

Uncovering tomorrow's innovation hotspots

The cities striving for emerging
technology leadership

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About this report

Uncovering tomorrow's innovation hotspots: The cities striving for emerging technology leadership is an Economist Intelligence Unit report, sponsored by Pictet, that explores where interest, innovation and commercial activity around emerging technologies are active and growing at scale. Its primary aim is to identify cities that are in a position to challenge, in the future, the leadership of the world's largest innovation hubs, widely regarded to be Silicon Valley, New York and London.

The report's findings are based partly on analysis of venture capital funding of firms involved in developing emerging technologies or products based on them, and partly on data relating to universities, networking activity and other facets of city innovation environments.

Additional insights were obtained from interviews conducted with the following authorities on innovation, entrepreneurship and cities:

- Richard Florida, professor and director of cities, Martin Prosperity Institute, University of Toronto
- Carlo Ratti, director, SENSEable City Laboratory, Department of Urban Studies and Planning, MIT

- Daniele Rotolo, senior lecturer in science, technology and innovation policy, University of Sussex
- Scott Stern, professor of technological innovation, entrepreneurship and strategic management, MIT Sloan School of Management

The research also benefited from advice provided by a panel of experts consisting of the following:

- Pierre-Alexandre Balland, professor of economic geography and network science, Utrecht University and visiting professor, MIT Media Lab
- Margareta Drzeniek-Hanouz, deputy head of social and economic agendas, World Economic Forum
- Christopher Haley, head of new technology and start-up research, Nesta
- Margaret O'Mara, professor of history, University of Washington
- David Ricketts, strategic innovation fellow and leader, City Innovation Program, Harvard University Technology and Entrepreneurship Center

This report was written by Denis McCauley and edited by Jeremy Kingsley.

Executive summary

In September 2018 *The Economist* asked if Silicon Valley had peaked, arguing that the Valley's relative importance has begun to decline as other innovation hubs have become more attractive for technology entrepreneurs.¹ Similar questions could be asked about other major centres of technology innovation and industry around the world, such as New York and London. As the cost of living and operating in these hubs has escalated, other cities have developed similar innovation ecosystem attributes, if at a smaller scale, for emerging technologies that are likely to shape the industries of tomorrow. As innovation becomes more dispersed and new technological paradigms emerge, what cities are in a position to challenge the leadership of today's innovation powerhouses in the coming years?

This report attempts to answer that question by examining where, aside from the aforementioned big three, commercial activity in today's emerging fields of technology is most vigorous. Such fields include artificial intelligence (AI), advanced manufacturing, augmented and virtual reality (AR/VR), blockchain, and other technologies that have the potential to become engines of future economic growth, much as the internet and mobile connectivity did before them.

The report's findings are based partly on analysis of venture capital (VC) funding of firms developing these technologies and bringing innovations in them to market—a direct indicator of commercialisation activity at city level—and partly on data relating to universities, networking activity and other facets of city innovation environments.

VC funding data are the most direct indicator of such activity available at city level.

Our key findings are:

- **Emerging technology strengths are broad-based in the main pretenders.** Of the 24 cities making our top table of potential challengers, the five highest scorers are Beijing, Tel Aviv, Toronto, Los Angeles and Paris. All show heightened commercial activity in at least four fields of emerging technology.
- **AI and advanced manufacturing are the main fields of competition.** All the top challenger cities are fostering substantial commercial activity in AI and advanced manufacturing. In other fields, Tel Aviv is a pace-setter in computer vision, Los Angeles in AR/VR and Toronto in nanotechnology. Lower down the table, Singapore is developing into a leading blockchain hub, as is San Diego in advanced biosciences.
- **Universities are a key ingredient to emerging tech leadership.** Enabling factors of innovation in cities are difficult to measure. However, common to all the top challengers is the presence of not one but several large universities with advanced degree and research programmes in specific emerging tech fields such as AI, robotics, mixed reality and nanotechnology.
- **There's no innovation without communities.** The sharing of knowledge and advice in formal and informal networks is recognised to be integral to successful innovation hubs. This activity is also difficult to quantify, but a look at proxy indicators such as Meetup groups suggests that community activity is extensive in Paris, Toronto and elsewhere in fields such as blockchain, AI and advanced manufacturing.

¹ "Silicon Valley is changing, and its lead over other tech hubs narrowing", *The Economist*, September 1st 2018.

1. INDUSTRIES OF THE FUTURE

The internet, mobile technology and big data have all had a profound impact on business and society in the past two decades. Technologies are emerging and being commercialised today that promise to be as influential in shaping how we live and work. They also have the potential to become engines of economic growth, and the foundations of new “tech” sectors along the lines of fintech and healthtech today. There are nine fields of technology still at the early stages of maturity that, based on the views of experts and analysis of current and projected growth trends, we feel have such potential:

AI and machine learning	Computer vision
Augmented and virtual reality	Nanotechnology
Advanced manufacturing and robotics	Energy storage
Blockchain	Quantum computing
Advanced biosciences	

AI is likely to prove the most influential of these, for the reason that its capabilities will underpin advances in all the other listed fields and many more besides. Like the internet, it is a general purpose technology that, according to Scott Stern, professor of technological innovation, entrepreneurship, and strategic management at MIT Sloan School of Management, is changing not just products, but the process of innovation itself.

Much, if not most, of the development and commercialisation of these technologies is

What constitutes an emerging technology?

The nature of emerging technologies defies easy definition. According to Daniele Rotolo, Diana Hicks and Ben Martin, an emerging technology has five defining attributes: radical novelty, relatively fast growth, coherence, a prominent impact, and uncertainty and ambiguity.² PwC, a global consultancy, identifies an emerging technology based on the speed of its take-up, the scale of public and private investment, the potential for it to go mainstream, its global reach, its technical viability, and its industry relevance across more than one sector.³ Novelty, rapid growth and potential impact are common elements in these and other definitions.

taking place in large cities or metropolitan regions. The main reasons for this include: the presence of world-class universities, conducting bleeding-edge research and producing specialist talent; a concentration of financial resources; good communications and physical infrastructure; and public policies that promote and fund local innovation and entrepreneurship in these fields. Such attributes make large cities attractive locations for emerging tech start-ups and, along with them, the R&D and science labs of large companies looking to acquire such capabilities of their own.⁴

² Daniele Rotolo, Diana Hicks and Ben Martin, “What is an emerging technology?”, *Research Policy*, Vol 44 (10): 1827–1843, December 2015.

³ Warren Tucker, “The eight emerging technologies you should learn to love”, PwC website, accessed June 9th, 2019.

⁴ For a discussion of such factors in technology innovation overall, see Victor Mulas, Michael Mingas and Hallie Applebaum, *Boosting Tech Innovation Ecosystems in Cities*, The World Bank, 2015.

Elite challenges

Silicon Valley, New York and London are widely recognised to be the world's innovation powerhouses, figuring in the elite group of ecosystems in the major city-level studies that have been published in recent years.⁵ All, however, face stiff challenges to their continued attractiveness and growth, including exorbitant living costs, transport difficulties and, in the case of London, Brexit-related political uncertainty. "Tech entrepreneurs are beginning to find living and operating in these cities a big hassle," says Richard Florida, professor and director of cities at the University of Toronto. "We may very well see other cities start to rival them as emerging technology hubs."

There are a handful of other cities where commercial activity in emerging technologies has been growing rapidly and at scale. The purpose of our research is to determine which of these has the potential to challenge the leading positions of today's innovation powerhouses in the foreseeable future. To do this, we've analysed data from 135 cities on VC funding of firms in the nine emerging technology fields listed above between 2012 and 2017.⁶

Why VC funding? One reason is that it has been shown to play a vital role in the commercialisation of ideas and products of highly innovative businesses.⁷ VC firms

mostly finance, of course, start-ups and other young companies, providing the latter the wherewithal to take their idea to a critical stage of viability. VC firms are often able to sniff out the most promising and economically impactful firms among the broader mass.⁸ For these reasons, VC funding of technology commercialisation—especially by start-ups—is a reasonable proxy for emerging technology innovation.

As in any exercise of this nature, there are caveats to be considered. One, as Mr Stern points out, is that new technologies and the initial products based on them are often brought to market by large companies that acquire and build on the ideas of young firms. Another caveat, according to Carlo Ratti, director of MIT's SENSEable City Laboratory, is that many start-ups today set themselves up in multiple cities, basing their main office, for example, close to plentiful sources of VC funding while developing their products or ideas elsewhere, including overseas. "Start-ups are increasingly acting like multinationals," he says.

When, however, the objective is comparing cities worldwide on technology-specific commercial activity, VC funding is, at the moment, the only robust indicator that can be measured in a comparable manner across the many dozens of cities around the world. This means it is the best place to start.

⁵ These include Startup Genome's *Global Startup Ecosystem Report* (published periodically since 2011), the *Global Tech Hubs Report* published by CB Insights (2018), and *Rise of the Global Startup City*, authored by Richard Florida and Ian Hathaway and published by the Center for American Entrepreneurship (2018).

⁶ The data were sourced from Crunchbase in May 2019. In order to ensure complete data from all the cities in our analysis (there is often a time lag in the reporting of unannounced funding deals), we opted to include data up to the end of 2017.

⁷ Matteo Rossi, "The Contribution of Venture Capital to Innovation", *Triple Helix*, 2017; Will Gornall, Ilya Strebulaev, "The Economic Impact of Venture Capital: Evidence from Public Companies", Stanford Graduate School of Business, November 2015.

⁸ Two University of Sussex academics termed these high-impact firms "gazelles" for their outperformance of the broader universe of less impactful start-ups ("muppets"). Paul Nightingale and Alex Coad, "Muppets and gazelles: political and methodological biases in entrepreneurship research", Sussex Research Online, 2014.

2. TOMORROW'S POWERHOUSES?

Which cities have the potential to challenge the leadership of today's technology innovation powerhouses? Using the proxy of VC funding, 24 cities exhibit the characteristics of significant scale (number of deals) and high growth (increase in the number of deals) that merit our closest attention. These are listed in Figure 2, which shows scores generated for each city, and each field of technology, by an Economist Intelligence Unit model. (See "How the cities are scored" for model details.)

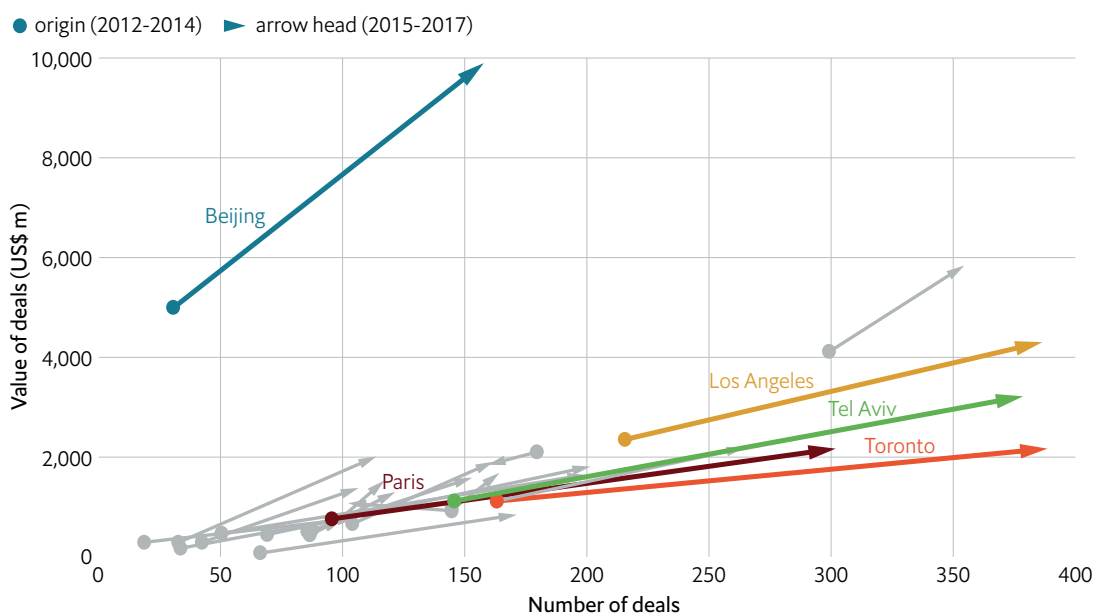
It is apparent from the table that most of the cities have broad-based strengths in several emerging technology fields. Beijing, for example, has a score of 50 or higher in six different technology fields and is the highest-scoring city in two of them: AI and advanced manufacturing. Four cities—Tel

Aviv, Toronto, Paris and San Diego—exhibit similarly high scores in five technology fields. Only four cities in the table (Chicago, Denver, Washington, DC, and Minneapolis) score at this level in just one technology.

The table also suggests that, among different fields of emerging technology, deal-making is especially active in AI and advanced biosciences. (The latter includes technologies such as genetics, biopharma and biotechnology.) A look at the underlying data confirm this: total deals in each of these fields feature in 38% of the cumulative number of deals registered across all 24 cities recorded in 2015-17.⁹

A handful of cities stand out for their breadth of activity in several emerging technology

Figure 1: Growth in VC deal activity, 2012-14 to 2015-17, 24 cities



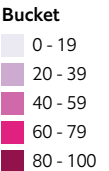
The chart indicates the pronounced trajectory in deal activity of the top cities. Grey arrows indicate deal activity for the remaining 19 cities.

Source: Crunchbase, The Economist Intelligence Unit

⁹ Crunchbase includes numerous data points for each individual funding deal. Amongst these is the specific field of activity of the recipient firm, which includes its products or services and the key features of them. These descriptions allow funding deals in each city to be categorised by field of technology.

Figure 2: Innovation hotspot scores (24 cities)

	Overall	Artificial intelligence	Advanced manufacturing and robotics	Blockchain	Computer vision	AR/VR	Energy storage	Nano-technology	Advanced biosciences	Quantum computing
Beijing	72	83	82	69	69	7	66	0	37	0
Tel Aviv	65	72	59	59	72	56	17	35	46	0
Toronto	62	66	62	46	36	24	86	78	41	88
Los Angeles	62	65	64	41	31	79	52	34	29	0
Paris	59	66	64	53	6	17	66	45	48	0
San Diego	57	52	62	45	52	23	10	68	64	0
Singapore	54	56	39	96	44	4	0	52	33	0
Berlin	50	60	59	54	46	29	23	24	31	0
Bangalore	48	60	47	0	53	53	61	0	21	0
Seattle	47	53	49	44	53	49	50	52	30	0
Montreal	47	56	55	51	39	38	62	51	46	0
Barcelona	40	42	32	51	45	18	0	50	44	0
Stockholm	40	52	34	38	18	52	47	50	23	0
Anaheim	38	46	44	23	4	48	65	40	28	0
Chicago	38	56	47	42	49	2	37	44	12	0
Vancouver	38	45	43	52	38	16	56	16	27	74
Austin	37	57	8	53	51	16	34	19	17	0
Denver	35	37	42	51	38	28	24	25	22	0
Washington, DC	33	43	40	34	0	27	33	0	17	67
Minneapolis	31	0	31	0	0	50	34	0	33	0
Atlanta	30	39	3	47	44	30	0	51	11	56
Philadelphia	30	41	36	50	28	50	0	32	23	0
Raleigh	30	30	21	0	51	22	0	10	29	0
Newark	26	33	21	52	17	50	24	30	14	0



Source: Crunchbase, The Economist Intelligence Unit

How the cities are scored

The scores shown for each city are based on a model created by The Economist Intelligence Unit, drawing on data from Crunchbase, a business information database. Each score (overall and in each field of technology) is on a normalised scale of 0 to 100, where 100 is the best score. The scores display the relative performance of each city within a subset of 24 cities, those with at least 100 deals in the most recent period, 2015-17. (As our focus is on challengers, an upper threshold was set of 500 deals in that period, which resulted in the elimination of the San Francisco Bay Area, New York, London and Boston from our calculations.)

The scores are based on four indicators: the absolute number of deals recorded in 2015-17, and the growth of that figure compared with the whole period under analysis, 2012-17, as well as the absolute value of deals recorded in 2015-17, and the growth of that figure compared with 2012-17. The absolute indicators and growth indicators have been weighted equally.

fields, and/or for their leadership in one or two individual ones. Beijing and Paris, for example, are benefitting from determined government efforts to become world-leading centres of AI and robotics development. The advances in AI made by Tel Aviv start-ups are spilling over into the activities of firms developing computer vision, bioscience and manufacturing technologies, not to mention its legions of cyber-security firms. Toronto is building on its industrial engineering heritage to support the growth of firms with expertise in robotics, nanotechnology and other fields



Deal-making is especially active in AI and advanced biosciences

of advanced manufacturing. Los Angeles is a hotbed of innovation in augmented and virtual reality, technologies that support the film, gaming and other creative industries.

Figure 3: Scores by technology area, top five cities



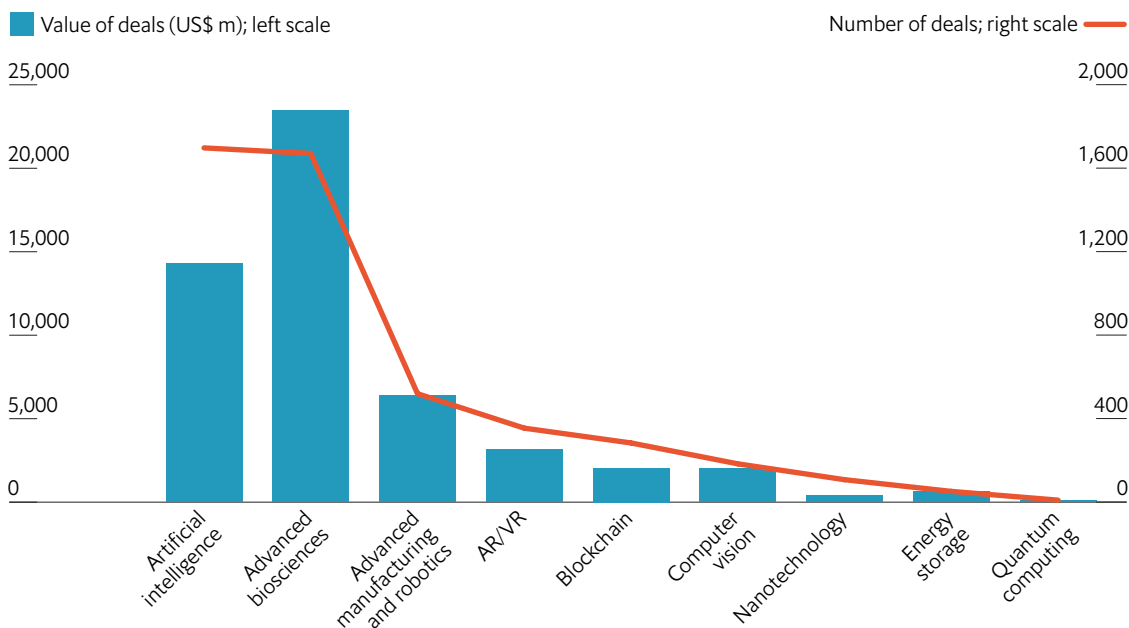
Source: Crunchbase, The Economist Intelligence Unit

¹⁰ <https://innovationmatters.economist.com/beijing/artificial-intelligence-manufacturing>
<https://innovationmatters.economist.com/los-angeles/mixed-reality-technology>

Beyond these top five are cities meriting mention for their strengths in individual areas. San Diego, for example, is the high scorer in the funding of biosciences firms. Singapore accounts for nearly a third of all deals across the 24 cities involving blockchain firms, which are helping to fuel a thriving fintech industry. Blockchain activity is also prevalent in Berlin, but the city stands out equally for local firms' development of intelligent manufacturing technologies, supporting Germany's leading role in the Industry 4.0 movement.

There are signs of reduced deal-making in some cities in the past year. This appears to be the case in Beijing, for example, due to slower economic growth and the escalation of US-Chinese trade tensions. Reports also indicate a cooling of activity involving AR/VR firms in Los Angeles as sales of products such as headsets have not met previous growth expectations.¹⁰ The fundamentals of both cities' innovation ecosystems remain strong, however, suggesting that any slowdowns are likely to be temporary.

Figure 4: Total value and number of VC deals, 2015-17, 24 cities



Source: Crunchbase, The Economist Intelligence Unit

3. ECOSYSTEM PILLARS

Deal-making is a form of innovation output—evidence for or validation of innovation, rather than innovation itself—and of course draws only a partial picture of emerging technology innovation in a city. Just as important are the key inputs, or enabling factors, which may be summarised as policy, talent, science and community.¹¹

The top cities in our list of potential innovation hotspots possess these assets in abundance. In Beijing and Paris, as mentioned earlier, recent co-ordinated central and municipal government policies are arguably the key drivers of innovation ecosystem growth. Development of AI and manufacturing technologies in Toronto is benefitting from the Canadian government's Advanced Manufacturing Supercluster programme. The Israeli government and military have been actively supporting start-up activity in technologies such as AI and computer vision, which are considered vital to national security. Few governments can match that of Singapore when it comes to determination to develop world-leading technology capabilities, which is currently manifested in its efforts around blockchain.

University challenges

Talent and scientific capabilities are provided mainly by universities. "Great universities are a vital element of any successful innovation ecosystem," says Mr Florida. "They aggregate talent in the form of students and academics who want to commercialise technology and build something for the real world." Increasingly, says Mr Ratti, they are incubators of new businesses in their own right.

Our innovation hotspots of the future each boast multiple universities that perform these roles in specific technology fields. For example, among Beijing's 91 tertiary institutions are those such as Tsinghua, Peking and Beihang universities, which run specialised degree and research programmes in AI, materials science and nanotechnology. At least four of the more than a dozen universities in the Toronto-Waterloo Corridor do the same. Institutions such as École Polytechnique, Sciences Po Paris and École des Ponts ParisTech provide AI and robotics specialists to the French capital's emerging technology businesses. Other Paris universities offer advanced programmes in advanced biosciences. "Mixed reality labs" are found at Los Angeles-based universities such as UCLA and USC, among others.



The sharing of knowledge and ideas in communities can build confidence and reduce uncertainty in the development of emerging technologies

Daniele Rotolo

It should be noted that far from all universities are adept at technology transfer and commercialisation. However, a few in the aforementioned cities, such as Tsinghua and Beihang universities in Beijing and Caltech in Los Angeles, are all among the higher scorers in the "industry income" category of the *Times Higher Education* World University Rankings.¹²

¹¹ The World Bank refers to these enablers broadly similarly, as people (entrepreneurs and technology talent); economic assets (including firms, finance and universities); physical and communications infrastructure; public policy that promotes innovation; and networking assets (including communities, accelerators and mentor networks). Victor Mulas, Michael Mingas and Hallie Applebaum, *Boosting Tech Innovation Ecosystems in Cities*, The World Bank, 2015.

¹² *Times Higher Education* World University Rankings 2019.

(The category captures the knowledge-transfer activity of the ranked universities based on the research income they earn from industry.)

Idea networks

When a new technology emerges, says Daniele Rotolo, senior lecturer in science, technology and innovation policy at the University of Sussex, it is not enough that policy, talent and science assets exist in a city. They also need to come together in a spirit of interdisciplinary and transdisciplinary collaboration that helps to develop a common language and creates momentum around the technology's development. "Communities play this role," he says, bringing together entrepreneurs, engineers, university-based specialists and, often, government representatives. Their main contribution to an innovation ecosystem is the sharing of knowledge, ideas and, sometimes, resources.

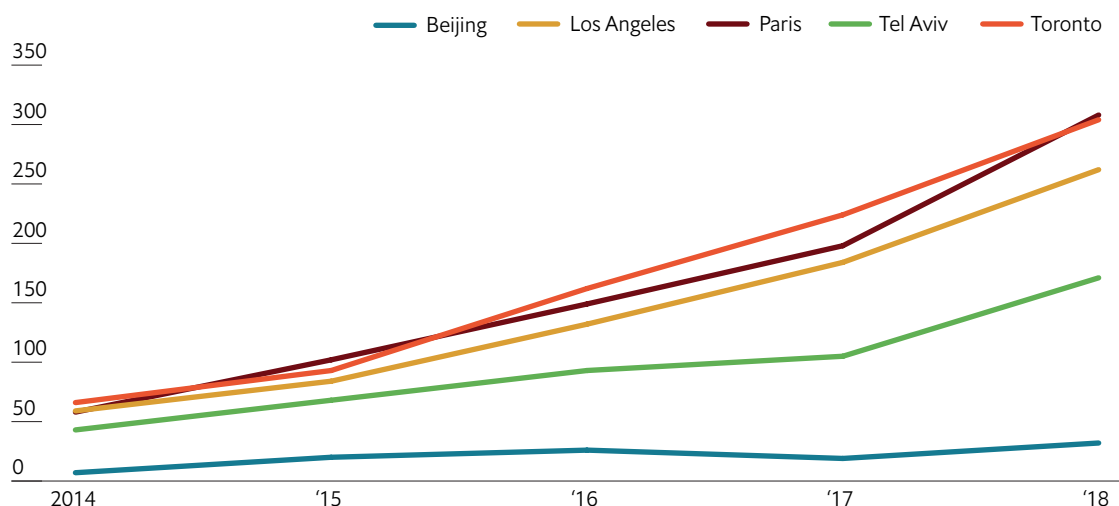
It is difficult to gauge the level of community activity in cities in quantitative terms, as comparable data on the number or frequency of events and other gatherings is not readily available. When it comes to technology,

however, Meetup groups provide a clue. These are groups organised online, using the Meetup platform, around specific topics. Tech-focused groups are popular in several of the cities in our study, numbering (as at May 2019) close to 1,200 in Paris, over 700 each in Toronto and Tel Aviv, and over 500 in Los Angeles.

When it comes to emerging technologies, blockchain and related areas such as cryptocurrencies are a popular Meetup theme, as are groups devoted to AI and machine learning. Robotics, 3D printing and other manufacturing technologies figure among group themes in Paris and Toronto, while groups devoted to augmented and virtual reality are predictably more numerous in Los Angeles than in other cities.

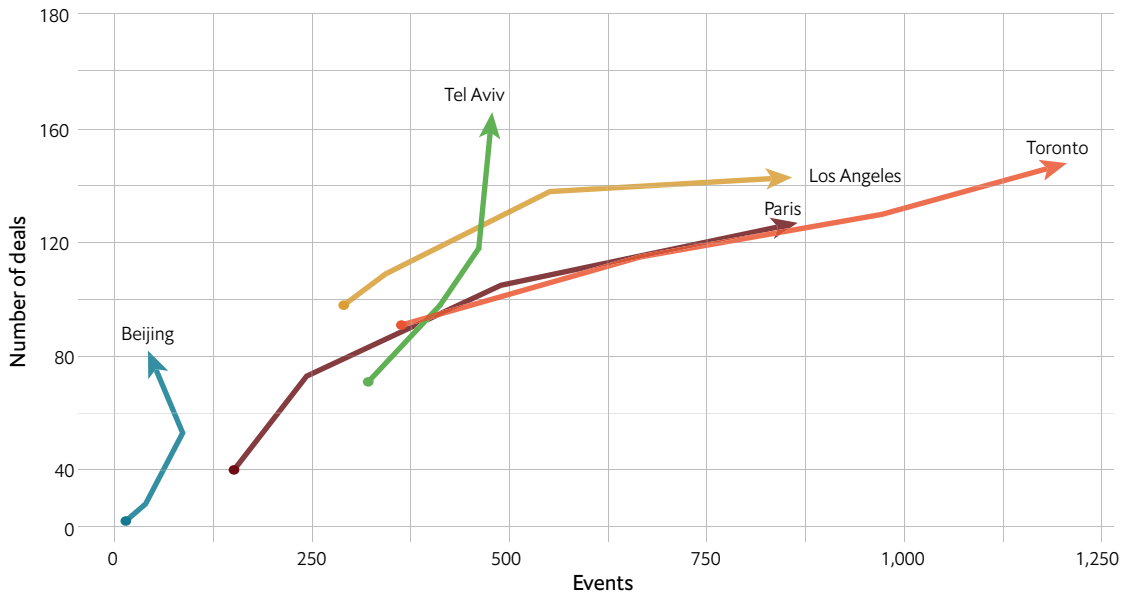
Communities such as these serve an additional purpose, says Mr Rotolo. "The development of emerging technologies comes with a good deal of uncertainty and ambiguity—about opportunities of applications, selection of standards, as well as technical challenges. The sharing of knowledge and ideas in communities can help build confidence and reduce this uncertainty and ambiguity."

Figure 5: Number of Meetup groups relating to emerging technologies, 2014-18



Note: Meetup groups based on topics relating to The Economist Intelligence Unit's focus technologies; July numbers
Source: Meetup.com, The Economist Intelligence Unit.

Figure 6: Deal activity and Meetup events, select technology areas, 2014-2017 trajectories



Source: Meetup.com, Crunchbase, The Economist Intelligence Unit

Conclusion

Comparing cities' strengths and weaknesses on a quantitative basis is always challenging, especially on a subject as elusive and imprecise as innovation. Fortunately, the understanding of what local factors contribute to technology innovation, and how its outputs can be measured, is advancing. So is the collection of data, from cities in the developed and developing worlds alike. All the experts interviewed for this report and many others are conducting research and building models that will help us to better understand the DNA of thriving innovation hubs. We hope that our research, by focusing on the development of emerging technologies, contributes to that endeavour.

As the research advances, it is likely that contributors to technology innovation will come into focus that had previously been underappreciated or were difficult to quantify. One is a city's quality of life. Successful innovation hubs are places that people, particularly highly educated and highly skilled labour, want to live. As housing and other living costs rise, commuting becomes more difficult, and air quality fails to improve, hubs such as Silicon Valley, New York and London may lose some of their shine with technology innovators, entrepreneurs and the talent that support them. The potential rivals to those cities we've highlighted in our research undoubtedly face similar challenges. All need to consider the impact that such factors will have on their ability to thrive as hotspots of innovation.

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LONDON

20 Cabot Square
London, E14 4QW
United Kingdom
Tel: (44.20) 7576 8000
Fax: (44.20) 7576 8500
Email: london@eiu.com

GENEVA

Rue de l'Athénée 32
1206 Geneva
Switzerland
Tel: (41) 22 566 2470
Fax: (41) 22 346 93 47
Email: geneva@eiu.com

NEW YORK

750 Third Avenue
5th Floor
New York, NY 10017
United States
Tel: (1.212) 554 0600
Fax: (1.212) 586 1181/2
Email: americas@eiu.com

DUBAI

Office 1301a
Aurora Tower
Dubai Media City
Dubai
Tel: (971) 4 433 4202
Fax: (971) 4 438 0224
Email: dubai@eiu.com

HONG KONG

1301
12 Taikoo Wan Road
Taikoo Shing
Hong Kong
Tel: (852) 2585 3888
Fax: (852) 2802 7638
Email: asia@eiu.com

SINGAPORE

8 Cross Street
#23-01 Manulife Tower
Singapore
048424
Tel: (65) 6534 5177
Fax: (65) 6534 5077
Email: asia@eiu.com