 ranking positions occurring between 2019 and 2029.
- Bangkok: an improvement of 5 rank places over the same period.
- Beijing and Dublin: each with a predicted improvement of 4 places by 2029.

Although there are a variety of explanations of what is driving the more significant predicted changes in a city's performance, the key drivers are over, or under, performance in:

- Annual growth of business activity and population;
- The structure of the city's business base and the capacity for additional digital adoption; and
- Growth of both the size and the capabilities of the city's labor force (i.e. the human capital dimension).

For example, Shanghai is expected to perform strongly in terms of economic and labor force growth, as well as the proportion of its business base that is involved in both developing and utilizing advanced digital technologies. Hence, Shanghai is among the cities that is expected to achieve the most significant improvement in its digital capital ranking over the next decade or so.



Contributions of the 4 Digital Technologies

A key part of the data economy growth predicted over the next decade will result from the growth of a set of data intensive, interconnected technologies such as AI, IoT, Blockchain and 5G. With that in mind, the other main purpose of this report is the focus on the economic contributions of those digital technologies to the annual value of economic activity taking place in each of the 60 leading cities.

A series of datasets – including those relevant to economic, business, demographic and labor market performance – have been used to estimate the current contribution of the 4 technologies to each of the cities covered by this report. The study has also used current forecasts for economic growth, demographic change and predicted adoption rates for the 4 technologies to produce predictions of the potential quantity of economic value for each technology in each city in the years 2024 and 2029.

The future predictions of gross value added (GVA) created are measured in US Dollars (US$) using a 2019 price base. Therefore, the predictions take into account the potential future effects of inflation.

The table below summarizes the current and expected future value of the contribution from the 4 technologies individually and in total across the portfolio of 60 cities. Overall, the annual value contributed by the 4 technologies is expected to increase from nearly US$169 billion p.a. in 2019 to US$392 billion p.a. by 2024. By 2029 they will contribute nearly US$721 billion p.a.

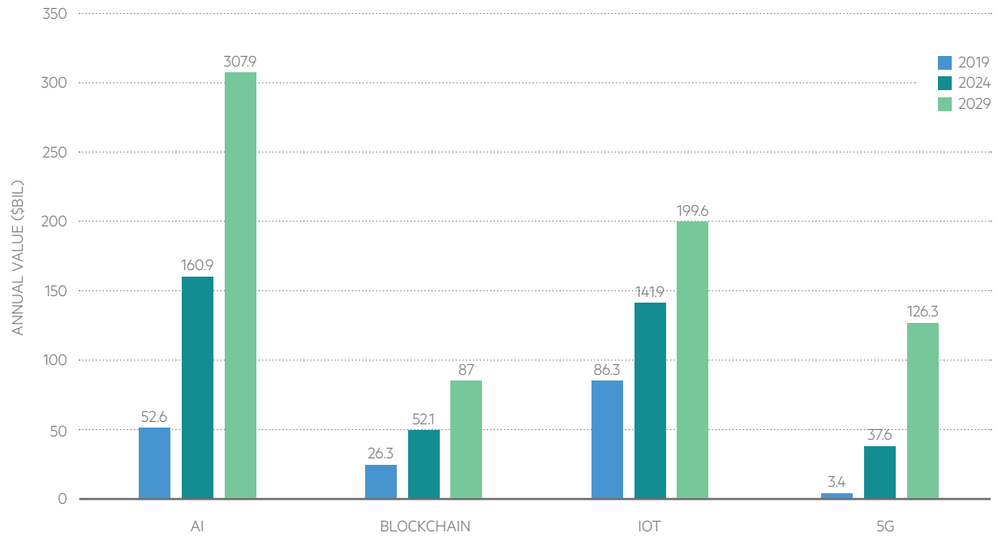


Table 1.1: Aggregate value of technology to 60 leading cities: 2019, 2024 and 2029 ($US billions, 2019 prices)

While the contribution of each technology to the economies of the 60 cities is set to increase significantly, the overall increase in value created is expected to be dominated by the contribution from AI. Indeed, of the overall anticipated increase in annual value of US$552 billion, 46% is expected to be contributed by AI alone.

A further 22% of the overall increase is expected from 5G and nearly 21% from IoT, while Blockchain is expected to account for the final 11%.

Although the absolute growth in the contribution is expected to be dominated by AI, it is 5G that is expected to grow at the fastest rate over the 2019-2029 period: this is because 5G is an emerging technology and is expected to grow rapidly from a low baseline position.

In terms of contributions from individual cities, in 2019, the largest annual value (GVA) associated with the 4 technologies is estimated to occur in Tokyo (US$12.80 billion p.a.). By 2029 the annual value of this contribution is predicted to grow to nearly US$42 billion. However,

"Overall, the annual value contributed by the 4 technologies is expected to increase from nearly US$169 billion p.a. in 2019 to US$392 billion p.a. by 2024. By 2029 they will contribute nearly US$721 billion p.a."

future growth in Tokyo is expected to be amongst the slowest of the leading digital capitals.

By 2029 the largest contribution to annual economic output from the technologies is expected to be generated in New York City (US$46.14 billion p.a.) followed by Shanghai (US$42.31 billion p.a.).

The principal drivers for growth in annual contribution of the 4 technologies is primarily the expected increase in the scale of supply and use of the technologies in commercial, public administrative and domestic applications in each city. The cities that are expected to be faster at adopting the technologies are expected to do comparatively well, but the underlying expected growth rates in overall size of the economy and the growth in the population, and per capita income, also play a key role in explaining the relative performance of cities.

Recommendations and Opportunities for Businesses

If businesses want to benefit fully from growth in the digital economy, they need to start taking action today. The economies of digital capitals around the world will only continue to grow, albeit at different speeds depending on a number of factors such as economic and government stability.

If you consider that, the transport and logistics industry already regularly makes use of sensors installed in their vehicles to help schedule maintenance and ensure drivers optimize fuel consumption when out on the roads while at the same time, financial services organizations are starting to use AI-powered fraud detection programs to sift through huge amounts of records and find anomalies quickly, preventing illegal activity, it's clear that now is the time to plan how business can harness the potential that these innovative technologies offer.

Provided below are some recommendations that businesses should seriously consider if they are to remain competitive in this rapidly growing technological environment.

Take Advantage of Competitive Digital Platforms

There are unrealized opportunities for businesses that have not yet created the adaptable technology platforms which would allow them to deploy each of these technologies, working with key partners, allow them to deploy each of these specialized technologies to gain competitive advantage:

- The 4 technologies explored are only growing in importance as they enable businesses to create and gain intelligence from their data in ways that have never been achieved before.
- An adaptable technology platform will differentiate a business' agility by reducing the time it takes to connect to partners, providers and markets using the latest technologies.
- This will enable companies to tailor their technology deployments at speed and to meet, and even exceed, their needs in an increasingly competitive environment.

Invest in Talent

This report highlights one key area where investment is crucial: a skilled workforce. It is clear that cities and businesses should incubate and invest in technology talent to ensure they continue to have the skills to operate, deliver and capitalize on innovative technologies.

Major cities are vital in creating and hosting high value and innovative commercial activity through their role as locations for knowledge-driven business clusters. As a result, the high density of business networks in the city means the availability of talent and the presence of key infrastructure is also usually found in those places. With today's new technologies, this can very quickly lead to a major skills shortage and prevent businesses from being able to harness the power of their technology innovations.

Investing in digital apprenticeships and supporting college and university digital training programs is essential to the future success of all digital capitals.

Think Urgently About Your Future Technology Strategy

Businesses should continuously invest in upgrading and expanding their technology strategies to stay ahead of business need. The business that is not ready to take advantage of these technologies is the one that is going to rapidly lose ground against its competitors.

Identify the Partners, Suppliers and Key Players That Should Be In Your Competitive Ecosystem

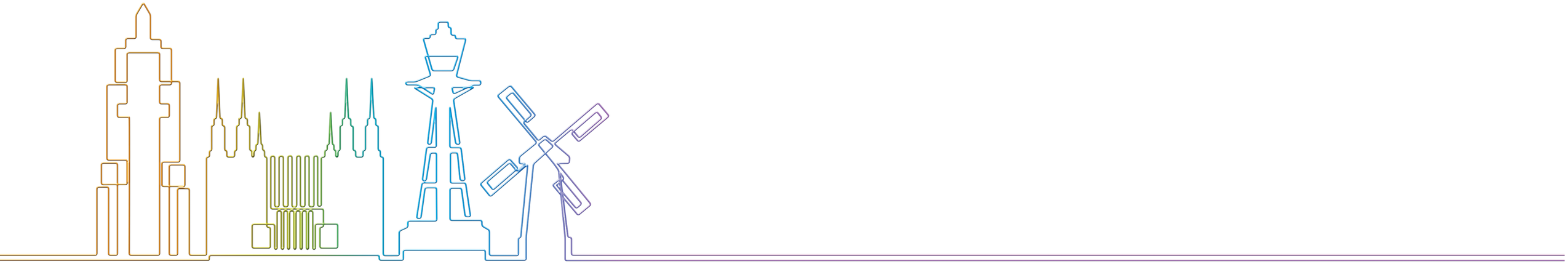
For cities and businesses, having technical networks that can be rapidly and seamlessly connected to a global digital ecosystem is vital to fostering innovation and enabling a wider, global connection.

There is good evidence that major cities will be increasingly important in creating and hosting high value and innovative commercial activity through their role as locations for knowledge-driven business clusters or ecosystems.

Ecosystems are geographically concentrated networks of interconnected companies and allied organizations (such as universities and research institutes; financial services organizations and their suppliers) operating within a specific industry or sector.

Successful ecosystems are usually characterized by a high volume of interactions. For example, where companies work collaboratively to create competitive advantage, exchange ideas, develop innovative products or processes, and go on to launch joint ventures, a competitive service or new businesses together.

02
Introduction



Purpose of the Study

The creation and sharing of information has always been at the heart of civilization. However, in recent decades the continuous development of larger and faster information storage and processing systems has led to an enormous increase in the rate at which data is created, stored, and made useful in terms of helping organizations and individuals communicate and make better decisions. It has also opened up new opportunities for improved delivery of healthcare, education, entertainment and many other applications.

The rate at which digital technology constantly develops means that we continue to see huge increases in the creation of data. According to recent estimates, there is likely to be a world-wide annual growth rate for data generation of 61% p.a. up to 2025[3]. This massive growth is driven by huge increases in data-intensive technologies in industry, commerce, and financial systems; in the vehicles that move human passengers or freight; through to electronic communications such as email and social media; via streamed movies, TV, sport, gaming and other forms of digital entertainment; and so on.

Future growth in data generation and usage will be increasingly driven by new or evolving forms of digital technology, such as AI and advanced robotics. It will also be stimulated by the imminent roll-out of the 5th generation of mobile network connectivity (5G), which will enable the widespread use of new applications such as virtual/augmented reality (VR/AR).

The economic contribution of digital information has been termed the data economy: this is the financial and economic value generated by the creation, storage, retrieval and use of highly-detailed business and organizational data at high speeds via sophisticated technologies.

The economic contribution of the data economy to national economies has been previously examined in an earlier study also commissioned by Digital Realty dating from 2018. The 2018 Digital Realty Data Economy report focused in particular on the current and potential size and value of the digital economy in 4 European countries: Germany, the Netherlands, the Republic of Ireland and the UK.

In this new report the focus has shifted from the contribution of data to the economy of a small number of countries to that of a much larger group of leading international cities. There is an abundance of evidence that much of the technological development and commercial innovation that is driving the data economy is taking place in major cities, and larger cities are where a constantly growing number of people work and/or reside.

[3] https://www.networkworld.com/article/3325397/idc-expect-175-zettabytes-of-data-worldwide-by-2025.html

Why the Focus on Cities?

In this new study, the focus of attention has switched from countries to cities. This is appropriate, because the concept of civilization is both defined and driven by urbanization and the growth of increasingly large and complex cities.

Also, in the modern, knowledge-driven and data-fueled digital economy, cities are becoming even more important to economic and social development. This is because cities – especially major conurbations such as London, New York City, Paris and Singapore and Tokyo – are the locations for the highest density of human and business interactions. They are also the places with the world's largest concentration of highly-qualified workers and entrepreneurs, and the places where many of the world's leading universities and research institutes are located. Such cities usually possess the fastest and densest concentrations of digital, transportation and other infrastructures that makes it easier for talented people to meet, share ideas, collaborate and develop new forms of products, services and applications.

In addition, there is good evidence that major cities are likely to be increasingly important in creating and hosting high value and innovative commercial activity through their role as locations for knowledge-driven business clusters. Clusters are geographically-concentrated networks of interconnected companies and allied organizations (such as universities and research institutes) operating within a specific industry or sector.

Successful clusters are usually characterized by a high volume of interactions between firms, where creative and professional people meet, exchange ideas, develop innovative products or processes and go on to launch joint ventures or new businesses together.[4]

For a variety of reasons, cities are often places that many leading technology-led clusters or ecosystems (such as information technology, life sciences, media and financial services) develop most successfully, despite the higher costs for businesses of operating in large cities. This is because of the high density of business networks, the availability of talent and the presence of key infrastructure usually found in larger cities, the advantages of which more than offset the higher property and other costs associated with being located there.

For all these reasons, this latest report focuses on the particular role that cities currently, and in the future, will play in the data economy. Specifically, the research assesses the current and potential future rankings of 60 major cities across the globe in terms of their contribution to the world's data economy. The objective of the research is to provide estimations of the scale of value and opportunity that cities and businesses could create if they provide the infrastructure, skilled workforces, commercial environment and other factors that allow businesses located there to compete within the modern, data fueled digital economy.

[4] https://www.economist.com/news/2009/08/24/clustering

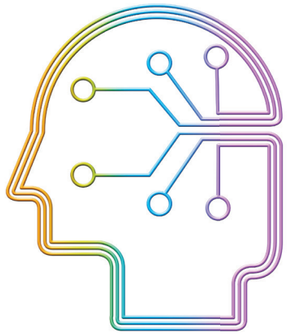
Focus on Data and 4 Specific Technologies

The 2018 Digital Realty Data Economy report highlighted the increasingly important role that data plays in the modern economy. To recap briefly, over the past 20 years, fast evolving advances in technology have led to a huge increase in the rate at which new data is being created. These trends are being sustained, hence the scale of predicted increase in data generation highlighted earlier in this introduction.

Predicted growth rates in data generation of around 60% p.a. are being driven in part by the increasing use of a range of data-intensive technologies and applications, such as IoT and Blockchain. In addition to these relatively established digital technologies, emerging and complementary technologies such as AI and 5G are also expected to drive explosive increases in the future creation and consumption of digital data.

The creation of these applications and services is expected to drive huge increases in business activity and career opportunities, but also potentially huge increases in benefits for users of the technologies and society as a whole.

Moreover, to a very substantial extent, the ability of an individual city (and the surrounding hinterland that depends on that city) to compete globally will be influenced – at least in part – by its ability to generate products, services and applications that harness these evolving and emerging digital technologies. For that reason, as well as the digital capital rankings, the research has also studied the potential impact of the 4 technologies on the current and future economies of the world's leading cities, and which cities will lead in each technology, the next decade's 'digital capitals'.



Approach to the Study

DATA ECONOMY RANKINGS

As the first step in the ranking process of the data economies, a desk-based review was undertaken of the global evidence regarding the business benefits of digital technology. This review also identified potential sources of the latest available data covering international business and economic datasets.

A second step involved the assembly and analysis of a range of economic, demographic and business datasets to identify a shortlist of nearly 100 cities for potential inclusion in the Digital Capitals Index. The longlist was abbreviated to a shortlist of 60 cities through the use of data and following consultation with Digital Realty and their advisers.

Third, a set of potential digital economy indicators was proposed and agreed with Digital Realty. The 10 selected indicators covered the following families for each of the shortlisted cities:

1. The overall size of the city-level economy
2. The scale of activity of businesses operating in data-intensive business sectors plus the rate of adoption of digital technology among other businesses
3. The scale of consumer demand for data and digital applications
4. R&D: the presence of a leading university or universities in cities
5. The quality of telecommunications infrastructure
6. Human capital: the proportion of the workforce with advanced data skills
7. The stability of the local political environment, levels of crime and other metrics of governance
8. Quality of life indicators, such as the quality of health, public education, the efficiency of public transport and environmental indicators
9. Support for the data sector such as through open data policies
10. The quality of the environment for business (i.e. the ease of doing business, including for international companies)

Development Economics gathered quantitative data relevant to each family of indicators, as far as possible using single sources to facilitate consistent scoring and ranking on each indicator. Further details on the data sources used are provided in Chapter 5 of this report.

Future predictions of the absolute and relative rankings for data economies were also developed in the study. These were developed by harnessing information on – amongst other things – the expected trajectories of change with respect to the size and structure of each city's economy; demographic and labor market forecasts; expected trajectories of growth in digital adoption by both businesses and consumers; recent trends in performance of universities; and trends in digital infrastructure provision.

CONTRIBUTIONS OF THE 4 TECHNOLOGIES

Apart from ranking the current and potential future contribution of digital capitals, the study also quantified the current and potential future economic contribution – in the form of Gross Value Added (GVA) – of the 4 specific digital technologies: AI, IoT, Blockchain and 5G.

The approach taken to producing current estimates involved the gathering and analysis of information on the size, structure and productivity of the business sectors and workforces operating in the digital economy of each selected city. The quantification of future predicted estimates of contributions harnessed a range of forecasts, both for the economy and labor market of each city but also the likely rates of adoption of each digital technology by the city's business base, its public sector and the householder population of each city.

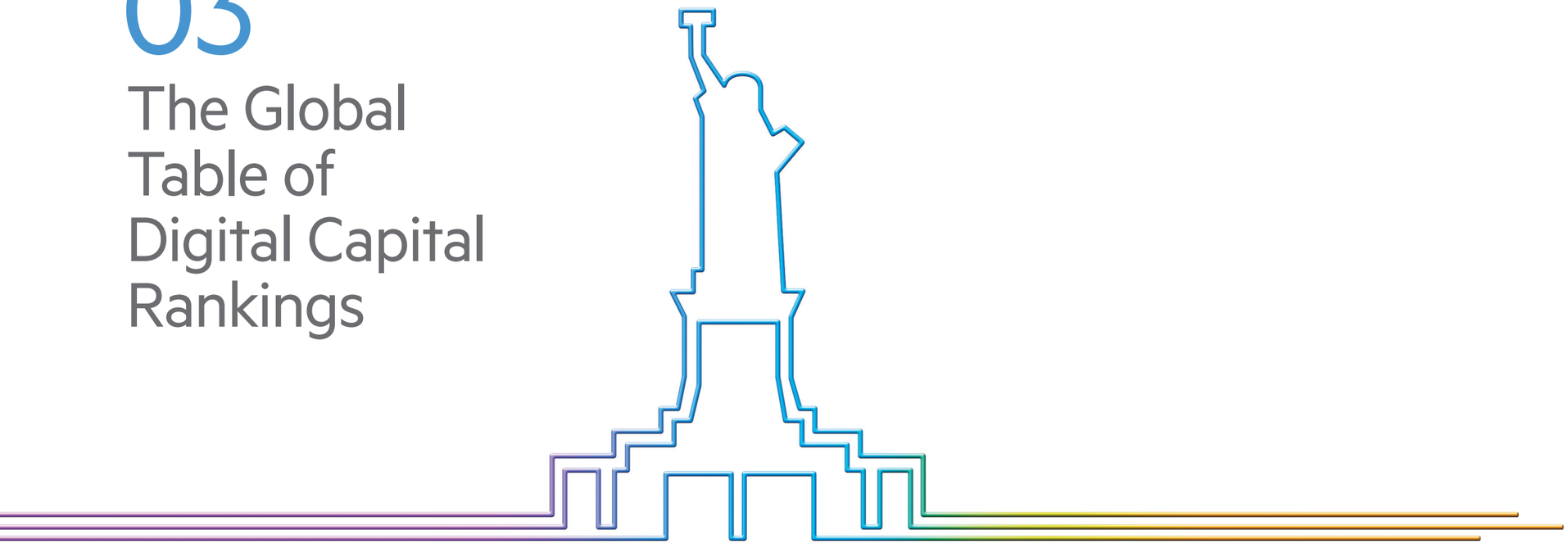
Structure of the Report

The remaining chapters of this report are structured as follows:

- Chapter 3: presents the summary table of global digital capital rankings.
- Chapter 4: explores the drivers for the huge increase in data generation and usage that is currently occurring and expected to continue. It also introduces the 4 specific technologies that are the focus of the assessment in this report. The chapter also further explores the role of cities in the modern, technology-driven economy.
- Chapter 5: provides more details of the method and data sources used in the assessment of current city rankings.
- Chapter 6: provides a predicted forward look at how the city rankings could evolve over the next 5-10 years.
- Chapter 7: provides details on the value of the current and potential future contributions of the 4 technologies across the portfolio of cities.
- Chapter 8: presents the conclusions and a series of calls to action on the part of governments, businesses and other entities.

03

The Global Table of Digital Capital Rankings



This chapter summarizes one of the key outputs of the report: the rankings of the world's top 10 digital capitals in ranked order. To establish the rankings, 10 families of indicators were used:

ECONOMY SIZE
The estimated size of the city's economy, measured in terms of annual GVA adjusted for purchasing power parity.

BUSINESS DIGITAL ADOPTION
The proportion of the city's business base that is predominantly involved in providing digital services or that although operating in other sectors of the economy has largely adopted digital modes of provision of services.

CONSUMER DEMAND FOR DATA
The estimated scale of demand among the city's population for digital communications and other services.

HIGHER EDUCATION R&D
The scale and quality of the city's university, research institute resources and higher education teaching resources.

DATA INFRASTRUCTURE
The estimated capacity and efficiency of the city's fixed and mobile data infrastructure.

HUMAN CAPITAL
An assessment of the size, skills and qualifications of the city's working age population.

CITY GOVERNANCE
A measure of the efficiency and safety of the city.

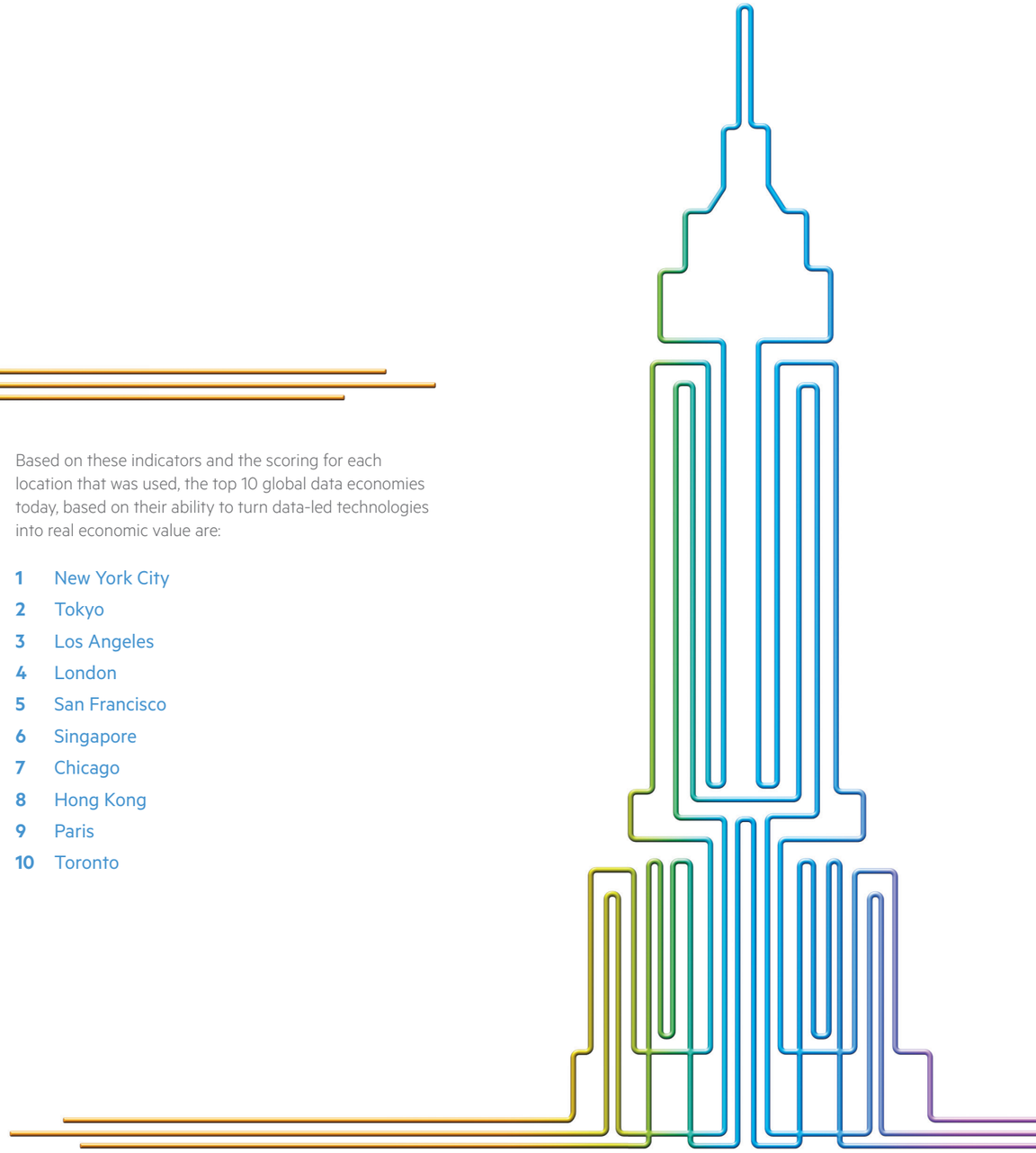
QUALITY OF LIFE
A measure of the availability of the city's compulsory years education, public health and public transport resources and the quality of the city's environment (considering aspects such as air quality, etc.).

DATA OPENNESS
This measure is an assessment of the open data ranking of the nation state within which the city is located. (Thus, all cities located in the same country received the same scoring for this indicator.)

BUSINESS SUPPORT ENVIRONMENT
This measure is an assessment of the ease of doing business. The critical factors include tax policies, openness to inward investment, openness to skilled immigration, intellectual property protection and levels of corruption. Because many of these factors are mainly influenced by national policy it was decided to use a single national ranking for all cities located in the same country.

Based on these indicators and the scoring for each location that was used, the top 10 global data economies today, based on their ability to turn data-led technologies into real economic value are:

1. New York City
2. Tokyo
3. Los Angeles
4. London
5. San Francisco
6. Singapore
7. Chicago
8. Hong Kong
9. Paris
10. Toronto



The table below sets out the ranking scores for the world's top 60 digital capitals. The ranking score for each city in the 10 categories of indicators listed above is provided in the columns. It also provides the city's overall score across the 10 categories. It should be noted that because '1' is the highest score that can be gained against each category, the best performing city is the one with the lowest score. Finally, the table also provides the overall ranking of the cities when the category scores are added together. For example, New York City has the best overall score (of 95). Thus, New York City is the highest ranked city overall.

City	Country	Economy size	Business digital adoption	Consumer demand for data	Higher education R&D	Data infrastructure	Human capital	City governance	Quality of life	Data openness	Business support environment	Overall score	Overall rank
New York City	USA	2	7	2	3	25	3	31	17	4	1	95	1
Tokyo	Japan	1	11	1	14	11	8	5	20	31	17	119	2
Los Angeles	USA	13	12	6	2	19	2	29	32	4	1	120	3
London	UK	8	6	13	4	22	1	44	16	1	23	138	4
San Francisco	USA	50	3	25	1	5	10	39	12	4	1	150	5
Singapore	Singapore	3	1	28	8	7	29	9	10	45	12	152	6
Chicago	USA	16	20	17	5	10	9	54	20	4	1	156	7
Hong Kong	Hong Kong	10	2	20	11	4	15	4	35	41	22	164	8
Paris	France	4	9	14	13	15	5	42	15	16	35	168	9
Toronto	Canada	23	10	26	6	20	21	18	7	18	27	176	10
Berlin	Germany	15	18	39	19	24	4	21	6	22	13	181	11
Seoul	South Korea	5	4	15	18	27	13	19	36	28	32	197	12
Amsterdam	Netherlands	47	5	53	17	12	23	12	4	17	21	211	13
Sydney	Australia	12	14	41	16	44	20	17	4	19	29	216	14
Munich	Germany	35	22	51	10	29	36	2	1	22	13	221	15
Austin	USA	54	28	57	12	2	24	15	29	4	1	226	16
Houston	USA	21	23	30	39	6	27	52	32	4	1	235	17
Melbourne	Australia	14	24	43	9	38	22	33	8	19	29	239	18
Dallas	USA	52	16	24	32	35	11	37	29	4	1	241	19
Madrid	Spain	26	19	29	42	8	28	11	19	26	37	245	20
Phoenix	USA	49	29	42	25	23	12	46	24	4	1	255	21
Taipei	Taiwan	51	13	16	29	45	18	1	37	25	28	263	22
Washington D.C	USA	55	17	36	22	51	7	49	23	4	1	265	23
Frankfurt	Germany	29	33	56	32	28	30	24	2	22	13	269	24
Manchester	UK	30	35	44	15	43	17	48	18	1	23	274	25
Yokohama	Japan	18	32	40	32	32	45	3	25	31	17	275	26
Miami	USA	58	31	27	28	36	16	43	32	4	1	276	27
Nagoya	Japan	45	40	12	39	18	41	6	28	31	17	277	28
Beijing	China	11	43	8	7	14	37	28	44	54	38	284	29

City	Country	Economy size	Business digital adoption	Consumer demand for data	Higher education R&D	Data infrastructure	Human capital	City governance	Quality of life	Data openness	Business support environment	Overall score	Overall rank
Brisbane	Australia	40	21	54	20	32	43	13	13	19	29	284	29
Atlanta	USA	57	30	34	44	3	32	53	31	4	1	289	31
Geneva	Switzerland	59	25	60	26	16	40	8	3	39	16	292	32
Stockholm	Sweden	53	8	58	27	30	34	32	9	15	26	292	32
Osaka	Japan	41	36	48	32	21	38	7	27	31	17	298	34
Moscow	Russia	9	38	7	31	41	6	23	58	42	46	301	35
Birmingham	UK	44	37	52	23	40	25	50	20	1	23	315	36
Shanghai	China	6	44	4	30	58	19	25	41	54	38	319	37
Busan	South Korea	31	26	38	53	31	33	16	39	28	32	327	38
Dublin	Ireland	48	15	59	24	9	44	38	11	46	36	330	39
Incheon	South Korea	39	42	46	59	13	46	14	40	28	32	359	40
Lisbon	Portugal	60	27	50	47	37	39	10	14	44	44	372	41
Hangzhou	China	38	49	33	21	1	51	35	53	54	38	373	42
Rome	Italy	42	41	45	32	34	31	45	26	38	42	376	43
Santiago	Chile	24	39	37	44	52	42	40	38	27	43	386	44
St Petersburg	Russia	20	45	35	47	46	26	20	59	42	46	386	44
Bangkok	Thailand	25	47	9	58	17	53	26	50	59	45	389	46
Mexico City	Mexico	22	51	11	53	26	35	57	47	40	49	391	47
Sao Paulo	Brazil	19	46	5	32	48	52	58	43	35	57	395	48
Jakarta	Indonesia	27	54	3	53	49	14	47	54	48	48	397	49
Istanbul	Turkey	7	34	22	42	56	50	36	48	52	54	401	50
Shenzhen	China	17	50	18	39	60	55	30	49	54	38	410	51
Rio de Janeiro	Brazil	36	48	19	53	47	48	59	42	35	57	444	52
Ankara	Turkey	28	52	55	47	53	47	22	51	52	54	461	53
Manila	Philippines	33	59	10	47	42	57	55	52	58	50	463	54
Bangalore	India	37	58	49	32	50	54	34	55	49	51	469	55
Mumbai	India	43	57	31	44	55	60	27	56	49	51	473	56
Lima	Peru	34	56	32	47	57	49	56	45	47	56	479	57
Cairo	Egypt	32	53	21	53	59	56	41	60	60	60	495	58
Delhi	India	46	60	23	47	54	59	51	57	49	51	497	59
Fortaleza	Brazil	56	55	47	59	39	58	60	46	35	57	512	60

04

Cities and the Data Economy

This chapter introduces the most important factors in driving change in the scale, role and importance of leading cities in the modern, knowledge and data-driven global economy. These factors encompass the opportunities and possibilities that are being created for new digital products and services enabled by technological advances, which are also contributing to an explosion in the volume of data that is being created and shared.

The chapter also provides further explanation for the inclusion and focus within the report on 4 rapidly evolving digital technologies that are expected to be of crucial importance to the world's economy (and society generally) over the next decade – AI; IoT; Blockchain; and 5G.

A further, linked aspect of the modern economy covered in this chapter is the important and strengthening role of cities as places where innovation, productivity growth and value-creation are increasingly occurring. This trend is driven by the phenomenon of business clustering and by the increasing concentration of high value economic activity in major cities. These aspects are explored in the final section of this chapter.

Digital Economy and Data Growth

The huge increase in data generation that has been experienced in recent years has been driven by advances in digital technology which have led, for example, to the proliferation of connected devices and sensors in both business and household situations.

Business use of data has also increased exponentially, driven by the increasing number of digital devices and sensors used on manufacturing production lines, in telecommunications, in energy production and distribution, in the delivery of healthcare, in managing public transportation systems, and in the movement of freight and passengers.

The growth of consumer data has also been stimulated by the increasing consumer demand for digital entertainment at home and while on the move, ranging from video and music streaming to online computer gaming and the sharing of pictures, videos and other information on social media.

The often-quoted statistic that 90% of all the data generated during human history has been created in just the past two years actually dates from 2013[5]. However, the increasing rate at which data is being created, despite the elapse of time, means the statistic is still reasonably accurate.

Such is the current intensity of data creation and sharing that the current (2019) estimates of the daily generation of data includes:[6]

- 294 billion emails being sent.
- 65 billion messages being sent on WhatsApp.
- 5 billion internet searches being made.
- 4 petabytes (PB) of data are created on Facebook.
- 4 terabytes (TB) of data are created from each connected car.

[5] Source IBM: https://www.ibm.com/blogs/insights-on-business/consumer-products/2-5-quintillion-bytes-of-data-created-every-day-how-does-cpg-retail-manage-it/
[6] https://www.visualcapitalist.com/how-much-data-is-generated-each-day/

The increase in the rate at which data is being generated currently shows no signs of diminishing, driven by an increasing range of industrial, government and consumer applications. The amount of data generated each day is expected to be further boosted as newer technologies such as virtual reality and autonomous vehicles are introduced and become widespread in their usage

Various predictions of the scale of data generation are available, all of which anticipate continued huge increases in the volume of data production, but the most widely cited prediction is the one quoted in the introduction to this report (i.e. the prediction by IDC in 2018 that there is likely to be a world-wide annual growth rate for data generation of 61% p.a. up to 2025[7]).

This global growth is being driven by ever larger numbers of people being connected to digital devices for an increasingly large number of uses and applications. However, it is expected that the creation of data by businesses will become even more important than that by consumers, as the number of sensors and devices in industrial, commercial, infrastructure, healthcare, transportation and many other situations increases exponentially.

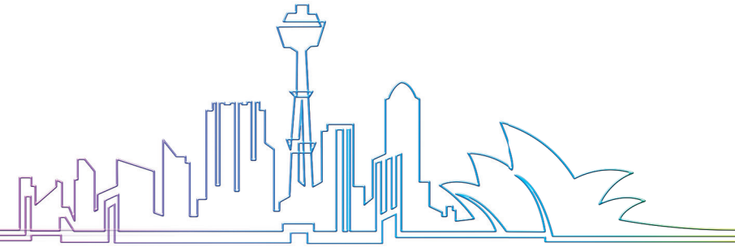
The continuing increase in the generation and sharing of data is being further boosted by the emergence and development of 4 interlinked digital technologies: AI, IoT, Blockchain and 5G. The opportunities and issues associated with each of these technologies is summarized in the next section of this chapter.

"The continuing increase in the generation and sharing of data is being further boosted by the emergence and development of 4 interlinked digital technologies: AI, IoT, Blockchain and 5G."

[7] https://www.networkworld.com/article/3325397/idc-expect-175-zettabytes-of-data-worldwide-by-2025.html

The 4 Technologies

Although there are important linkages and overlaps between and across the 4 technologies focused on in this report, it is worthwhile discussing the potential of each technology, starting with AI.



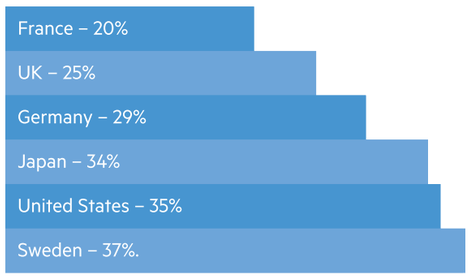
AI

There is no commonly accepted definition of AI, partly because there is also no universal definition of what is meant by human intelligence. However, most attempts to define AI refer to a set of rapidly-developing computer-based technologies used by machines and devices to simulate elements of human behavior, such as sensing, learning, reasoning and decision-making. A key consideration is that AI is driven by the analysis of very large amounts of data in real time.[8]

AI is already in widespread use in a number of business applications such as: virtual assistants; product recommendations on e-commerce sites; the automation of document review; financial transactions; and in the detection of insurance fraud. Retailers and distribution companies are already using AI to optimize their storage and distribution systems, and to manage their warehousing capacity and vehicle fleets more effectively.

One recent prediction is that the global market for AI services could reach US$191 billion by 2025 compared to just US$21 billion in 2018[9] This is equivalent to annualized growth of nearly 37% p.a. over this period.

Key drivers for the rapidly growing market for AI are the growing importance of big data analytics, the increasing adoption of cloud-based computing and the strength of demand for virtual assistants. Moreover, a number of studies have predicted that AI offers the potential to deliver significantly improved levels of labor productivity in developed economies. For example, research undertaken by Accenture has predicted that AI could deliver average labor productivity improvements including:[10]



IOT

IoT is a relatively mature technology that describes an asset or device that is fitted with a sensor producing data on its use. Connected objects ('things') can include industrial machinery, vehicles, infrastructure (such as traffic signals) and household goods such as refrigerators. The total number of active device connections is currently estimated to be 19.4 billion, of which 8.3 billion are estimated to be IoT objects. The number of active device connections is expected to reach over 34 billion by 2025, of which 21.5 billion are expected to be IoT objects.[11]

The potential of IoT to enhance productivity is linked to a growing ability to analyze and make decisions based on the volume of data being generated. Such decisions include those that can unlock efficiency gains and/or manage potential production or operational problems much more quickly. For example, sensors can be used to warn when machine parts are wearing out or need maintenance, resulting in fewer instances of machines failing or operating at sub-optimal levels of efficiency.

One recent estimate is that the global IoT market is expected to be worth US$923 billion by 2025, with the global market experiencing average annual growth of nearly 28% p.a. over the 2019-2025 period[12]. The relative maturity of the IoT market is reflected in this predicted compound annual growth rate (CAGR), which is slightly lower than the levels predicted for AI and Blockchain.

5G

Although there is, as yet, no agreed global specification of what 5G communications technology actually is, the essential feature is that 5G would bring much higher levels of network reliability, service availability and retainability and also faster speeds of data transfer and improved performance. The practical definition used here is that 5G would provide data download speeds of around 100+ megabits per second (Mbps) in most urban/suburban areas, with speeds of up to 20 gigabits per second (Gbps) in densely populated urban areas.

[8] Artificial Intelligence and Automation in the UK: House of Commons Library Briefing Paper No. 8152, December 2017
[9] https://menafn.com/1098660408/Artificial-Intelligence-Market-worth-19061-billion-by-2025-with-a-Growing-CAGR-of-366?src=Rss
[10] Accenture (2018): Why Artificial Intelligence is the Future of Growth
[11] https://iot-analytics.com/state-of-the-iot-update-q1-q2-2018-number-of-iot-devices-now-7b/
[12] https://www.techrepublic.com/article/industrial-iot-market-will-hit-922b-by-2025-driven-by-cost-savings-and-availability/

Expectations for the 5G user experience include the following:

- Enhanced mobile broadband capability with significantly faster speeds and uninterrupted user experience.
- Support for large-scale machine-to-machine (M2M) communications (e.g. sensors on a production line or on a transportation system) and helping to facilitate IoT deployment across a range of applications.
- A high level of reliability. This is a further requirement given the increasing importance likely to be placed on mobile communications by individuals and business, and the increasing use of mobile networks to support M2M communications and business critical applications.
- Low level of latency (i.e. the time taken to transmit data over a network is reduced to very low levels). Low latency will enable a range of new innovative use cases such as AR/VR.

5G is closely associated with at least 3 other technologies that are either simultaneously under development or are already in deployment.

- **IoT:** 5G is a complementary enabling technology, creating the potential for large numbers of connected devices.
- **Cloud computing and big data analytics:** 5G creates the potential to provide a further boost to the existing production and efficiency benefits of cloud computing and big data analytics by enabling the capture and high-speed transmission of even larger volumes of data.
- **AR/VR:** the technical specification of 5G creates the potential for a considerably enhanced AR/VR experience for users, thereby providing a significant boost to this emerging technology.

5G has the capacity to enable these 3 linked technologies to be deployed to their full potential, but it would be incorrect to attribute 100% of the productivity and wider economic impact benefits of these 3 associated technologies to 5G alone.

The types of uses and applications expected to be enabled by 5G are very wide-ranging and include the following:

- More intelligent vehicles (e.g. monitoring navigation, safety and environmental performance).
- Improved performance of public transport, utilities and other infrastructure systems.
- Smart homes.
- Healthcare and social care applications.
- Accelerated transition to 'Industry 4.0' manufacturing technologies.
- Many different applications in the spheres of media and entertainment e.g. virtual reality entertainment and gaming.

BLOCKCHAIN

In 2017 the Confederation of British Industry (CBI) – a highly reputable organization representing the UK's largest businesses – produced a report identifying critical technologies that were set to 'disrupt' ways of doing business.[13] This report identified Blockchain as having the second greatest potential as a 'disruptive' technology among businesses (i.e. the power to change the way businesses operate, particularly in terms of procurement and supply-chain efficiency).

Blockchain is a technology that decentralizes the way that information about transactions is shared, offering considerably enhanced potential for generating trust and confidence in and the security of supply chains. Essentially, Blockchain works as an electronic transaction-processing and record keeping system, allowing various participants to track information and transactions through a secure system and eliminating the need for third-party verification.

Blockchain also creates considerable potential to speed up, create cost efficiencies and de-risk supply chains by removing intermediaries.

Although the fastest adopters of Blockchain have been the financial services and retail distribution sectors, there has also been considerable interest from other industries including manufacturing, media, telecommunications and healthcare.

A recent estimate is that the global Blockchain technology market is set to reach nearly US$58 billion by 2025, with an average annual growth rate of over 69% over the 2019-2025 period.[14]

[13] CBI (October 2017): Disrupting the future: how businesses can embrace Artificial Intelligence, Blockchain and the Internet of Things
[14] https://www.grandviewresearch.com/press-release/global-blockchain-technology-market

The Role of Cities in Data-Fueled Economies

A further factor highly relevant to this study is the growing role of cities in the modern, technology-driven economy. Cities are especially important because they often play host to high-value business clusters or ecosystems.

In particular, clusters/ecosystems are usually characterized by a high volume of interactions between businesses, where creative and professional people meet, exchange ideas, develop innovative products or processes and go on to launch joint ventures or new businesses together.[15] Clustering is widely acknowledged to be particularly important to knowledge-intensive and high-value business activities, such as life sciences, electronics, IT, telecoms, aerospace, media industries and financial services. These are all industries driven by innovation and the constant creation of new services, products and applications.

London's financial services, for instance, have congregated in Canary Wharf, an area close to the London Stock Exchange and a hub of highly-connected data centers located in London's Docklands area.

Clustering is especially important for knowledge-based industries because localized specialization generates significant competitive advantages. These advantages include, but are not limited to:[16]

- Firstly, the creation of a larger pool of specialized skills and labor resources – such as is available in larger urban areas – creates potential benefits for both workers and employers. This can occur by enhancement of the range of readily available career paths and promotional opportunities for workers, and by increasing the size of the skilled labor pool for employers.
- Secondly, businesses and other employers can benefit from the sharing of specific inputs where, for example, the goods and services produced by one business may be used as inputs by another. The close proximity of companies in a high-density business ecosystem – such as is present in larger cities – can also result in the development of specialized relationships between businesses, including sharing of R&D efforts, and the sharing of infrastructure and specialized facilities and/or equipment. This can lead to boosted innovation and productivity and/or the reduction of costs.
- Thirdly, close proximity of a high-density network of technology businesses – such as is present in larger cities – can significantly speed up and make more effective the sharing of know-how and information, thereby creating positive 'spillover effects' and the raising of productivity. These interactions can be described as 'creative collisions' between different parts of the cluster leading to fresh innovations and accelerated advancement in scientific knowledge and discovery. These types of advantages result in businesses located in clusters benefiting from a highly-competitive ecosystem where technological progress and other innovations originate and spread at a faster rate. Examples include the clustering of high-value financial services in New York City and London, the IT and life sciences clusters in the San Francisco area, and media industries in Los Angeles.

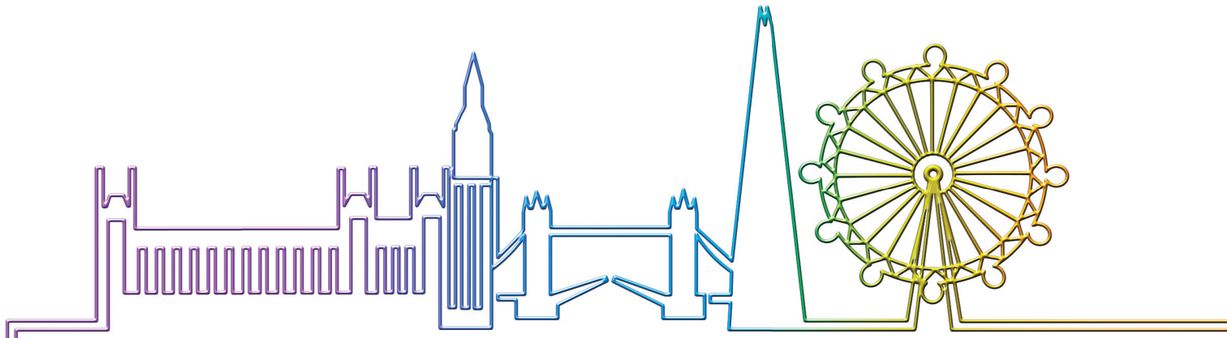
These advantages mean that cities are very often the location (or at least the focal point) of globally-competitive technology-driven clusters because they can offer the following advantages:

- The presence of a high density of business networks, offering opportunities for ready access to other companies that can be customers, suppliers and/or collaborators.
- Labor markets that are both broad and deep, facilitating the recruitment and retention of skilled workers.
- More convenient access to international transportation connections via major airports.
- Location of major universities as locations of technological innovation and research, and the production of highly-skilled/qualified workers in the form of graduates.
- The potential availability of specialist infrastructure, such as research facilities, etc.
- Access to complementary professional, financial and other relevant services such as legal, accounting, marketing and other expertise.

Having described how cities in general can offer businesses competitive locational advantages in the modern, technology-driven and data-fueled economy, in the next chapter the world's largest cities are compared in order to establish current digital capital rankings.

[15] https://www.economist.com/news/2009/08/24/clustering
[16] Michael Porter, Clusters and the New Economics of Competition, Harvard Business Review, November-December 1998

05 Overview of Current Digital Capital Rankings



Having summarized the current digital capital rankings in Chapter 3, here additional details are provided about the approach used to score each of the international cities against the criteria used.

Indicators and Data Sources

The global rankings of the digital capitals are constructed by gathering the most recent available data for 10 families of indicators of the current economic, business, demographic, infrastructure and other characteristics that influence the scale and level of participation in the modern digital economy. More details on each of the criteria and the indicators used are provided below.

SIZE OF THE ECONOMY

The first criteria used is a measure of the overall size of the individual city's total economy. This is measured in terms of the scale of economic output (GVA) produced by the city annually in terms of US Dollars, with adjustments made to reflect productivity and local currencies using a purchasing power parity approach.

One challenge is that usually there are a variety of definitions available for the geographical and population coverage of any one city, such as the municipal area or urban area, through to the wider urban area surrounding major cities. For example, for London these choices include:

- Inner London.
- The area corresponding to Greater London – which is the UK Government's standard region of London, or the Urban Area.
- A wider city-region area (also known as the Primary Urban Area) which as well as the standard region also includes neighboring or satellite towns such as Dartford, Watford and Woking.

Here it was decided that the most appropriate international definition and the one for which consistent data was available corresponded to the 'middle definition' (i.e. the urban area).

Data on the human and business population in each city, plus the annual value of production per capita was then used to estimate the current annual value of economic activity taking place in each urban area.

BUSINESS DIGITAL ADOPTION AND ECONOMY

This criterion is a blended indicator that considers several aspects that relate to the extent to which digital technologies are important to the economy of each city.

- First, the score considers the extent to which digital technologies have been adopted by all businesses and other employers (including government organizations) in the city.

- The second aspect that was covered is the estimated extent of the take-up by businesses and public agency users of the 4 digital technologies (AI, IoT, Blockchain and 5G) included in this study.

- The third aspect is the extent to which companies that are part of the supply chain for digital technologies are locally present in each city. This was taken into consideration through estimation of the annual value of delivery of digital technology services by supplying businesses located in the city.

CONSUMER DEMAND FOR DATA

Having considered the supply side, the third indicator considers the demand for data on the part of the city's urban population. This is based on the estimated annual per capita demand for digital data multiplied by the estimated size of the city's population. The demand for data takes into account a number of sub-indicators, including number of mobile phone subscriptions; fixed broadband data usage; and social media usage.

HIGHER EDUCATION + OTHER R&D ASSETS

This indicator involved the gathering of information on the scale, quality and relevance of the research and teaching resources available at universities and other higher education institutions in each urban area. If specialist research institutes relevant to any or all of the 4 digital technologies were known to be present in the urban area, this was also reflected through a manual upwards adjustment to the city's scoring. Essentially, scores were awarded for the scale (e.g. number of students, value of research grants awarded, etc.) and quality of the research and higher education institutions located in each urban area.

DATA INFRASTRUCTURE

This indicator takes account of the estimated capacity and efficiency of the city's fixed and mobile data infrastructure. This was assessed using current data on average mobile and fixed broadband data download speeds.

HUMAN CAPITAL

This indicator considers the size, skills and qualifications of the city's working age population. There are two aspects included within the scoring and ranking process:

- Firstly, there is a general assessment of the qualifications of the city's working age population, considering the proportion and size of the workforce that is educated to degree level or equivalent, and also considering the proportion (and number) of workers that have no qualifications.

- The second aspect considers the proportion and size of the workforce that are 'digital workers' (i.e. the number of workers) and proportion of the workforce that are IT professionals (covering occupations such as computer systems designers and analysts, software developers, database administrators, information security analysts, etc.).

GOVERNANCE

This is a measure of the efficiency of municipal governance provided in the city, including aspects such as crime rates, corruption levels, etc.

QUALITY OF LIFE

This criterion considers the ability of the city to attract and retain technology- and knowledge-based investment and talent. This is assessed by producing an overall score based on a range of quality-of-life indicators, such as the quality of the city's primary and secondary education and public health systems, the efficiency of the city's public transport system, and the quality of the city's environment (based on air quality readings).

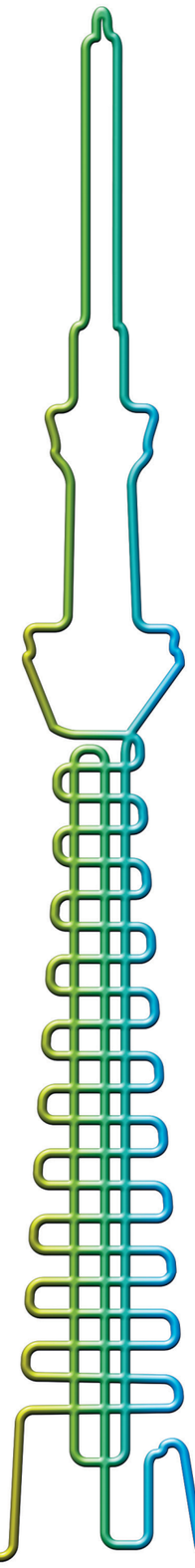
DATA OPENNESS

This indicator is different to those described above in that it applies to the national level rather than the specific city. Essentially, the score applied to cities is the national score achieved for data openness in the current edition of the open data barometer (ODB). This score reflects national policies with respect to the availability of government business datasets and other types of data.

BUSINESS SUPPORT ENVIRONMENT

This measure provides an indication of the perceived ease of doing business in each city. The key component parts of this assessment are considered to include the business and personal tax burden, openness to inward investment and property ownership, policies with respect to international movement of digital industry talent, other skilled workers and entrepreneurs, intellectual property protection and levels of corruption.

Due to the fact that many of these factors are mainly influenced by national policy, it was decided to use a single national ranking for all cities located in the same country.



Spotlight on the Current Rankings

As indicated in Chapter 2, the current top 10 digital capitals for 2019 are assessed to be as follows:

1. New York City
2. Tokyo
3. Los Angeles
4. London
5. San Francisco
6. Singapore
7. Chicago
8. Hong Kong
9. Paris
10. Toronto

Of these highest ranked cities, 5 are located in North America (with 4 in the US), 3 in the Asia-Pacific region and 2 (London and Paris) in Europe. If the list is expanded to include the top 20 cities, the regional representation expands to 8 cities in North America, 6 in the Asia-Pacific region (including 2 in Australia) and 6 in Europe.

It is also notable that each of the top 20 digital capitals is in a developed country. The highest ranked city in a developing country is Beijing (although it should be noted that some commentators no longer regard China as a developing country). The highest ranked city that is located in a country that is widely regarded as a developing country is Bangkok, at number 46.

One interesting dimension to the list is the comparative performance of cities located in India compared to China. Excluding Hong Kong (ranked 8th), there are 4 Chinese cities included, with an average rank of 40. This is significantly better than the average rank of the 3 Indian cities, which is 57.

Amongst the other members of the so-called BRIC countries:[17]

- Russia has 2 representatives, with an average rank of 39.

- Brazil has 3 representatives, with an average rank of 53.

Another increasingly used designation is the so-called MIKT group countries[18], which are also fast-developing economies that are somewhat smaller (in population terms) than the BRICs. There are 7 cities located in MIKT

[17] The BRIC countries of Brazil, Russia, India and China are among the world's largest developing countries. They are widely regarded as being well advanced in terms of their progress towards becoming fully-developed economies.
[18] The MIKT countries are Mexico, Indonesia. Korea and Turkey.

countries that are included in the assessment of global digital cities:

- South Korea has 3 cities, including Seoul (ranked 12th overall), plus Busan and Incheon. The average ranking of the Korean cities is 30.
- Turkey has 2 representatives: Istanbul and Ankara, with an average ranking of 52.
- Indonesia (Jakarta, ranked 49) and Mexico (Mexico City, ranked 47) have one representative each.

One aspect that is evident from the overall list of rankings is that size is important, in terms of size of the economy but also the scale of business activity and the scale of consumer demand for data (which is linked to both the size, wealth and attitudes to the use of data devices on the part of the human population – with several aspects of this positively correlated with the size of the urban area population).

As a variation on the analysis, it is insightful to consider how the rankings vary when the size of a city's population is accounted for. The table below presents an attempt to normalize the scores and rankings when population is factored in (i.e. a calculation of the average number of points scored per million of the city's population).

The list below sets out the rankings for cities on a population-adjusted basis:

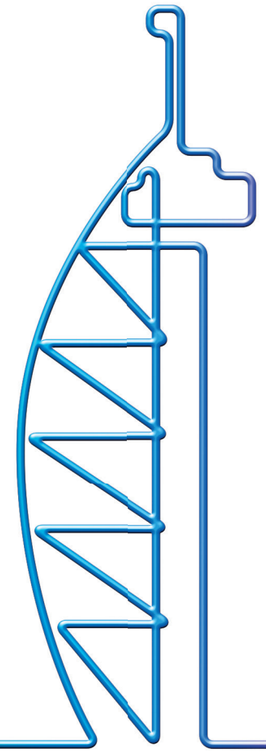
1	Geneva	1,447
2	Lisbon	736
3	Miami	691
4	Atlanta	688
5	Washington D.C	377
6	Stockholm	303
7	Austin	286
8	Dublin	281
9	Dallas	201
10	Fortaleza	196
11	Phoenix	176
12	San Francisco	170
13	Amsterdam	153
14	Rome	131
15	Birmingham	129
16	Nagoya	121
17	Brisbane	121
18	Incheon	120
19	Frankfurt	116
20	Osaka	112

Unsurprisingly, cities in developed countries continue to dominate the overall list. However, it is a number of smaller or medium-sized urban areas (such as Geneva, Lisbon, Miami and Dublin) that now dominate the top 10. The only city in a developing country that appears in the top 10 is Fortaleza in Brazil.

It is also worth noting that a handful of cities appear on both the population-adjusted and the unadjusted lists of the top 20 locations. 3 of these are located in the US (San Francisco, Austin and Dallas), plus Amsterdam in the Netherlands.

"Of these highest ranked cities, 5 are located in North America, 3 in the Asia-Pacific region and 2 in Europe. If the list is expanded to include the top 20 cities, the regional representation expands to 8 cities in North America, 6 in the Asia-Pacific region and 6 in Europe."

06 Future Digital Capitals Rankings



In addition to the current rankings, this report also reviews the potential for changes in the future comparative status of the digital capitals, both in terms of absolute scores and relative rankings. The time period over which potential future changes are considered is a 5-10 year time horizon.

Of course, the future cannot be known with any certainty, so to a large degree any prediction of the future must be speculative. Moreover, of the set of 10 indicators selected to assess the absolute and relative performance of cities, some more than others are inherently more capable of being predicted.

Future Influences on Indicators

Indicators for which a scale of change can be predicted with some degree of confidence include those linked with the size and characteristics of a city's human population. Indicators of this type include:

- The scale of potential future consumer demand for digital data – although there are other influences also, such as the rate at which new applications that are driven by data are developed and disseminated in the marketplace.
- The supply of human capital – that is, a workforce with the skills, qualifications and entrepreneurship to supply and maintain digital services linked to the 4 technologies considered in this report.

Several indicators that are to some extent linked to economic growth rates of cities can also be predicted with some level of confidence. The indicator of the potential future value of a city's economy is obviously linked to population, but it is also linked (amongst other things) to:

- the future size of the city's business population
- the sectoral structure of the business base, and
- the rate of increase in productivity growth amongst businesses, workforces and other factors of production.

The extent to which technological change occurs (including the adoption of the 4 digital technologies considered in this report) will be directly linked to both business structure and future productivity growth performance.

Technological change is also clearly linked to future changes in other indicators, such as the quality of data infrastructure. Although the relative performance of individual cities is harder to predict there is more scope for relative improvement amongst cities located in faster growing developing countries compared to those in higher income economies such as Europe and North America.

One indicator that would only be expected to change at a slower rate is quality of life: this is because the relative performance of compulsory years of education, public health, public transport systems, etc. require large investments that would normally be expected to take

years to implement. Cities that are experiencing faster growth in their human populations (such as those in developing countries) face challenges to maintain the level of services for larger numbers of citizens, as well as increasing the quality of service to existing populations.

It is also the case that several of the indicators are influenced by government policy decisions rather than somewhat more predictable business, economic, technological or demographic trends. Examples of this include data openness and the business support environment (with the latter influenced by matters such as taxation and immigration policies).

Other indicators are difficult to predict because they are driven primarily by local factors rather than longer term demographic, business or technological trends. Examples include the performance and ratings of universities and research institutes, and the effectiveness of city governance.

Drivers for Changes in Rankings: Economic Growth

In terms of the factors that are linked to rates of economic growth and population size, the cities in developing countries have the most potential to substantially increase their absolute scores, especially those in high growth economies such as China, India and Indonesia.

The potential future size of the economy of cities is driven by factors including population, size and structure of business activity and the rate of productivity growth. Adoption of digital technology has a direct influence on productivity growth. Although the proportionate share of technological change in overall productivity growth varies from economy to economy (and a range of predictions based on different sources of evidence exists),

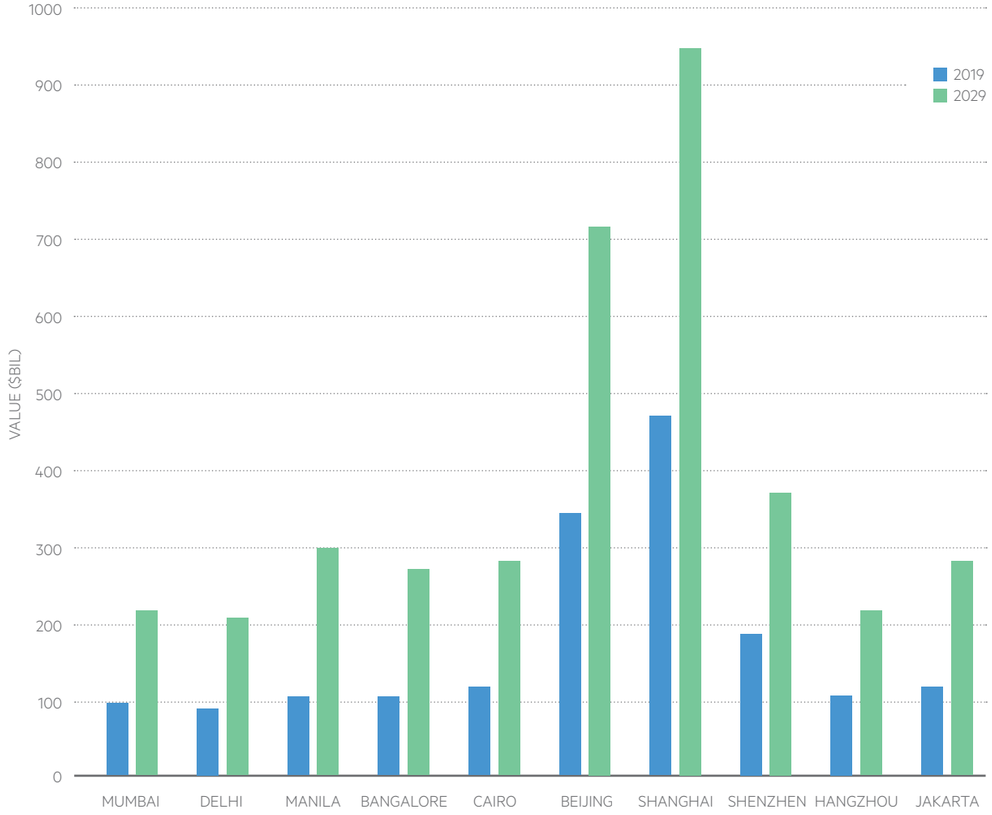


Table 6.1: Fastest growing city economies by value: 2029 vs 2019 ($US billions, 2019 prices)

a typical assumption is that around 35% of productivity growth is linked to technological innovation in the workplace:

City	2019 rank	2029 rank	Change in Indicator Rank (places)
Mumbai	43	22	21
Delhi	46	30	16
Manila	33	16	17
Bangalore	37	21	16
Cairo	32	17	15
Beijing	11	4	7
Shanghai	6	1	5
Shenzhen	17	15	2
Hangzhou	38	27	11
Jakarta	27	19	8

Table 6.2: Fastest growing city economies by value: 2029 vs 2019 ($US billions, 2019 prices)

All of the top 10 fastest growing cities are expected to at least double the real value of their economies over the next decade, driven by a combination of population growth, business expansion and productivity improvements. The most dramatic shift is in the expected performance of Shanghai, which on these predictions would become the world's largest city economy by annual value of production by 2029.

By contrast, the economies of leading cities in developed countries are expected to grow at a slower rate: the majority of cities in this category are expected to experience real growth in the value of their economies of between 30%-45% over the next decade, but there are some notable exceptions.

> "Of the 16 cities that are expected to lose at least 2 ranking positions, it is notable that 7 are located in 3 countries: Japan (3), South Korea (2) and the UK (2)."

On the positive side, cities such as Dublin (81% growth), Sydney (59%) and Melbourne (57%) are expected to see significantly above-average growth compared to their developed country peers. On the other hand, some cities are expected to grow the value of their economies much more slowly: examples of this include Rome (14%) and Tokyo (16%).

Predicted Digital Capitals Rankings, 2024 and 2029

In some cases, the pace of expected economic growth, growth in consumer demand and the business adoption of advanced digital technologies are – when combined with other factors – expected to be sufficient to generate significant changes in the overall rankings of cities by 2024. However, the period to 2029 allows for more significant changes in scores and relative ranking, because a full 10-year period provides sufficient time for the effects of faster growing economies and populations to make a more substantial difference to the absolute and relative performance of cities.

The table below provides a summary of the 2019 baseline rank for each city and the predicted rankings for 2024 and 2029 respectively.[19]

City	2019 ranking	2024 predicted ranking	2029 predicted ranking
New York City	1	1	1
Tokyo	2	2	3
Los Angeles	3	3	2
London	4	6	6
San Francisco	5	4	4
Singapore	6	5	5
Chicago	7	7	7
Hong Kong	8	9	10
Paris	9	8	9
Toronto	10	9	8
Berlin	11	11	12
Seoul	12	14	14
Amsterdam	13	12	11
Sydney	14	13	13
Munich	15	16	17
Austin	16	15	15
Houston	17	17	16
Melbourne	18	19	19
Dallas	19	18	18
Madrid	20	21	22
Phoenix	21	20	20
Taipei	22	23	24
Washington D.C	23	22	21
Frankfurt	24	24	23
Manchester	25	25	27
Yokohama	26	28	28
Miami	27	27	26
Nagoya	28	30	33
Beijing	29	26	25
Brisbane	29	29	30

City	2019 ranking	2024 predicted ranking	2029 predicted ranking
Atlanta	31	32	32
Geneva	32	31	31
Stockholm	32	33	34
Osaka	34	35	36
Moscow	35	37	38
Birmingham	36	36	37
Shanghai	37	34	29
Busan	38	39	39
Dublin	39	38	35
Incheon	40	41	43
Lisbon	41	42	44
Hangzhou	42	40	40
Rome	43	45	48
Santiago	44	43	42
St Petersburg	44	46	45
Bangkok	46	44	41
Mexico City	47	47	46
Sao Paulo	48	48	47
Jakarta	49	49	50
Istanbul	50	51	51
Shenzhen	51	50	49
Rio de Janeiro	52	52	52
Ankara	53	53	53
Manila	54	56	56
Bangalore	55	54	54
Mumbai	56	55	55
Lima	57	57	58
Cairo	58	58	59
Delhi	59	59	57
Fortaleza	60	60	60

Table 6.3: Ranked cities: 2019, 2024 and 2029

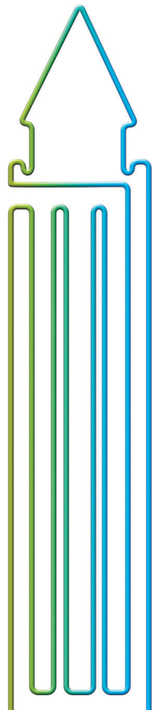
[19] If 2 cities have the same score, they get the same ranking but then the ranking score skips. E.g. if 2 cities are ranked equal 9th the next ranked city below is ranked 11th.

Some of the more substantial changes expected over the period 2019-2029 include the following:

Cities	Gain in ranking places
Shanghai	8
Bangkok	5
Beijing, Dublin	4
Amsterdam, Delhi, Hangzhou, Santiago, Toronto, Washington DC,	2

Cities	Gain in ranking places
Nagoya, Rome	5
Incheon, Lisbon, Moscow	3
Hong Kong, London, Madrid, Manchester, Manila, Munich, Osaka, Seoul, Stockholm, Taipei, Yokohama	2

Table 6.4: Largest changes in expected rankings: 2019-2029



Although there is a variety of explanations about what is driving the more significant predicted changes in rankings, the most important factors that influence the potential for a city to change its relative position are significant divergences from the expected average rate of:

- Annual economic growth and population
- Structure of the city's business base and the capacity for additional digital adoption, and
- Growth in both the size and the capabilities of the city's labor force (i.e. the human capital dimension).

For example, Shanghai is expected to perform very strongly in terms of economic and labor force growth, as well as the proportion of its business base that is involved in both developing and utilizing advanced digital technologies.

On the other hand, among the established elite it is considered that London and Hong Kong are at the greatest risk of losing ground against major rivals. In the case of London, the uncertainties of Brexit are likely to deliver a significant check on future rates of business growth and investment. There are also uncertainties about the ability of the UK to continue to attract world-class talent in information technology and other professions where skills shortages are expected to continue to exert an influence.

In the case of Hong Kong, there are significant short-to-medium term political, business and economic risks and uncertainties that could see the city lose ground against competitors in mainland China and elsewhere in the Asia-Pacific region.

Elsewhere in Asia, Beijing and Hangzhou are also expected to gain at least 2 ranking places by 2029. In North America, Toronto and Washington DC are expected to also gain 2 places each.

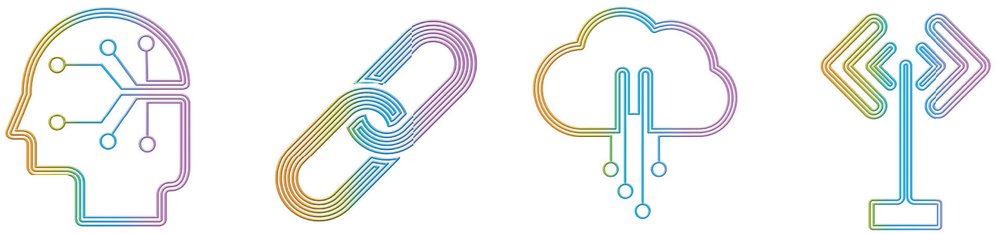
Among the European challengers, Amsterdam and Dublin appear to be particularly well placed to gain from any loss of ranking by London. However, these cities also have their own growth dynamic, and are expected to improve their rankings against other cities in the list.

Of the 16 cities that are expected to lose at least 2 ranking positions, it is notable that 7 are located in 3 countries: Japan (3), South Korea (2) and the UK (2). None are located in North America or China, with Manila the only representative in this group from the world's developing economies.

However, despite the expected rise of Beijing, Dublin and Shanghai overall the 2029 rankings are expected to be broadly similar to those for 2019.

07

Contributions of the 4 Technologies



Apart from the digital capital rankings, the second main objective of this report is to provide estimates of the current contributions of 4 key, growing digital technologies (AI, IoT, 5G and Blockchain) to the 60 cities, and also to predict how these contributions are likely to change over the next 10 years. The assessment focuses on the value of the current contribution (i.e. that estimated to be occurring in 2019), as well as predictions for two future years: 2024 and 2029.

Contribution of the Technologies and Digital Capital Rankings

The future size and contribution of the 4 technologies in each city will play a direct role in influencing the current and predicted future digital capital rankings that were highlighted in previous chapters. However, the current and future rankings will not be the same as the rankings for the contributions of the 4 technologies, individually or in total.

The main reason for this is that the quantification of the contribution of the 4 technologies relates to a sub-set of the indicators used to estimate digital capital rankings, such as the size of the economy, the level of digital adoption, higher education rankings and also aspects of human capital (i.e. the digital skills base). Moreover, although the focus of this part of the report is on 4 specific technologies, these technologies do not represent the entirety of the digital and data economy of any city. This is because other important digital technologies – such as digital entertainment; some types of important digital communications; the production of digital hardware, software and support; advanced robotics; and so on – also make important contributions to the overall data economy of a city or country.

Overall Picture

Available baseline economic and business data has been used to estimate the current value of the 4 technologies to each of the cities covered by this report. In addition, current forecasts for economic growth, demographic change and predicted adoption rates of technologies have been used to produce future predictions of the potential quantity of economic value for each technology in each city for the years 2024 and 2029. The future predictions of GVA created are measured in US Dollars using a 2019 price base. Therefore, the predicted changes account for the potential future effects of inflation.

Overall, the annual value contributed by the 4 technologies is expected to increase from nearly US$169 billion p.a. in 2019 to US$392 billion p.a. by 2024. By 2029, they will contribute nearly US$721 billion p.a. While the contribution of each technology to the economies of the 60 cities is set to increase significantly, the overall increase in the expected value created is predicted to be dominated by the contribution from AI. That is, of the overall anticipated increase in annual value of US$552 billion, 46% is expected to be contributed by AI. A further 22% of the overall increase is expected from 5G and nearly 21% from IoT, while Blockchain is expected to account for the final 11%:

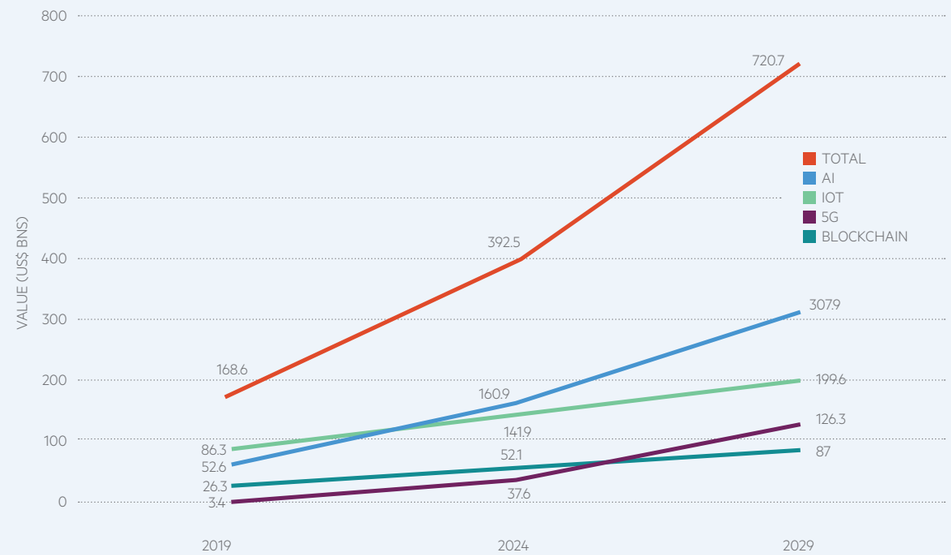
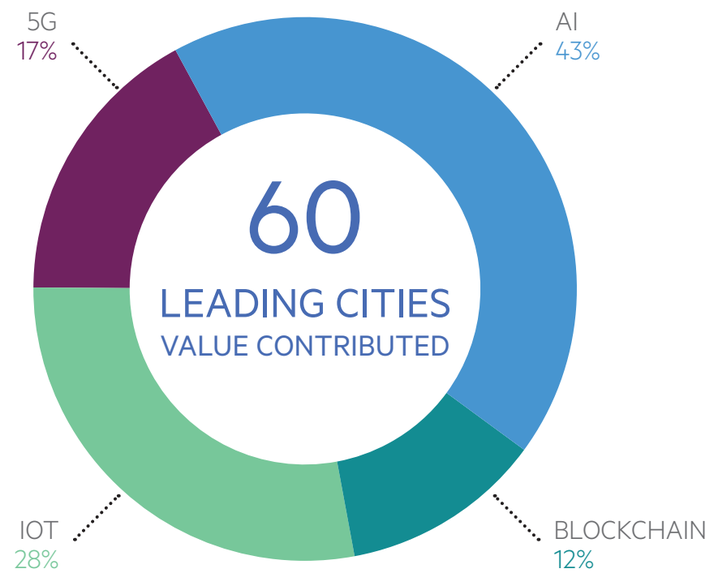


Table: 7.1: Value contributed by 4 technologies to 60 leading cities, 2019-2029 (US$ billions, 2019 prices)



7.2: Value contributed by 4 technologies to 60 leading cities represented as a percentage, 2019-2029

It is also worth noting the expected average value to cities from each of the 4 technologies:

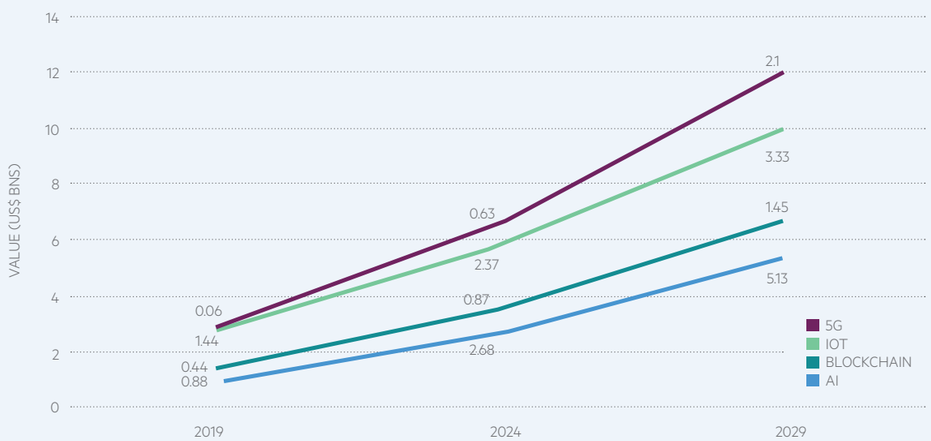


Table 7.3: Average value contributed by 4 technologies to 60 leading cities: 2019, 2024 and 2029 (US$ billions, 2019 prices)

The average contribution is expected to increase from US$2.81 billion p.a. in 2019 to US$12.01 billion p.a. by 2029. Although the absolute growth in the contribution is expected to be dominated by AI, it is clear from tables 7.2 and 7.3 that 5G is expected to grow at the fastest rate over the 2019-2029 period. This is because 5G as an emerging technology in 2019 is growing from a much smaller base compared to the other 3 technologies.

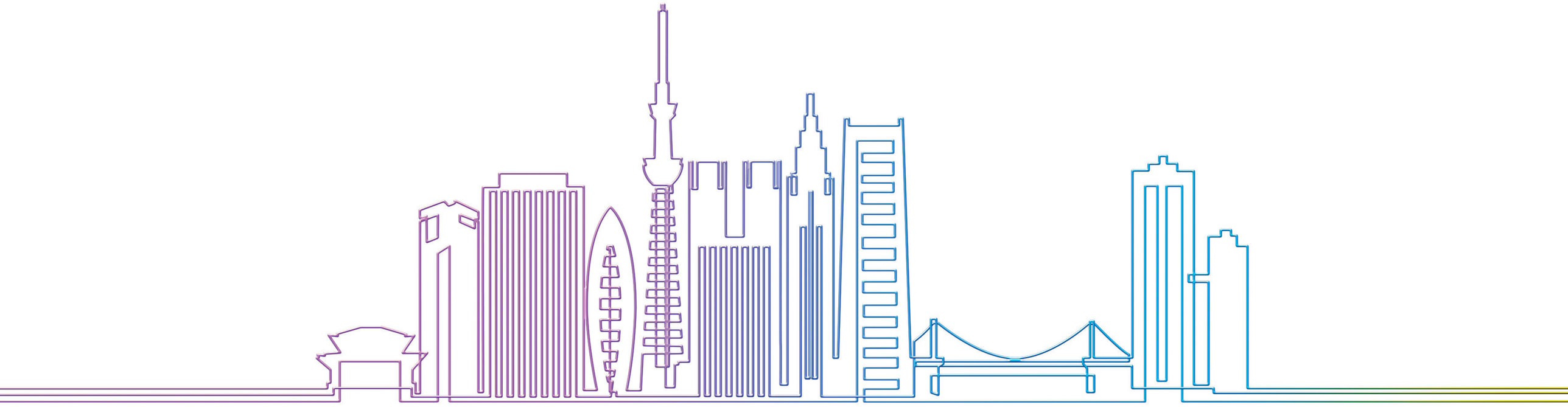
Expected Changes in Value and Rankings Among Digital Capitals

The next graph provides estimates of the aggregated value contributed to the economies of the current top 10 cities from our 4 digital technologies in 2019. The table also shows the expected future aggregate value generated by the 4 technologies for both 2024 and 2029, and the rankings for each of the two future years.

Currently, in 2019, the largest annual value associated with the 4 technologies occurs in Tokyo (US$12.80 billion). By 2029 this is expected to grow to nearly US$42 billion. However, growth in Tokyo is expected to be amongst the slowest of the leading cities, and by 2029 Tokyo's ranking is expected to slip from 1st to 3rd.

City in 2019 ranked order	Aggregate annual value to cities, 2019	Aggregate annual value to cities, 2024	Aggregate annual value to cities, 2029	% growth, 2019-2029
1. Tokyo	12.80	26.18	41.97	228%
2. New York City	11.15	25.66	46.14	314%
3. Singapore	9.05	21.32	39.29	334%
4. Paris	8.31	18.22	31.37	277%
5. London	7.62	17.00	29.59	288%
6. Shanghai	7.32	19.88	42.31	478%
7. Seoul	6.59	14.84	26.10	296%
8. Hong Kong	6.53	15.63	29.31	349%
9. Los Angeles	6.12	13.45	23.12	278%
10. Moscow	5.28	13.90	21.96	316%

Table 7.4: Contribution of the 4 technologies to the top 10 leading cities: 2019, 2024 and 2029 (US$ billions, 2019 prices)



Changes in the expected rankings of the top 10 leading cities are summarized in the table below. Note: Beijing is expected to replace Moscow as a top 10 city by 2024.

City	2019 rank	2024 rank	2029 rank
Tokyo	1	1	3
New York City	2	2	1
Singapore	3	3	4
Paris	4	5	5
London	5	6	7
Shanghai	6	4	2
Seoul	7	8	9
Hong Kong	8	7	8
Los Angeles	9	10	10
Moscow	10	11	11

Table 7.5: Contribution of the 4 technologies to the top 10 leading cities: expected changes in ranking, 2019-2029

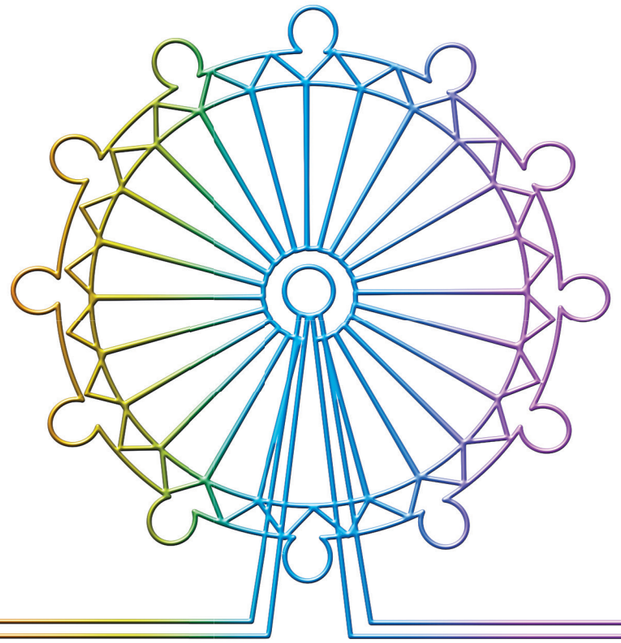
It is also worth considering the average ranking of cities across the continents in 2019 and looking forward to 2024 and 2029.

Continent	Average rank of cities 2019	Average rank of cities 2024	Average rank of cities 2029
Africa	50	42	33
Asia	27	26	25
Europe	29	31	33
North America	34	35	35
Latin America	40	41	41
Pacific	20	20	21

Table 7.6: Contribution of the 4 technologies to global regions: expected changes in rankings, 2019-2029

Currently, the Pacific region has the highest ranking. However, it should be highlighted that this region contains just 3 of the top 60 cities, each in a single developed country, Australia.

A more significant potential trend is expected to occur in Asia, where the average ranking is projected to improve from 27.7 in 2019 to 24.7 by 2029. This reflects the fast growth of most Asian cities (although the Japanese cities are exceptions to this trend). The average growth of Asian city rankings is largely at the expense of Europe, whose average ranking is expected to decrease from 29.4 to 32.8 over the same period.



Technology Growth Rankings, 2019–2029

When considering the technology growth rankings, it is interesting to examine the main locations of growth – in both absolute and relative terms – for each of the 4 technologies – AI, IoT, 5G and Blockchain.

AI

The largest annual contribution to AI by 2029 is expected to be generated in New York City (US$19.86 billion). The largest increase in annual value generated when 2019 is compared to 2029 (US$16.35 billion p.a.) is also expected to occur in New York City, followed by Shanghai (US$15.39 billion p.a. increase in annual value).

The largest relative increase among these top 10 wealth generating cities is expected to occur in Beijing (701%) followed by Shanghai (698%). The lowest proportionate growth is expected to occur in Tokyo (353%).

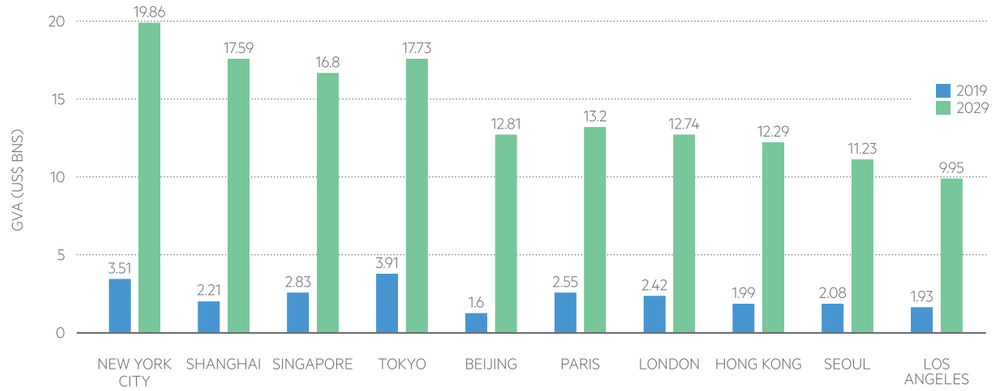


Table 7.7: Annual value linked to AI: 2019 and 2029 ($US billions, 2019 prices)

It is also worth highlighting where the fastest proportionate growth is expected to occur amongst the full portfolio of 60 cities. The table below highlights the top 10 rankings for proportionate (percentage) growth between 2019 and 2029.

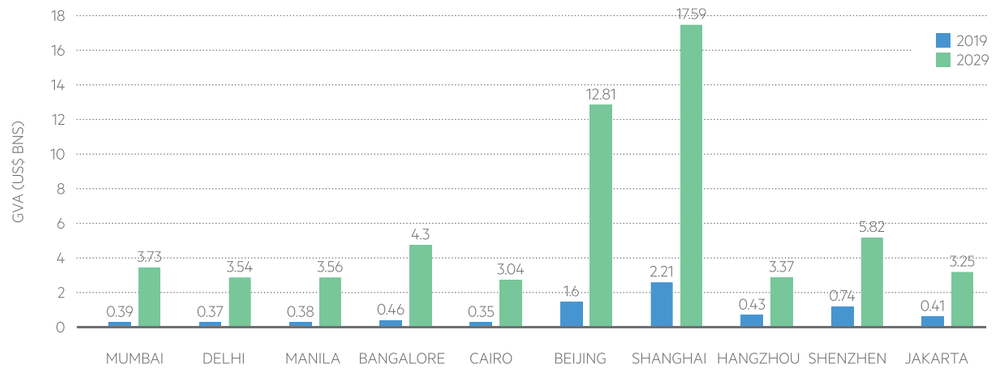


Table 7.8: Fastest rate of annual GVA growth linked to AI: 2019 and 2029 (US$ billions, 2019 prices)

The fastest growth location in proportionate terms is expected to be Mumbai (854%) followed by Delhi (849%) and Manila (843%). All the top 10 growth cities are located in Asia, with the exception of Cairo.

BLOCKCHAIN

The largest annual contribution by 2029 is predicted to occur in Shanghai (US$6.12 billion). The largest increase in annual value generated in 2029 compared to the estimated 2019 situation is also expected to occur in Shanghai, with an increase in annual value of US$4.75 billion. The city with the second highest potential is expected to be New York City (increase of US$3.62 billion p.a. over the 2019-2029 period), followed by Singapore (US$3.32 billion p.a. increase in value).

The largest Blockchain contribution to an economy in 2019 is Tokyo (US$1.96 billion per annum), but the rate of growth in Tokyo is expected to be lower than among the other leading cities, with an overall growth of 155%. This compares to growth of 349% in Shanghai:

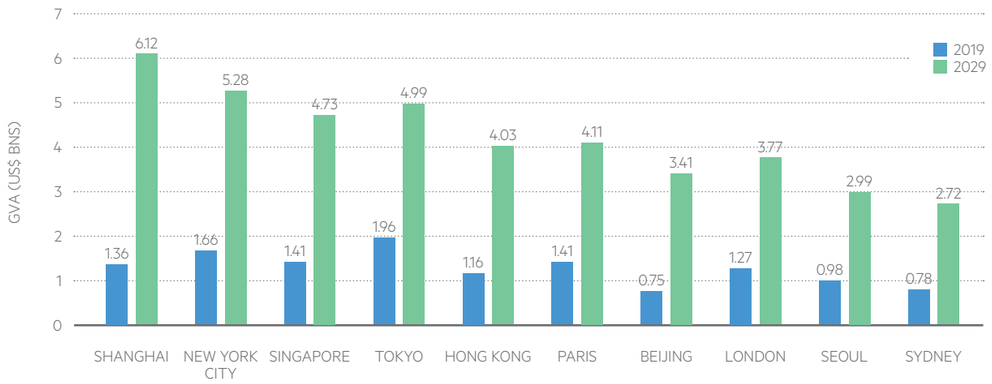


Table 7.9: Annual value linked to Blockchain: 2019 and 2029 (US$ billions, 2019 prices)

The fastest proportionate growth for Blockchain is predicted to occur amongst the same set of developing country cities as was identified above for AI. The table below highlights the top 10 rankings for proportionate (percentage) growth of GVA contributed by Blockchain between 2019 and 2029.

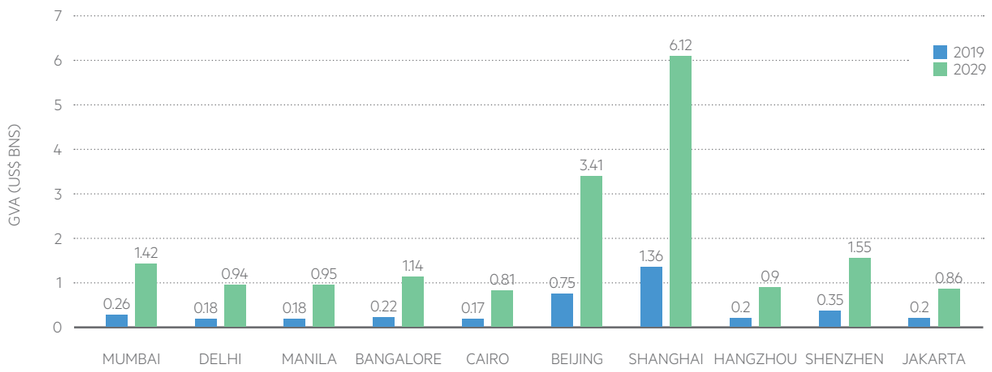


Table 7.10: Fastest rate of annual GVA growth linked to Blockchain: 2019 and 2029 (US$ billions, 2019 prices)

INTERNET OF THINGS

The largest annual contribution to city-level GVA from IoT technology by 2029 is predicted for New York City (US$12.85 billion p.a.). However, the largest increase in annual value generated when 2029 levels are compared to the 2019 baseline is expected to be generated in Shanghai, with an increase in annual value of US$7.78 billion over the 10-year period.

The growth rate in value occurring over this period is slightly higher in Beijing (217%) compared to Shanghai (215%).

As with Blockchain, the largest IoT contribution to an economy in 2019 is Tokyo (US$6.68 billion per annum), followed by New York (US$5.75 billion):

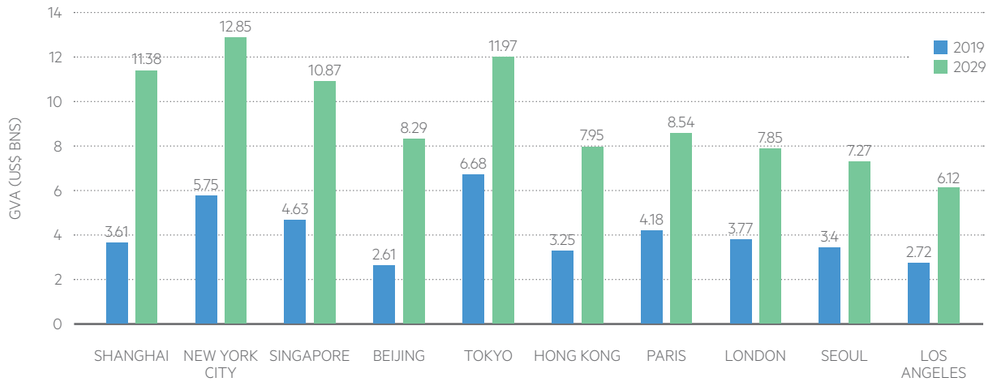


Table 7.11: Annual value linked to IoT: 2019 and 2029 ($US billions , 2019 prices)

In terms of the proportionate growth expected over the 2019-2029 period, the fastest growth of all is expected to occur among leading cities in developing countries (identified in the graph below) for AI and Blockchain. This is largely because these cities' IoT value is rising from a comparatively low base (with the exception of Shanghai and Beijing, which have already established large IoT economies but are expected to experience fast rates of growth generally).

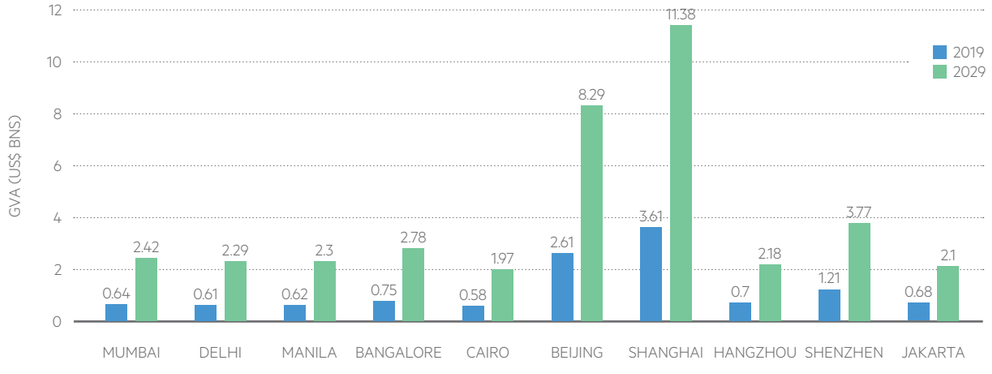


Table 7.12: Fastest rate of annual GVA growth linked to IoT: 2019 and 2029 ($US billions, 2019 prices)

5G

In most cases, the estimated contribution from 5G in 2019 is significantly smaller because the technology is still emerging, and in many places is currently being trialled through pilot projects. The main focus of this section, therefore, is on the absolute levels of GVA associated with 5G expected annually by 2029. The table below sets out the predictions, with estimated 2019 baseline figures also included.

Table 7.13: Annual value linked to 5G: 2019 and 2029 (US$ billions, 2019 prices)

By 2029 the largest annual value is expected to be generated by New York City (US$7.92 billion p.a.) followed by Shanghai (US$7.21 billion) and Tokyo (US$7.02 billion).

08 Conclusions

Current Digital Capital Rankings

One objective of this study has been to create a set of rankings for 60 digital cities identified as global hubs for digital knowledge creation and commercial activity. The production of rankings for these 60 cities – termed digital capitals – has been undertaken by gathering and analysing data covering business, economic, demographic and labor market metrics. In addition, information on other indicators covering aspects such as the quality of city-level infrastructure, governance and quality of life indicators has also been gathered and assessed.

Of these top 60 data economies, the 10 most competitive cities are currently assessed to be as follows:

1. New York City
2. Tokyo
3. Los Angeles
4. London
5. San Francisco
6. Singapore
7. Chicago
8. Hong Kong
9. Paris
10. Toronto

Amongst the determinants of current position in the rankings, one of the most important is the scale and complexity of digital business and commercial activity taking place in the leading digital capitals. For example, nearly all of the top 10 hubs are leading global locations for data intensive industries, such as financial services, IT, media and entertainment and professional services.

It is also notable that the current list of highest performers is dominated by long-established cities in leading advanced economies such as the US, UK, France and Japan, as well as the leading Asian trading centers of Hong Kong and Singapore.

Predicted Future Data Economy Rankings

In addition to the current rankings of digital capitals, the study has also examined economic, commercial and demographic growth forecasts, as well as considering other factors such as expected trends for the adoption and use of digital technologies. These insights have been used to develop predictions of changes to digital capitals rankings for future years. As a result, by 2029 the world leading digital capitals are expected to be ranked as follows:

1. New York City
2. Los Angeles
3. Tokyo
4. San Francisco
5. Singapore
6. London
7. Chicago
8. Toronto
9. Paris
10. Hong Kong

The research found that within the current list of the highest performing cities, it is London and Hong Kong that are at the greatest risk of losing ranked places between 2019 and 2029. On the other hand, Toronto is assessed as having the greatest potential to improve its current placing.

Additional changes are also expected outside the current top 10 list. Among the cities that have the greatest potential to improve their position between 2019 and 2029 are:

- Shanghai: with a predicted increase of 8 ranking positions occurring between 2019 and 2029.
- Bangkok: an improvement of 5 rank places over the same period.
- Beijing and Dublin: each with a predicted improvement of 4 ranking positions by 2029.

The most important factors that influence the potential for a city to change its relative position are significant divergences from the expected average rate of:

- Predicted annual growth in business activity and population;
- Structure of a city's business base and the capacity for additional digital adoption; and
- Growth of both the size and the capabilities of a city's labor force (i.e. the human capital dimension).

The other main purpose of this report is to quantify the current and future economic contributions of technologies that will be key to driving growth in data economies around the world – AI, IoT, Blockchain and 5G – with the annual value of economic activity taking place in each of the 60 cities.

Various datasets have been utilized to estimate the current value of the 4 technologies to each of the cities covered by this report. Current forecasts for economic growth, demographic change and predicted rates of adoption of the technologies have also been used to produce predictions of the potential future economic value contributed by each of the 4 digital technologies in each city in the years 2024 and 2029.

Overall, the annual value contributed by the 4 technologies across the portfolio of 60 cities is expected to increase from nearly US$169 billion p.a. in 2019 to US$392 billion p.a. by 2024 (2019 prices). By 2029 the annual value is expected to increase still further, to US$721 billion p.a. (also 2019 prices).

While the contribution of each technology to the economies of the 60 cities is set to increase significantly, the overall increase in the expected value created is likely to be dominated by the contribution from AI. This is because of the overall anticipated increase in annual value from the 4 technologies, 46% is expected to be contributed by AI alone.

A further 22% of the overall increase is expected from 5G and nearly 21% from IoT, while Blockchain is expected to account for the final 11%.

> "It is clear that cities and businesses should incubate and invest in technology talent to ensure they continue to have the skills to operate, deliver and capitalize on innovative technologies."

In terms of contributions from individual cities, in 2019, the largest individual aggregate contribution associated with the 4 technologies is estimated to occur in Tokyo (US$12.80 billion p.a.). By 2029 the annual value of this contribution is predicted to grow to nearly US$42 billion. However, future growth in Tokyo is expected to be amongst the slowest.

By 2029, the largest individual contribution to annual economic output from the technologies is expected to be generated by New York City (US$46.14 billion p.a.) followed by Shanghai (US$42.31 billion p.a.).

The principal drivers for growth in annual contribution of the 4 technologies is primarily the expected increase in the scale of supply and use of the technologies in commercial, public administrative and domestic applications in each city. The cities that are expected to be faster at adopting the technologies are expected to do comparatively well, but the underlying expected growth rates in overall size of the economy and the growth in the population and per capita income also play a key role in explaining their relative performance.

Recommendations and Opportunities for Businesses

The forecast growth in annual value contributed by the 4 digital technologies is a prediction and is not guaranteed. To ensure that cities achieve the potential scale of growth in future annual value anticipated by this study, businesses, governments and other stakeholders will need to continue to invest in digital infrastructure, in R&D and in workforce skills.

If businesses want to benefit fully from growth in the digital economy they need to start taking action today. The economies of digital capitals around the world will only continue to grow, albeit at different speeds depending on a number of factors such as economic and government stability.

Provided below are some recommendations that businesses should seriously consider if they are to remain competitive in this rapidly growing technological environment.

Take Advantage of Competitive Digital Platforms

There are unrealized opportunities for businesses that have not yet created adaptable technology platforms that, working with key partners, allow them to deploy each of these specialized technologies to gain competitive advantage:

- The 4 technologies explored are only growing in importance, enabling businesses to create and gain intelligence from their data in ways that have never been achieved before.
- An adaptable technology platform will differentiate a business' agility by reducing the time to connect to partners, providers and markets using the latest technologies.
- This will enable companies to tailor their technology deployments at speed and to meet, and even exceed, their needs in an increasingly competitive environment.

Invest in Talent

This report highlights one key area where investment is crucial: a skilled workforce. It is clear that cities and businesses should incubate and invest in technology talent to ensure they continue to have the skills to operate, deliver and capitalize on innovative technologies.

Major cities are vital in creating and hosting high value and innovative commercial activity through their role as locations for knowledge-driven business clusters. As a result, the high density of business networks in the city means the availability of talent and the presence of key infrastructure is also usually found in those places. With today's new technologies, this can very quickly lead to a major skills shortage and prevent businesses from being able to harness the power of their technology innovations.

Investing in digital apprenticeships and supporting college and university digital training programs is essential to the future success of all digital capitals.

Think Urgently About Your Future Technology Strategy

Businesses should continuously invest in upgrading and expanding their technology strategies to stay ahead of business need. The business that is not ready to take advantage of these technologies is the one that is going to rapidly lose ground against its competitors.

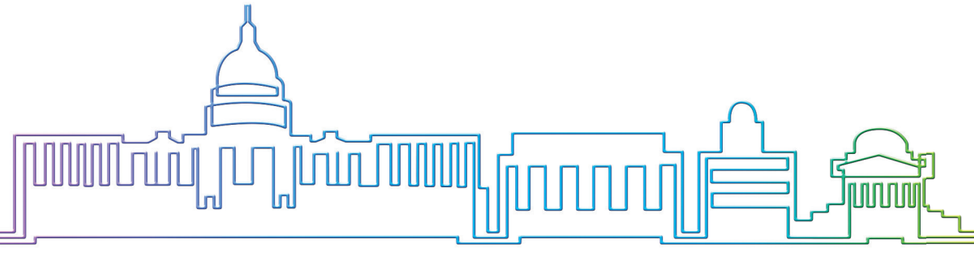
Identify the Partners, Suppliers and Key Players that Should Be In Your Competitive Ecosystem

Cities and businesses having technical networks that can be rapidly and seamlessly connected to a global digital ecosystem is vital to fostering innovation and enabling a wider, global advantage.

There is good evidence that major cities are likely to be increasingly important in creating and hosting high value and innovative commercial activity through their role as locations for knowledge-driven business clusters or ecosystems.

Ecosystems are geographically-concentrated networks of interconnected companies and allied organizations (such as universities and research institutes; financial services corporates and suppliers) operating within a specific industry or sector.

Successful ecosystems are usually characterized by a high volume of interactions. For example, where companies work collaboratively to create competitive advantage, exchange ideas, develop innovative products or processes, and go on to launch joint ventures, a competitive service or new businesses together.



09 Glossary of Terms

Term used in report	Explanation
5G	The 5th generation of mobile network connectivity, expected to deliver significantly improved levels of network reliability, considerably faster data transfer speeds and improved performance with respect to latency.
Artificial Intelligence (AI)	A range of rapidly evolving computer-based technologies used by machines and devices to simulate elements of human behaviour such as sensing, learning, reasoning and decision-making.
Blockchain	Blockchain is an electronic transaction-processing and record keeping technology that benefits users by decentralizing the way that information about transactions is shared. Blockchain provides users with a method of tracking information and transactions securely and by eliminating the need for third-party verification.
Clusters / Ecosystems	Clusters are geographically concentrated networks of interconnected companies and other organizations (such as universities, research institutes and public agencies) operating within a specific industry. Successful clusters are usually characterized by a high volume of interactions and collaborations between businesses and other cluster participants.
Data Economy	The financial and economic value created by the storage, retrieval and analysis via software and other tools of very large volumes of business and organizational data at high speed.
Gross Value Added (GVA)	GVA is defined as the net value contributed to the economy by a company, industry or other economic entity. This includes compensation of employees, company profits and contributions to the Exchequer.
Internet of Things (IoT)	A system of assets or devices that are fitted with a sensor producing data that is stored and available for analysis, and which can be used to deliver production efficiencies or other improvements in the way the system operates. For example, sensors on machines that can be used to predict the need for maintenance or use of spare parts before the machine fails and production time is lost.
Petabyte (PB)	1 Petabyte (PB) = 1,000 billion bytes of data.
Terabyte (TB)	1 Terabyte (TB) = 1,000 Gigabytes of data. 1,000TB equals 1PB.
Compound Annual Growth Rate (CAGR)	CAGR is the rate of return that would be required for an investment to grow from its beginning balance to its ending balance, assuming the profits were reinvested at the end of each year of the investment's lifespan.

DIGITAL REALTY

Powering your digital ambitions