Cities, Innovation and Entrepreneurial Ecosystems: Assessing the Impact of the COVID-19 Pandemic

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Abstract

A potential impact from the COVID-19 pandemic is that the nature, rates and spatial configuration of innovation may change within and across cities. To examine these potential changes this paper draws on findings from data gathered through interviews, surveys and secondary data over two time periods: prior to the pandemic; and during the fallout from the pandemic .The paper utilises the concept of 'entrepreneurial ecosystems' and the analysis finds significant adaptability and resilience across the ecosystems addressed. It is argued that these ecosystems are not only likely to survive, but to actually thrive as the requirement for new technological solutions and applications allows them to maintain their innovative capacity and capability. It is further found that more spatially distributed patterns of entrepreneurial innovation are emerging across a wider range of cities and regions, which is leading to changes in the spatial economics of innovation. It is concluded that the pandemic is likely to heighten rather than slow down these trends and are likely to continue until any new unforeseen global shock with the capacity to destabilise such patterns occurs.

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Introduction

In a book published in 2020, the political economist Hilton Root (2020, p. 12) states that '… a multipolar world is emerging that is vulnerable to unexpected shocks from any corner … the entire network structure of international relations is becoming more locally coupled, with increasingly dense connectivity in trade, diplomacy, weapons and finance'. Root (2020) presents a highly convincing thesis concerning the density of global connectivity and its ongoing progression, and his comments concerning vulnerability with shocks emerging from any corner almost reads as prophetic. Although it is unlikely that he had the COVID-19 pandemic in mind, a result of the crisis that ensued in the aftermath of the pandemic is a potential negative externality in the shape of the fear – perceived or real – of being in close proximity with a health debilitating contagious virus, as well as the networks that allow its global transmission. Furthermore, it is argued by some that the concentration of the COVID-19 disease in densely populated cities may lead to a retreat of both people and economic activity from these urban areas (Batty, 2020; Nathan and Overman, 2020; Adler et al., 2020; Florida et al., 2021). For example, Garrett (2020) states that 'the Covid-19 pandemic will reverse the trends of globalisation and urbanisation, increasing the distance between countries and among people. These changes may make for a safer and more resilient world, but potentially one that is also less prosperous, stable and fulfilling.'

Such arguments indicate a potential double-edged effect, with innovation and economic development suffering as a result of new behavioural trends (Glaeser, 2020; 2022). In particular, there is the possibility that an upshot from the pandemic is that human behavioural changes may impact on the nature, rates and spatial configuration of innovation, especially within and across cities. To examine these potential changes in the urban innovation landscape, this paper draws on findings from data gathered through interviews and surveys with informants over two time periods: prior to the pandemic and during the fallout from the pandemic. These informants consist of individuals operating in the field of innovation and entrepreneurship in the cities of New York, Los Angeles, London, Berlin, Tokyo and Shanghai. In order to widen the study across a larger cohort of cities, the paper also undertakes a quantitative analysis of data for cities of all sizes and stages of economic development across the globe.

This paper adopts the metaphor of the 'ecosystem' – or more fully the 'entrepreneurial ecosystem' - to capture the means by which entrepreneurial innovation is performed and undertaken through the innate interdependencies existing between the elements and components of such systems. The paper seeks to examine the immediate and likely longer term impact of COVID-19 on the types of ecosystems that have emerged within cities to foster entrepreneurship-driven innovation (Autio et al.,

2014; Audretsch and Belitski, 2017). These processes of urban entrepreneurial innovation have developed rapidly in recent years in certain cities, particularly global cities (Glaeser et al., 2021). However, what is unclear is the extent to which these ecosystems have become embedded and enduring within their respective city environments. Therefore, the paper analyses the adaptability and resilience of these ecosystems, as well as the changing nature of the spatial distribution of innovation agents and the networks that connect them.

Overall, the analysis finds significant adaptability and resilience across the ecosystems addressed, with the large majority of informants forecasting positive and optimistic scenarios in terms of the future of entrepreneurial innovation in their respective city. Furthermore, it is found that the emergence of more spatially distributed networks across a wider range of cities and regions is leading to changes in the spatial economics of innovation that go beyond traditional agglomeration theories.

The remainder of the paper is structured as follows. It first outlines the relationship between urban environments and entrepreneurial ecosystems as a means of generating the research questions that the empirical analysis seeks to address. Following the presentation of the methods for data collection, the empirical results and findings are presented in terms of the emergence, adaptability and resilience of urban entrepreneurial innovation ecosystems (or which we more simply refer to as entrepreneurial ecosystems), as well as the spatial distribution of the networks associated with these ecosystems. The analysis provides a means for reflecting on the changing spatial economics of innovation, which precedes the presentation of the conclusions.

Urban Innovation, Entrepreneurial Ecosytems and the Pandemic

Different crises often bring similar economic challenges in terms of unemployment, weakened markets and demand, and a lack of investment. All of these may either have a causal impact on, or be the result of, lower rates of economic development. Coupled with these factors is a concern that innovation may also be compromised as a result of poor economic conditions, which again hinders development. These arguments are relatively well-rehearsed as a result of the analysis of many crises over time (Tomaney et al., 2010; Giannakis and Bruggeman, 2017; Tan et al., 2020; Hardy and Sever, 2021). This suggestion of negative effects stems from the prevailing theory of the spatial economics of innovation, which is based on evidence that strongly points to cities and urban regions being the centres of innovation, with innovation density showing a high level of correlation with urban density (WIPO, 2019; Duranton and Puga, 2020). This is particularly the case for innovation driven by entrepreneurs seeking the advantages of agglomeration (Adler et al., 2019), and the confluence of science, technology and creativity (Johnson, 2008; Rodríguez-Pose and Lee, 2020).

Over a number of years, many important contributions have extolled the advantages of cities and urban regions (e.g. Florida, 2002, Glaeser, 2011), and more recently Bahcall (2019) has introduced an influential theory of the emergence and adoption of radical innovation, which he terms 'loonshots'. In summary, Bahcall (2019, p. 2) argues that 'The most important breakthroughs come from loonshots, widely dismissed ideas whose champions are often written off as crazy' and that 'Large groups of people are needed to translate those breakthroughs into technologies that win wars, products that saves lives, or strategies that change industries'. In particular, the value of the networks formed by these people lies in the way in which they are able to overcome the innate uneven distribution of knowledge (Hayek, 1945), especially connecting the originators and users of innovation (von Hippel, 1994). In essence, the value of these networks is their capability to aggregate knowledge that is necessarily located across different organisations and places (Lakhani and Panetta, 2007).

In general, the development path of an urban economy is dependent upon the quality of the innovation generating system it possesses and the assets within it. More recently, the role of particular places within urban environments, which are variously described as urban innovation spaces, districts or precincts, and conceptualized here as features of urban entrepreneurial ecosystems, are viewed as key catalysts of innovation-based urban development (Yigitcanlar et al., 2012). In essence, it would seem that such ecosystems echo the notion of cities as "Schumpeterian hubs" for recombining capital in order to generate innovation (Johnston and Huggins, 2016). In recent years, these processes of recombination and aggregation have been captured by the idea of 'open innovation', whereby organisations create systems to conect themselves to knowledge and allow the generation, dissemination and absorption of innovation (Chesbrough, 2020). In particular, the hollowing out of many large firms and organisations with regard to innovative capacity has led to an increased openness in innovative processes across agents, and a key growing component within this new innovation framework are entrepreneurs. In this sense, entrepreneurial ecosystems are now at the centre of efforts to promote economic development (Gumbau Albert, 2017; Nambisan et al., 2018; Qian, 2018; Malerba and McKelvey, 2020).

The relative uniqueness of the entrepreneurial ecosystem concept as a lens for understanding and explaining new forms of industrial organisation, innovation and economic development includes two interrelated dimensions. First, it is a multi-scalar concept that not only incorporates the behaviour of firms and organisations but also the behaviour of human agents, especially entrepreneurs, alongside the meta-behaviour of cities and regions as a whole (O'Connor et al., 2018). Indeed, the existing evidence points to entrepreneurial ecosystems as being most likely to exist and evolve in particular cities and regions, as well as potentially across them (Audretsch and Belitski, 2017; Alvedalen and Boschma, 2017; Spigel, 2020).

Second, it is a network concept, and while many theories of industrial organisation and innovation draw upon the notion of networks to explain various relationships, the idea of entrepreneurial ecosystems seeks to fully incorporate relational attributes and the role of human and social networks as the fundamental building blocks of the dynamics of economic development (Glaeser et al., 2016; Mack and Mayer, 2016; Roundy et al., 2018; Brown and Mason, 2017; Spigel, 2017, 2020). Given this, a key question is why particular cities have become key locations when there are numerous negative externalities to deter the generation such ecosystems. Potentially, digital technologies, deep tech, and especially life science and healthcare activity may have expanded cities to conform to Schumpeterian modes of growth based on three main ideas: innovations lead to long-run growth, entrepreneurial investments are motivated by prospects of monopoly rents, and new innovations replace old technologies (Aghion, Akcigit, and Howitt 2015). However, unlike previous periods of technological innovation, the 21st century model has resulted in much of the burden of innovation resting on the capabilities of start-ups rather than large corporates (Rossi and Di Bella, 2017; Feldman et al. 2021; Zukin, 2020, 2021). This raises our first research question:

Research Question 1: Why did some cities emerge as key locations for entrepreneurial ecosystems prior to the COVID-19 Pandemic?

Cosmopolitanism and outwardly facing behaviour may foster greater economic resilience and competitiveness, which suggests the possibility that some cities and regions possess more of the 'right' type of behaviour when it comes to catalysing innovation (Huggins and Thompson, 2021). Therefore, while the configuration and capability of ecosystems determines urban and regional development outcomes, at the micro-level it is the action of certain key human agents within cities who actually shape the nature and evolution of networks of people and organisations (Cook, 2020). In general, the value of these networks within and across cities and regions is regulated by a series of 'associational institutions' in the form of conventions with regard to collaboration and cooperation, especially associational business behaviour and the norms of trust and collective action. Cities, in particular, are considered to be key locations for high rates of network formation due to the high density of actors and high frequency of human interactions (Glaeser, 2011; Florida et al., 2017).

Arguments relating to this 'human interaction' phenomenon are largely associated with neoclassical growth theories, and the emergence of endogenous theories of growth have clearly and rightly steered this focus, but at the same time it has meant that some of the behavioural perspectives on urban development that were a feature of twentieth century urban theory have tended to become sidelined. For example, the works of Simmel (1903), Park (1915), Mumford (1937), Wirth (1938) and others all highlighted the dichotomy of the city in terms of the challenges raised by living in

densely populated places but also the wealth of possibilities it can offer. These theorists were predominately concerned with human behavior in the city. More recently, there has been a return to considering the role and importance of behavioural aspects as a means of explaining different rates of economic development across cities, particularly in terms of their innovative capabilities and adaptive capacity (Storper 2013; Storper et al. 2015; Huggins and Thompson 2021). Such adaptive capacity refers to the ability to change and evolve structures and dynamics in response to changes in the external environment (Martin and Sunley, 2011). In the case of the analysis in this paper, this is pertinent in relation to the potential impacts when such density and interaction is considered a potential threat resulting from a pandemic:

Research Question 2: How adaptive are cities likely to be in terms of remaining attractive and relevant locations for entrepreneurial innovation especially in light of behavioural changes associated with the COVID-19 Pandemic?

In recent years, the concept of 'entrepreneurial ecosystems' has quickly gained traction as a means for both theorising and making policy decisions concerning entrepreneurial activity and development in an era whereby large corporations increasingly outsource innovation, and networks of innovative entrepreneurial agents have become the lifeblood of economic development, with new forms of economic and social behaviour emerging (Stam, 2015; Feld and Hathaway, 2020). Fundamentally, the conceptualisation of an entrepreneurial ecosystem is a manifestation of the growing phenomenon of entrepreneurial innovation and the role of human agents – principally, but not exclusively, entrepreneurs – and their interdependent behaviour in complex and adaptive multi-scale networks that form the systems that either forge or constrain innovation (Audretsch et al., 2019; Feldman et al., 2019; Spigel, 2020). These developments may become extended and accentuated as a result of the COVID-19 pandemic, with entrepreneurship and the ecosystems supporting it becoming centre stage as many economies seek to rebuild. Building on existing concepts such as industrial clusters and innovation systems, the concept of an entrepreneurial ecosystem has grown in significance as a result of the real changes that are occurring within and across economies (Audretsch and Belitski, 2017). The agency and behaviour of these entrepreneurs, both individually and collectively, has become a larger cog in the innovation machine (Florida et al., 2017; Adler and Florida, 2021). Therefore, 'entrepreneurial innovation' is now at the heart of efforts to promote and sustain economic development (Autio et al., 2014), and this innovation-focused entrepreneurship can only be effectively explained and understood by addressing the behavioural aspects of this activity.

While cities as a whole may remain enduring locations for innovation, behavioural changes across society overall, as well as those engaged in the innovation economy, is potentially leading to the emergence of more spatially

distributed entrepreneurial innovation ecosystems (Kichko et al., 2020; JLL, 2022; Muro and You, 2022). The outcome of these emerging distributed ecosystems stems from a range of dynamic forces that can be encapsulated by the three primary factors: (1) the search for new knowledge and ideas – which pull people and firms to established innovation hubs but may also push them to more frontier locations (Fritsch and Wyrwich, 2021); (2) the pull factor of hubs due to agglomeration and amenity forces (Florida, 2002); and (3) push factors from behavioural changes resulting from negative externalities (Banczyk et al., 2018). Within the context of the COVID-19 pandemic, questions concerning the resilience of these ecosystems are clearly relevant. In this case, resilience refers to the ongoing process of ensuring the sustainability of these ecosystems, which will be underpinned by the adaptive capacity referred to above (Simmie and Martin, 2010):

Research Question 3: How resilient are urban entrepreneurial innovation ecosystems likely to be in the face of the challenges associated with COVID-19 Pandemic?

In terms of the spatial economics of innovation, there is an ever evolving process of spatial fixes emerging from the changing nature of the competition for innovation and the costs of joining and maintaining a position in this competition (Duranton and Kerr, 2015; Kichko et al., 2020). Innovation agents gain advantages from entering the highly competitive networks and markets that evolve in innovation hubs (Florida et al., 2020), but these may come at a cost, in terms of factors such as affordability and congestion, as well as the emergence of hyper competitive markets and networks within which it is difficult tmake viable returns on investment in innovation (Glaeser et al., 2021).

These dynamics conform to the underlying theories of the spatiality of innovation. McCann (2007) develops a model indicating that innovation is partly a function of face-to-face interaction as well as cost-related externalities. This model facilitates a better understanding as to how differing forms of innovation are likely to be either spatially concentrated or more geographically dispersed. It is this recursive relationship between these centripetal and centrifugal forces that underpin the emergence of more spatially distributed ecosystems. This is important as innovation does not just happen within cities but is actually a force underlying their formation and evolution (Florida et al., 2017). The attraction of entrepreneurial and innovative individuals represents a long-term factor in promoting economic development. Given that these agents tend to migrate to places that are conducive to their talents (Hall, 1998; Akcigit et al., 2017), sorting mechanisms are at play whereby people choose to live and work in particular places based on their preferences, tastes and values (Storper and Manville, 2006).

It is important to understand how and why these transformations are occurring to the geography of innovation, as well as how and why these trends are likely to evolve over time, especially in light of the pandemic. Globalised urbanization and the role of cities in driving this phenomenon is already well acknowledged (Brenner and Keil

2020, Storper 2013), and at the same time globalization is considered to have acted as a catalyst for urban resurgence and the emergence of new global centres (Sassen 2020; Scott 2008). Coupled with the rise of Chinese globalization (Derudder and Taylor 2020; Root 2020), as indicated above, many cities in the western world have progressed their role as innovation hubs and created new development paths following the great recession (Adler and Florida 2021; Zukin 2020):

Research Question 4: How is the spatial distribution of entrepreneurial innovation likely to evolve across locations in the period following the COVID-19 Pandemic?

If size matters for innovation, this potentially calls into question the extent to which predictions that cities, especially big expensive cities, will hollow out as a result of the COVID-19 pandemic (Carlino and Kerr, 2015; Florida et al., 2017). Some influential commentators already argue that these processes were gaining momentum prior to the pandemic (Florida, 2017), but in many ways this can be considered part of the natural evolution of cities and places as a result of known changing preferences. A fear of nearness to other people is something much more unknown (Batty, 2020). In part, government policy responses to the pandemic will drive how this evolves (Nathan and Overman, 2020). However, from an innovation perspective this issue of location is perhaps more complex than it first appears in a number of respects: first, the type and nature of innovation that occurs at different locations; and second, and more fundamentally, the extent to which innovation should be conceptualised and analysed as a place-based phenomenon rather than, or at least as well as, the networks through which it is generated and distributed (Shearmur, 2012). Furthermore, in terms of the nature of innovation, there is a growing evidence base indicating that cities are not the only sources and that more peripheral and rural locations often generate significant levels of innovation (Shearmur, 2015; Fitjar and Rodríguez-Pose, 2020; Fritsch and Wyrwich, 2021):

Research Question 5: Which types of location are likely to become more or less attractive for engaging in entrepreneurial innovation in the period following the COVID-19 Pandemic?

Methodology

The analysis presented below is based on two connected primary datasets supplemented with secondary data from a commercial provider of annual data on entrepreneurship activity in a large number of cities across the world. Initially, primary data was collected from interviews with 132 individuals undertaken in 2018/19. These individuals were engaged in entrepreneurial innovation and were located across six cities: Berlin (28 individuals) London (21 individuals), Los Angeles (15 individuals), New York (21 individuals), Shanghai (17 individuals), and Tokyo (30 individuals). When this study first started in 2018 these relatively large global cities were chosen as case studies due to background research suggesting that they were among a cohort of

cities that were rapidly establishing entrepreneurial innovation ecosystems. The interviews were undertaken with entrepreneurs, venture capitalists, the operators of incubators, accelerators, co-working spaces, universities, policymakers, as well as representatives of large corporates. These interviews were undertaken by the paper's authors and were largely administered face-to-face during field visits to each location, and Table 1 indicates the full breakdown of numbers of interviewees by city and the organizational type they represent. These interviews were analysed by a thematic approach based on coding the transcripts and notes according to the original conceptual framework, as well as subsequently analysing the data under each theme to identify the salient factors.

The working hypothesis at the time of the original interviews was that the type of ecosystems emerging in these case study cities would shed light on the development processes other cities and regions around the world may need to adopt in order to innovate and compete effectively in the future. During the time when the authors were analysing and writing-up the results from the interviews the COVID-19 pandemic took hold. This led to questions regarding the validity of the original findings in the new and unknown world that was emerging (Batty, 2020; Nathan and Overman, 2020; Florida et al., 2021). Therefore, it was decided that a systematic approach to analysing these changes was required. In 2021 (June/July) an online survey – mainly consisting of Likert-type scale questions – was administered to all previous interviewees (email messages with a link to the questionnaire were sent to each informant). The key themes covered in the questionnaire relate to the three key concepts underpinning the conceptual framework presented above, i.e. the adaptability, resilience, and spatiality of urban entrepreneurial ecosystems.

In total, 46 usable responses were received across the six cities (two respondents in the US had recently relocated to another city but were able to comment on the focus city) consisting of 6 (13.0%) responses from Berlin, 8 (17.4%) from London, 5 (10.9%) from Los Angeles, 8 (17.4) from New York, 12 (26.1) from Shanghai, and 7 (15.2%) from Tokyo. It is the results from this questionnaire that largely inform the analysis presented below along with some of the relevant findings from the original set of interviews. Table 1 shows in parentheses the breakdown in the number if responses to the survey by city and the organizational type represented by individual respondents. Comparing the relative number of interviewees by city and organizational type with the number of respondents to survey by these same characteristics it is clear that there is a strong relationship between the percentage of interviewees and survey respondents across each. This suggests that the results from the survey are unlikely to be based on any form of response bias in relation to the original sample frame.

Table 1 About Here

Table 2 provides an overview of the characteristics of cities from which primary data was collected. Although the cities differ in terms of the size, they have relatively similar employment rates (percentage of working age population in work), and with some subtle differences, similar industrial structures. Shanghai and to a lesser extent Tokyo possess more employment in manufacturing than the European and US cities, which are now almost entirely service based. Differences in innovation manifests itself in a number of ways with Los Angeles and Tokyo having more patents registered per capita, and the financial hubs of London and New York having lower levels of R&D spending as a proportion of Gross Value Added (GVA), which is likely to be partly a function of industrial structure.

Table 2 About Here

This primary data is supplemented by secondary data obtained from the commercial data provider StartupBlink, which operates as an aggregator of data from various sources, such as Crunchbase, on entrepreneurship activity across cities. In particular, data is drawn from the StartupBlink startup ecosystems rankings (StartupBlink, 2020). This provides annual data on the top 1000 cities in terms of entrepreneurial innovation. The data is collected on an annual basis for more 1,000 cities across the globe to map the location of startups, entrepreneurial business and innovation, along with those activities associated with promoting entrepreneurial innovation (StartupBlink, 2020). It provides a ranking of cities and countries using three groups of components: Quantity; Quality; and Business Environment. The quantity component incorporates not just the new businesses created, but also covers those entities and activities associated with supporting the formation of these startups and nurturing their growth. This means that the measure captures: startups, coworking spaces, accelerators and startup events.

The quality element provides insights as to how well startups are driving innovation. To achieve this, the measure includes existing high growth businesses that have moved beyond the startup phase and are associated with urban growth (Pantheon companies) and also high value (US$1billion+) startups (Unicorns). The final business environment element considers the ease of doing business in the city, associated with the infrastructure present (internet freedom; and R&D investment). In order to provide some economic context of the entrepreneurial innovation activity of the cities, we use a national measure of development as is utilized by the World Economic Forum (WEF) in their Global Competitiveness Reports (Schwab, 2017). These divide countries into factor driven, efficiency driven, and innovation drven economies, as well as those in transition between stages. The WEF data can be used to categorise the national stage of development for 993 cities in 2019 and 978 cities in 2021.

To understand the situation during the pandemic, data is drawn from the Oxford COVID-19 Government Response Tracker to understand the severity of the restrictions

imposed on the population and businesses of the six cities (Hale et al., 2021). Figure 1 provides an overview of the stringency of the government interventions imposed over the COVID-19 Pandemic period. Understandably, as the first country to be affected by the emergence of the virus, China imposed restrictions earlier than other countries. However, the response overall is relatively similar as the Pandemic took hold. This included a number of lockdowns and work from home/stay at home orders and less frequently school closures. For cities such as London, Berlin, Los Angeles and New York this reduced the possibility for in person face to face communication. During surges in infection rates (Spring 2020, Autumn 2020, Winter/Spring 2021) non-essential retail and hospitality operations were closed, or only allowed to operate restricted hours with reduced capacity.

Figure 1 About Here

It is worth noting that Japan never imposed domestic restrictions to the same degree as the other countries in the sample. This means that other countries became more similar to that of Japan as they eased restrictions in the summer of 2021. However, as well as domestic restrictions, countries imposed restrictions on international travel. Japan and China retained strict restrictions on international travel over the entire period, whereas countries such as the UK and Germany imposed restrictions and testing regimes in a less blanket fashion, instead basing restrictions on rates of infection in other countries, with the US falling between these extremes. In summary, although the exact mix of restrictions and periods of easing and tightening may differ between the cities, the overall stringency measure shown in Figure 1 indicates a similarly broad restriction on life and business over the period of study.

Urban Ecosystem Emergence

Prior to the Covid-19 pandemic, changes were already occurring within urban economic systems and these were impacting on the relationship between innovation, entrepreneurship and economic development (Nambisan et al., 2019; Feld and Hathaway, 2020). Taken together, it is these changes that partly explain the emergence of entrepreneurial innovation ecosystems in a number of cities. Many of the interviews undertaken in 2018/19 indicated that firms on public markets had become more risk averse, short-term focused, and therefore less innovative, especially with less of an appetite for disruptive innovation. This was accentuated by the 2008 financial crisis, with one upshot being that investment for innovation was becoming more focused around private markets, venture capital and entrepreneurship-driven innovation. Initially, these trends were more associated with North America and Europe, but Asia followed due to a realisation that the nature of innovation was rapidly changing. This is illustrated by Figure 2 which shows the pattern of venture capital investments for the five countries where the six cities of interest are located.

Figure 2 About Here

Given the different absolute amounts of venture capital investment within countries these have been indexed with 2014 used as the base. Both before and particularly during the pandemic all five countries where the cities of focus are located experienced a large increase in venture capital investment. This means that 2021 was a record year for venture capital investment for all of these countries with the exception of China, which peaked in 2018. Over the COVID-19 pandemic period (2019 to 2021) Germany (220%, US$13.5 billion) and the UK (157%, US$21.6 billion) saw the largest percentage increases in venture capital investment. In absolute terms this is dwarfed by the increase of US$185.2 billion seen over this period in the USA (128% increase).

In summary, the original interviews undertaken for this study indicate that the emergence of new ecosystems in certain cities underpinned by growing venture capital can be captured by three key developments: (1) changes in the form and type of investment by the public and private sectors in infrastructure – both hard and soft – to promote innovation; (2) the emergence of new innovation practices – especially 'open' practices – that have become increasingly associated with the contemporary urban economic landscape; and (3) the efficiency of urban innovation and economic development. In particular, the costs, investments and inputs required to innovate were shifting, with firms having to invest more and more resources into the networks and relationships that are required to access ideas. Building and maintaining relationships is expensive. There are tangible costs in the form of events – innovation theatre – and the engagement of intermediaries – innovation scouts – as well as significant intangible investment in the time required by firms to generate and sustain the social capital and network capital theyneed to develop their own ecosystems.

Firms increasingly looked to cities as a location to effectively engage in and manage these activities. At the individual level, within the technology sectors more people across all age groups were taking time to consider if they can develop an idea into a commercially viable innovation and business, especially in areas related to digital technologies. Many of these individuals also turned to cities, especially big cities, with the rapid growth of co-working spaces and incubators attesting to this development (Madaleno et al., 2021). As a result of these changes in both firm level and individual behaviour, many mainstay innovation players moved part of the burden, costs and, to some extent, the risk of innovation to start-up firms, new entrepreneurs, and purely aspirational entrepreneurs, rather than within the safety net of the corporation itself.

Partly as a result of growing open innovation practices and an unstable macroeconomic climate, the interviews pointed to the emergence of a phenomenon that can perhaps be best described as 'experimental entrepreneurship' (Lindholm-Dahlstrand et al, 2019). Fundamentally, more and more individuals were experimenting

with the idea of becoming entrepreneurs, especially technology entrepreneurs. This goes beyond the usual upturn in the numbers of self-employed workers during a financial crisis but appeared to have led to the emergence of ecosystems within cities that could become embedded and sustained. Indeed, these were our initial conclusions following the first set of interviews. Of course, the pandemic provides us with a context to analyse the extent to which such ecosystems have the endurance to meet the challenges stemming from such a large external shock.

The Adaptive Capacity of Ecosystems

In this context of this study, adaptability refers to the capability and capacity of a city's ecosystem to meet the challenges emerging from the pandemic (Mack and Mayer, 2016). Such adaptability is likely to rely on cities remaining an attractive location for entrepreneurial innovation especially in relation to the volume of technology-based entrepreneurs, the finance available to these entrepreneurs to fund innovation, and the availability of the networks required to foster open innovation and collaboration. As indicated by Table 3, the large majority of respondents to the online survey undertaken in 2021 consider that the attractiveness of their city would actually improve or, at a minimum, not suffer over the next five years. Only 15.5% of respondents forecast that there would be any reduction in the attractiveness of their city for technology-based entrepreneurship or the availability of finance for entrepreneurship and innovation, while a slightly higher percentage (26.1%) believed there would be some reduction in the attractiveness of their city as a location for open innovation and collaboration.

There are no clear or statistically significant differences in responses across cities, but London has a slightly higher percentage of respondents who consider that there may be some reduction in the attractiveness of the location for entrepreneurship and innovation. Although we did not explore the issue of Brexit in the questionnaire survey, the earlier round of interviews in London indicated that a reduction in the attractiveness of the city as a destination entrepreneurs and innovative activity as a result of Brexit was a concern for many stakeholders.

Table 3 About Here

In the context of entrepreneurial innovation ecosystems, adaptability relates to the manner in which entrepreneurs and innovative firms are capable of adjusting to significant changes in working conditions, especially the rapid growth in remote working. As also shown by Table 3, by far the majority of respondents consider that new forms of working will actually have either a beneficial impact or no negative impact on a number of factors. In particular, 82.3% of respondents suggest that new patterns of working will either improve or have no negative impacts on disruptive and radical innovation. Similarly, only 20.0% consider that there are likely to be negative impacts on more incremental innovation.

Alongside innovation, the capacity and capability to develop new markets for innovation is paramount to the success of ecosystems. Again, the majority of respondents do not see this area of activity suffering to any great extent, although a higher percentage (26.6%) suggest that this may have some negative impact. This is to be expected given that face-to-face interactions and the requirement for conveying tacit knowledge are acknowledged as being important features of markets for technology and innovation (Howells, 2002). Finally, the nurturing of skills and the development of new talent is obviously the lifeblood of innovation, with more than three-quarters (77.7%) of respondents believing that there will either be an improvement or no change on human capital development. This suggests that the rapid advances being made in digital learning and network systems appear to be providing adequate substitutes for face-to-face learning.

A major consideration regarding the future of urban ecosystems is the on-going nature of the institutional environment within which these ecosystems previously flourished (Mack and Mayer, 2016; Audretsch and Belitski, 2017; Audretsch et al., 2021). As already indicated, the hallmark of these urban ecosystems is the self-organisation that has arisen in cities as a result of the growth of entrepreneurially innovative environments such as co-working and incubator spaces, as well as the local availability of capital for innovation and the plethora of opportunities through networking events such as meet-ups and the like (Stam, 2015; Madaleno et al., 2021).

Table 3 indicates that although the majority of respondents consider that demand for innovation spaces and networks will either be unchanged or improve, there are also a significant proportion of respondents who anticipate some reduction in demand over the next five years. This is to be expected given that much remains unknown as to the probable balance between online and face-to-face interaction.

There are no discernible differences in responses across cities, with the exception being the number of respondents from London indicating a higher than average level of scepticism for demand, although this difference was not statistically significant. As can be anticipated, demand for both financial and human capital is largely expected to remain high or increased. Both paired t-tests and non-parametric rank Wilcoxon ranked signed tests indicate a statistically more positive perspective is held about the demand for finance than co-working space, incubator space and networking events, suggesting that the continuance of a strong flow venture capital is considered to be of paramount importance to maintaining the adaptive capacity of ecosystems.

Adaptability stemming from the pandemic across urban ecosystems is likely to be associated with firm-level strategic change (Nambisan et al., 2019; Cooper, 2021). Respondents were asked to assess strategic changes that are most likely to be the

focus of firms within their ecosystems over the next five years. As shown by Table 4, the majority of respondents indicated that most areas of business activity are likely to witness change, with the two areas seeing the most increased focus being a refocusing on new products/sectors with improved prospects (80.5% significant or slight increased focus) and a refocusing on core products/sectors (78.3% significant or slight increased focus).

A refocusing on both new and existing products and markets strongly indicates that firms within these ecosystems will be highly engaged in adaptability efforts as they seek to continue to innovate. This suggests that firms will develop new strategic plans, which is confirmed by the finding that 73.9% of respondents expect this area of activity to be a focus for most firms. New methods of working, and the need for creative solutions to meet new working and living conditions, indicate that there may need to be more adaptability in terms of the level of autonomy and independence given to staff. Almost three-quarters of respondents (71.7%) consider that this is likely to be an increased focus for firms within their ecosystems. Finally, a focus on cost cutting is considered to be the least likely focus of strategic change (52.2%), which implies that adaptability will be centred on attracting new investment rather than reducing running costs. In particular, paired t-tests and Wilcoxon paired tests indicate that respondents are significantly more likely to expect a reduced focus on cost cutting relative to that on longer term objectives associated with developing new strategic plans and seeking to refocus on new products/sectors with improved prospects.

Table 4 About Here

Urban Ecosystem Resilience

The findings presented above strongly suggest that entrepreneurial innovation ecosystems are showing, and will continue to show, considerable resilience in the global cities studied. In fact, it can be argued that some are actually flourishing further and building solidly upon their initial emergence. However, it is also important to address the resilience of cities as a whole in terms of rates of innovation and entrepreneurship, as well as economic competitiveness. Table 4 indicates that the majority of respondents consider that over the next five years rates of innovation will improve (60.9% of respondents) as well as rates of entrepreneurship (63.1%). This indicates that stakeholders generally believe that their cities will maintain an upward trajectory in terms of entrepreneurially-driven innovation. This general optimism is evidenced by a number of open comments as listed in Table 5 (column 2).

Table 5 About Here

The relatively high level of optimism towards entrepreneurial innovation can be somewhat tempered by the respondents' views on the broader future economic competitiveness of their city. As indicated by Table 4, less than one-half of all

respondents (41.3%) considered that the economic competitiveness of their city would improve over the next five years, with a further 39.1% indicating that economic competitiveness will fall. Both entrepreneurship and innovation are rated as showing significantly more resilience than overall competitiveness. This suggests that while entrepreneurship and innovation is expected to be relatively unharmed as a result of the pandemic, wider urban economies may not continue to grow in tandem. A number of respondents commented on this, with the view being that as new ways of working become normalised the density of people working in cities at any one time will be reduced. Inevitably, this is likely to have a negative impact on a number of areas of the urban economy especially in the service sectors. This is one of the minority of results where a significant difference was found between the ratings for any pair of cities with respondents from Shanghai more positive than those in New York regardless of using parametric (Tamhane t-test p-value 0.028) or non-parametric (Mann-Whitney U-test p-value = 0.007), perhaps reflecting a stronger manufacturing base.

Initial evidence suggests that the shock and restrictions associated with the COVID-19 Pandemic may have reduced broader innovative outputs as captured by patents as depicted in Figure 3. However, Figure 3 also indicates that patent applications have been in decline for a number of years in nations in which the cities are located with the exception of China. This indicates that innovation in these nations has already started to shift away from knowledge protection through patenting, as these economies continue to become increasingly service-based and whereby networked open source and open modes of innovation become central to achieving positive outcomes.

Figure 3 About Here

Finally, for urban resilience it is not only important that entrepreneurs adapt to the changing environment, but that this also manifests itself in an evolving entrepreneurial ecosystem (Mack and Mayer, 2016; Feld and Hathaway, 2020). As such, respondents were asked to rank a number of policy areas which they consider to be the most important for ensuring that their city remains a highly attractive and effective environment to engage in innovation. By far the most important area was considered to be 'access to finance', with 47.7% of respondents ranking it as their top priority, followed by 'education and skills development' (25.0% of respondents) and 'housing' (20.0%). 'Transport' (2.3%) and 'infrastructure for business' (4.8%) were considered to be the top priority by only one or two respondents. Interestingly, in the first round of interviews in 2018/19 transport and infrastructure featured far more prominently in discussions of policy intervention, now finance, skills and talent, and housing are clearly considered to be the focus for public policy (see Table 5 column 4).

The Spatial Distribution of Entrepreneurial Innovation and Networks

The initial interviews undertaken in 2018/19 indicated that many of the observations and trends relating to the now apparent resilience of ecosystems in these cities form

part of ongoing evolutionary processes that are reshaping these cities and their interconnections. Large and often global cities have become the hubs of innovation, having their own complex entrepreneurial innovation ecosystems based on a myriad of knowledge networks both within and beyond the city (Glaeser et al., 2021; Tavassoli et al., 2021). Many of these hubs have cemented their position as innovation hubs since the financial crisis of 2008 due to their greater ability to attract resources and capital. Coupled with the rapid development of these large urban innovation hubs, the first round of interviews found a complementary development to be the emergence of innovation 'satellite' cities and regions that are independent but connected with hubs. Therefore, the networks underpinning existing ecosystems were appearing to have become more spatially distributed.

Furthermore, the interviews indicated that while the deep circulation of actionable knowledge goes on within the city, the circulation of knowledge across cities tends to be more explorative and tentative. In the past these network patterns have been conceptualised in the form of 'local buzz' and 'global pipelines', representing the nature of local tacit exchange compared with the exchange of more explicit and codified knowledge across places (Bathelt et al., 2004). However, the interviews suggested that it is the interaction of actionable and explorative knowledge – rather than its tacit or codified nature - that determines the value of the more distributed ecosystems.

The survey results further suggest that more spatially distributed ecosystems are likely to continue to emerge. These more spatially distributed forms of open innovation are likely to be accelerated as a result of the outcomes of changes stemming from the pandemic. In particular, more than one-half of all respondents consider that new collaborations and relationships between ecosystem actors across cities within the same nation are likely to increase (56.9% of respondents) (Table 4). Furthermore, 55.5% of respondents expect there to be an increase in international collaboration and relationships across urban ecosystems.

No significant differences are found in the changing importance of local, national and international networks, but rather an expectation that all will grow in importance. If realised, this evolution will result in an increasingly globalised ecosystem through which innovation occurs. Alongside these more spatially distributed patterns of open innovation, the majority of respondents expect these to be complemented by an increased level of localised collaboration and relationships within particular urban ecosystems. This highlights the expected continuing importance of infrastructure and institutions such as co-working spaces and communities of support more broadly (Feld and Hathaway, 2020; Madaleno et al., 2021).

The StartupBlink data provides complementary evidence of the changing patterns of entrepreneurial innovation globally. Figure 4 illustrates changes in the distribution of

the top cities in terms of the startup ecosystem rankings between 2019 and 2021. In 2019 over three quarters of the cities were in national economies that could be defined as at the innovation-driven stage of development. By 2021 these developed economies still dominate, but they only contribute two thirds of the cities with the highest levels of entrepreneurial innovation. In general, all countries at other stages of development increased the percentage of the entrepreneurially innovative cities they hosted, but those in the efficiency-driven stage saw the largest increase from 10 percent of cities in 2019 to 16 percent of cities in 2021.

The analysis indicates that in recent years (2017 onwards) cities in Brazil (Belo Horizonte, Campinas, Florianopolis, Itajubá, Joao Pessoa, Juiz de Fora, Londrina, Maceio, Maringá, Natal, Recife, Ribeirao Preto, Rio de Janeiro, Santos, Sorocaba, Uberlandia, and Vitoria), Mexico (Cancun, Chihuahua, Colima, Culiacán, Hermosillo, Leon, Merida, and Puebla) and China (led by Beijing and Shanghai, but also including Xiamen, Hangzhou, Wuhan, Chengdu, Guangzhou and Zhuhai) have made significant gains in terms of establishing entrepreneurial ecosystems within an efficiency-driven national economy. Similarly, in terms of cities in factor-driven national economies, a host of cities in India (led by Mumbai, Bangalore and New Delhi, but also including Bari, Bhubaneswar, Vadodara, Lucknow and Thiruvananthapuram), the Ukraine (such as Dnepropetrovsk, Kharkiv, Odessa, and Donetsk – cities which since the onset of the conflict with Russia are likely to have suffered significant setbacks), as well as Dhaka (Bangladesh), Karachi (Pakistan) and Addis Ababa (Ethiopia) have seen rapid development in rates of innovation-led startups.

Among those nations transitioning from an efficiency-driven to an innovation-driven economy a number of cities in South America and Central and Eastern Europe are growing as centres for entrepreneurial innovation, in particular: Rosario and Cordoba in Argentina; Puerto Montt, Valparaiso and Concepcion in Chile; Pula, Rijeka and Dubrovnik in Croatia; Szeged and Debrecen in Hungary; Kaunas in Lithuania; and Brasov and Constanta in Romania. Finally, among cities in already innovation-driven nations it is largely smaller and second tier cities that are experiencing the most rapid growth such as: Fairfield, Marietta and Brookhaven in the United States; Hasselt in Belgium; Guimaraes, Portugal and Oviedo and Santander in Spain; Toulouse and Strasbourg in France; Bonn in Germany; and Kyoto, Osaka and Yokohama in Japan.

To specifically account for the pandemic period, Table 6 indicates those cities that have seen the biggest increase in their overall startup index score between 2019 and 2021. It initially highlights the continued rapid growth of a cohort of Chinese cities, as well as the growth of the case cities analysed in this paper and a number of other large and global cities. However, it further indicates the increasing growth of secondary locations for entrepreneurial innovation around the world, such as a host of US cities of vrious sizes as well as more provincial cities in Europe (including those mentioned above as

well as Valencia and Malaga in Spain, Gothenburg in Sweden and Leuven in Belgium). In summary, the key message from this analysis is that entrepreneurial innovation is becoming more spatially distributed not due to any particular spatial fixes in terms of switches in the location of related capital and resources, but largely due the global pie of capital devoted to such innovation continuing to grow via the new ecosystems that are emerging.

Table 6 About Here

In order to probe further into this phenomenon Table 7 indicates the types of places that respondents consider are most likely to become more attractive locations as nodes within more spatially distributed ecosystems. Small cities and towns in close proximity to larger cities are considered to be the most attractive (80.4% of respondents). This suggests that the spatial configuration of these ecosystem networks may take the form of a hub and spoke configuration, which to some extent is already the case with a large city such as London having strong existing innovation networks with Cambridge, Oxford and the Thames Valley. Berlin also has growing connectivity with second tier cities in relative close proximity such as Dresden, Leipzig and Potsdam. Indeed, medium-sized and second tier cities as a whole are considered to gain in the attractiveness (65.2%).

Rural locations are also viewed as growing in attractiveness (44.4%), which indicates that alternative working arrangements will lead to some entrepreneurs and innovators heading to alternative locations to live and work. Less likely to grow in attractiveness (32.7%) are small cities and towns not in close proximity to larger cities. Many of these places will be situated in relatively peripheral and economically lagging regions and locations outside of city regions and metropolitan areas. It is these places that are likely to face the biggest challenges in the post-pandemic environment, where limited scale means attempts to create local buzz may continue to be problematic (Capone et al., 2021), coupled with a lack of pre-existing connections to larger core cities and regions (Rodríguez-Pose and Fitjar, 2013). This is likely to result in a similar pattern of uneven development existing prior to the crisis (Florida et al., 2021). It is interesting to note that respondents in Tokyo and Shanghai differed significantly in their perceptions of more peripheral areas (rural areas and less connected small cities and towns), with those from the former being more positive than those in the latter (Tamhane t-test p-value = 0.036), perhaps reflecting the continued fast rates of urbanization across China as whole.

Finally, it should be noted that 37.8% of respondents suggest that large and global cities will become slightly less attractive as locations for entrepreneurship and innovation. Reflecting these expectations, responses relating to changes in the attractiveness of global cities are found to be statistically significantly more negative compared to those for second-tier cities and small cities in close proximities to

large urban centres. This makes intuitive sense given that some actors are likely to move to 'spoke' locations and second tier cities. However, the overall findings indicate that rather than there being a zero-sum movement of agents, over time there is likely to be an aggregate increase in the number of agents engaged in entrepreneurial innovation.

Table 7 About Here

Conclusions

This paper has sought to examine the future of innovation in cities, especially in light of the crisis brought upon by the COVID-19 pandemic. It has taken an entrepreneurial ecosystem perspective to consider the extent to which innovative agents in cities have the adaptability to remain resilient in the face of crisis. It has suggested that cities have become bases for innovation driven by entrepreneurship partly as a result of the outcomes from the 2008 financial crisis. This entrepreneurial innovation has been facilitated through the emergence of ecosystems that were initially associated with large cities but have now become more pervasive across a much wider range of city types. The analysis initially focused on six global cities across North America, Europe and Asia and the empirical evidence forecasts that not only do their ecosystems possess the adaptability and resilience to survive, but in some ways they will thrive as the requirement for new technological solutions and applications allows them to maintain their innovative capacity and capability. This analysis is complemented by a broader quantitative analysis of changes in cities across the world. The quantitative analysis confirms the likely resilience of innovation and entrepreneurship in large cities, but also highlights the growth of entrepreneurial innovation in smaller and second tier cities.

In conclusion, the analysis presented in this paper points to the continued evolution of the economic geography of innovation and entrepreneurship across the globe. In recent years, innovation has become an endeavour that is increasingly focused on startup ventures financed through external sources and coordinated through ecosystems that provide support through networks and open channels of communication between these startups, large corporates, venture capitalists and a host of other relevant stakeholders and ecosystem members. As this paper has shown, these actors, networks and ecosystems have increasingly coalesced in urban environments. Such changes in behaviour can potentially be curtailed and altered to new trajectories by a shock such as the COVID-19 pandemic and the obvious fers to health and well-being. Therefore, urban entrepreneurial ecosystems and urban innovation economies may have an inherent vulnerability and fragility in light of such fears. However, the evidence stemming from this study suggests that urban locations, especially large cities, have shown significant resilience and adaptive capacity during and after the pandemic.

In many ways, this period has seen the continuance of trends in the geography of innovation and entrepreneurship that were already occurring prior to the pandemic. New ecosystems are becoming increasingly forged across cities of different sizes leading to more distributed and diffused spatial patterns of innovation. This is impacting upon the spatial economics of innovation, with different types of location taking different roles in the urban innovation network hierarchy. Global cities are the hubs of these distributed networks and remain at the apex of this hierarchy, but second tier cities- especially those within city region configurations – are becoming increasingly active as innovation satellite locations. The evidence presented here suggests that the pandemic is likely to heighten rather that slow down these trends. As the global innovation economy expands and entrepreneurial activity is likely to form a larger slice of this economy, these trends are set to continue until any new unforeseen global shock with the capacity to destabilise such patterns occurs.

From a policy perspective, system shocks such as the pandemic are difficult to plan for, but it is clear that urban resilience, at least in the area of innovation, are correlated with the underlying strength of the hard and soft infrastructure of the economy. Those cities that have already developed significant co-working spaces, incubator spaces, finance for entrepreneurship and innovation and network resources are naturally more likely to have displayed greater resilience during the pandemic and even thrive in the period following it. These features are the ingredients that, along with human capital in the form of skills and talent, make up the recipes for successful and robust development at this time in economic history. Therefore, urban and regional policymakers should seek to ensure they have these in their armoury, not only as a defence to shocks to their economic systems, but more generally to enable their cities and regions to become opportunity spaces for the entrepreneurial innovation that generates economic development.

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Table 1: Interviewees and Survey Responses (in parentheses) by City and Interviewee/Respondent Type

City	Private Sector	Government/Public Sector	University	Total
Berlin	24 (5)	3 (1)	1 (0)	28 (6)
London	17 (6)	1 (1)	3 (1)	21 (8)
Los Angeles	10 (3)	4 (1)	1 (1)	15 (5)
New York City	14 (6)	4 (1)	3 (1)	21 (8)
Shanghai	8 (6)	8 (5)	1 (1)	17 (12)
Tokyo	19 (4)	7 (1)	4 (2)	30 (7)
Total	92 (30)	27 (10)	13 (6)	132 (46)
Percentage of Total	69.7% (65.2%)	20.5% (21.7%)	9.8% (13.0%)	100.0% (100.0%)

Table 2: Characteristics of the Case Study Cities

City	Berlin	London	Los Angeles	New York	Shanghai	Tokyo
Country	Germany	UK	USA	USA	China	Japan
Area	17,456	6,977	83,882	23,880	6,340	11,329
Population (000s)	5,343	12,451	17,788	19,785	24,240	36,231
Population Density (people per square km)	306	1,785	212	829	2,946	3,198
GVA ($ millions PPP 2015)	237,965	834,205	1,161,342	1,775,382	748,733	1,761,815
Employment Rate (% of working age population)[a]	75.5	76.3	72.4	74.9	74.7	76.9
Agriculture	0.0	0.0	0.1	2.0	0.1	0.6
Manufacturing	5.9	2.2	5.5	2.9	20.2	11.6
Construction	4.3	3.4	3.3	3.4	4.4	6.1
Distribution, Transport and Accommodation,	20.6	24.6	31.0	29.1	25.4	28.1
Information and Communication	5.8	7.7	3.0	3.5	6.9	9.0
Finance and Insurance	2.0	7.6	6.7	7.5	4.6	3.8
Real Estate	2.2	2.6	2.6	3.1	4.4	2.6
Professional and Scientific	19.7	23.6	22.7	22.5	15.6	5.5
Public Administration	28.9	25.8	25.6	28.7	16.1	23.7
Other Services	9.7	2.3	2.0	2.3	1.7	7.5
Patents (per million population)[b]	174.8	98.2	379.9	127.5	87.1	640.1
R&D Spending (% of GDP)[c]	3.4	1.2	4.8	1.5	3.9	3.5

Notes: Data extracted from OECD Statistics Regions and Cities theme (https://stats.oecd.org/) except where noted; The latest available data is presented for each city and measure; [a.] Employment data for Los Angeles and New York obtained from US Bureau of Labor Statistics (https://www.bls.gov/), London data obtained from NOMIS (https://www.nomisweb.co.uk/), Shanghai data draw from the China Statistical Yearbook (http://www.stats.gov.cn/tjsj/ndsj/2021/indexeh.htm), Tokyo data from Statistics Bureau of Japan (https://www.stat.go.jp/english/index.html); [b.] Patents data for Los Angeles and New York relate to the states of California and New York, Tokyo data relates to the Southern-Kanto region; [c.] R&D spending for Tokyo refers to Japan as a whole.

Table 3: Forecast Impact of the Covid-19 Pandemic on the Case Study Cities Based on the Survey Responses

	Significantly Reduced	Slightly Reduced	No Change	Slightly Improved	Significantly Improved
Attractiveness of the City as a Location for Entrepreneurship, Finance and Innovation over the Next Five Years					
Technology-based entrepreneurship	2.2%	13.3%	31.1%	44.4%	8.9%
Finance for entrepreneurship and innovation	2.2%	13.3%	31.1%	37.8%	15.6%
Open innovation and collaboration	2.2%	23.9%	17.4%	47.8%	8.7%
New Patterns of Working on Innovation, Markets and Talent over the Longer-Term					
Disruptive/Radical Innovation	2.2%	15.6%	35.6%	35.6%	11.1%
Incremental Innovation	4.4%	15.6%	28.9%	35.6%	15.6%
Developing New Markets	2.2%	24.4%	11.1%	46.7%	15.6%
Developing New Talent	6.7%	15.6%	24.4%	42.2%	11.1%
Demand for Hard and Soft Entrepreneurial Infrastructure over the Next Five Years					
Co-working spaces [a]	10.9%	30.4%	13.0%	30.4%	15.2%
Incubator space [b]	6.7%	26.7%	22.2%	40.0%	4.4%
Finance for entrepreneurship and innovation [a, b, c]	2.2%	8.7%	37.0%	37.0%	15.2%
Networks and networking events [c]	6.5%	34.8%	21.7%	26.1%	10.9%
Human capital, skills and talent	4.4%	15.2%	39.1%	28.3%	13.0%

Note: Wilcoxon Paired Tests indicate a significant difference in [a] demand for Co-working spaces and Finance for entrepreneurship and innovation (Z = -2.276, p-value 0.023); [b] demand for Incubator space and Finance for entrepreneurship and innovation (Z = -3.027, p-value 0.002); [c] demand for Networks & networking events and Finance for entrepreneurship and innovation (Z = -3.494, p-value 0.000).

Table 4: Forecast Changes in the Strategic Focus, Outcomes and the Spatial Distribution of Innovation Based on the Survey Responses

	Significantly Reduced Focus	Slightly Reduced Focus	No Change in Focus	Slightly Increased Focus	Significantly Increased Focus
Strategic Focus for Innovative Businesses over the Next Five Years					
Cutting costs for short term survival [a, b]	2.2%	10.9%	34.8%	43.5%	8.7%
Development of new strategic plans [a]	2.2%	8.7%	15.2%	39.1%	34.8%
Refocusing on new products/sectors with improved prospects [b]	0.0%	4.4%	15.2%	60.9%	19.6%
Refocusing on core products/sectors	0.0%	4.4%	37.0%	41.3%	17.4%
Autonomy given to staff to adapt to new demands	4.4%	8.7%	15.2%	47.8%	23.9%
Impact of the Covid-19 Pandemic on Innovation, Entrepreneurship and Economic Competitiveness over the Next Five Years					
Rates of innovation [c]	4.4%	21.7%	13.0%	43.5%	17.4%
Rates of entrepreneurship [d]	6.5%	17.4%	13.0%	43.5%	19.6%
Economic competitiveness [c, d]	6.5%	32.6%	19.6%	30.4%	10.9%
New Patterns of Working on the Spatial Distribution of Innovation Collaborations and Relationships over the Longer-Term					
New local (same city) collaborations and relationships	6.7%	11.1%	28.9%	42.2%	11.1%
New national (same country different city) collaborations and relationships	4.6%	9.1%	29.6%	36.4%	20.5%
New global (different country) collaborations and relationships	6.7%	6.7%	31.1%	33.3%	22.2%

Note: Wilcoxon Paired Tests indicates a significant difference in expected focus on [a] Cutting costs and Development of strategic plans (Z = -3.133, p-value 0.002); and expected focus on [b] Cutting costs and Refocusing on new products/sectors (Z = -2.845, p-value 0.004); as well as well as significant differences in impact on [c] Rates of innovation and economic competitiveness (Z = -2.405, p-value 0.016); and differences in impact on [d] Rates of entrepreneurship and economic competitiveness (Z = -2.493, p-value 0.013).

Table 5: Indicative Open Ended Comments on Resilience and Future Policy Priorities

Respondent by City	Indicative Comments on Resilience	Respondent by City	Indicative Comments on Future Policy Priorities
Respondent from Tokyo	"I see positive changes in the city. More and more people feel the necessity for innovative changes and becoming acceptable of an entrepreneurial approach, which does not necessarily require established results or brand."	Respondent from Tokyo	"Financial systems including loan, investment, and others are the key for all start-ups."
Respondent from Shanghai	"In Shanghai everything has recovered as to what it looks like before the pandemic, so I'm super optimistic about innovative activities."	Respondent from Shanghai	"Finance is always the most important incentive for business in hard times."
Respondent from Berlin	"Some industrial innovation in cities like Munich slowed down when the pandemic hit but tech based innovation seemed steady and then picked up even more speed."	Respondent from London	"Finance and skills are key."
Respondent from New York	"I think NYC will continue to flourish, however the issue of equity and accessibility will continue to serve as a reminder of the divide between the haves and have nots."	Respondent from Berlin	"The more expensive a city gets the more difficult it is to have innovative businesses with international talent."
Respondent from London	"I remain optimistic as to London's resilience as a hub for tech entrepreneurship, principally due to the infrastructure, and existing agglomeration economies that exist across and within the city."	Respondent from Berlin	"The main advantage of Berlin over London and Paris has been the low cost of living and general attractiveness of the area for young people. We are about to lose this advantage because of rising prices for housing."
Respondent from Los Angeles	"The LA area seems to have handled the pandemic well and is emerging more quickly than other parts of the world."	Respondent from Los Angeles	"Housing is by far number one, especially the cost of housing in the suburbs. Young people can't afford to live there."

Table 6: Leading Positive Changes in the Startup Performance of Cities 2019-2021

City	2019-2021 Percentage Change in Startup Index	Startup Index Score 2021	Startup Index Rank 2021
Beijing, China	334.3	66.05	3
Bonn, Germany	310.8	3.41	161
Xiamen, China	283.2	3.87	151
Shanghai, China	237.6	42.16	7
Hangzhou, China	165.0	13.17	33
Wuhan, China	141.5	2.97	174
New York, United States	98.0	110.78	2
Washington DC Area, United States	78.1	18.06	19
Kyoto, Japan	74.7	4.63	124
Guangzhou, China	74.0	6.89	65
Los Angeles Area, United States	70.8	58.44	4
Abu Dhabi, United Arab Emirates	70.6	3.19	169
Shenzhen, China	67.0	17.4	21
Osaka, Japan	58.9	4.56	128
Paris, France	52.0	25.3	11
Mumbai, India	50.5	19.41	16
Bangalore, India	48.6	25.37	10
London, United Kingdom	48.1	56.91	5
New Delhi, India	47.5	22.38	14
Boston Area, United States	46.8	49.84	6
Moscow, Russia	45.1	25.4	9
The Hague, The Netherlands	43.7	4.64	123
Toulouse, France	40.0	4.48	132
Tokyo, Japan	38.3	21.79	15
Seattle, United States	34.3	24.33	12
Seoul, South Korea	31.9	16.68	23
Singapore City, Singapore	29.4	15.71	25
San Diego, United States	26.1	17.27	22
Valencia, Spain	26.0	4.02	146
San Francisco, United States	25.1	329.0	1
Malaga, Spain	23.2	1.01	293
Zug, Switzerland	22.9	3.27	166
Philadelphia, United States	22.8	13.11	35
Denver, United States	22.1	13.55	30
Sao Paulo, Brazil	21.5	17.64	20
Minneapolis, United States	16.5	10.22	43
Gothenburg, Sweden	15.4	3.08	171

Source: Based on analysis of the Startup Blink datasets

Table 6 continued

City	2019-2021 Percentage Change in Startup Index	Startup Index Score 2021	Startup Index Rank 2021
Austin, United States	14.5	18.6	18
Munich, Germany	13.3	11.77	38
Tel Aviv Area, Israel	13.1	27.08	8
Stockholm, Sweden	11.6	15.75	24
Berlin, Germany	6.9	23.87	13
Dallas-Fort Worth, United States	6.4	15.54	27
Leuven, Belgium	6.1	0.87	311
Chicago, United States	3.9	19.12	17
Raleigh Durham, United States	3.4	10.47	40
Atlanta, United States	3.0	15.11	28
Leipzig, Germany	1.3	3.23	167
Franklin, United States	1.2	0.85	317

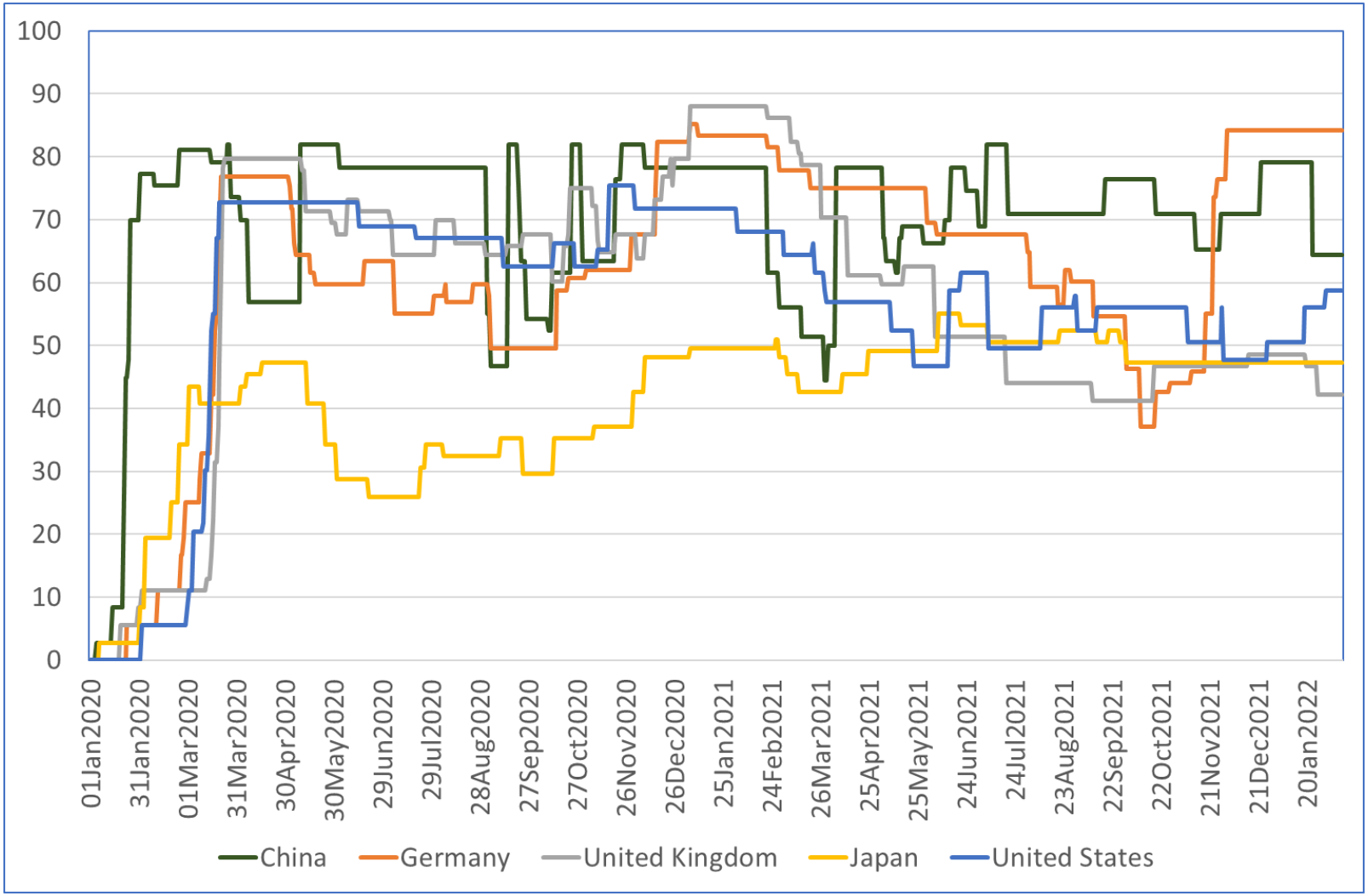
Source: Based on analysis of the Startup Blink datasets

Table 7: Forecast Changes in the Attractiveness of Location Types as Places to Engage in Innovation and Entrepreneurship over the Longer-Term

	Significantly Less Attractive	Slightly Less Attractive	No Change	Slightly More Attractive	Significantly More Attractive
Large/global cities [a, b]	2.2%	37.8%	37.8%	8.9%	13.3%
Medium-sized/second tier cities [a, c]	2.2%	13.0%	19.6%	50.0%	15.2%
Small cities and towns in close proximity to larger cities [b, d, e]	0.0%	6.5%	13.0%	63.0%	17.4%
Small cities and towns NOT in close proximity to larger cities [c, d]	6.5%	26.1%	34.8%	28.3%	4.4%
Rural locations [e]	13.3%	8.9%	33.3%	40.0%	4.4%

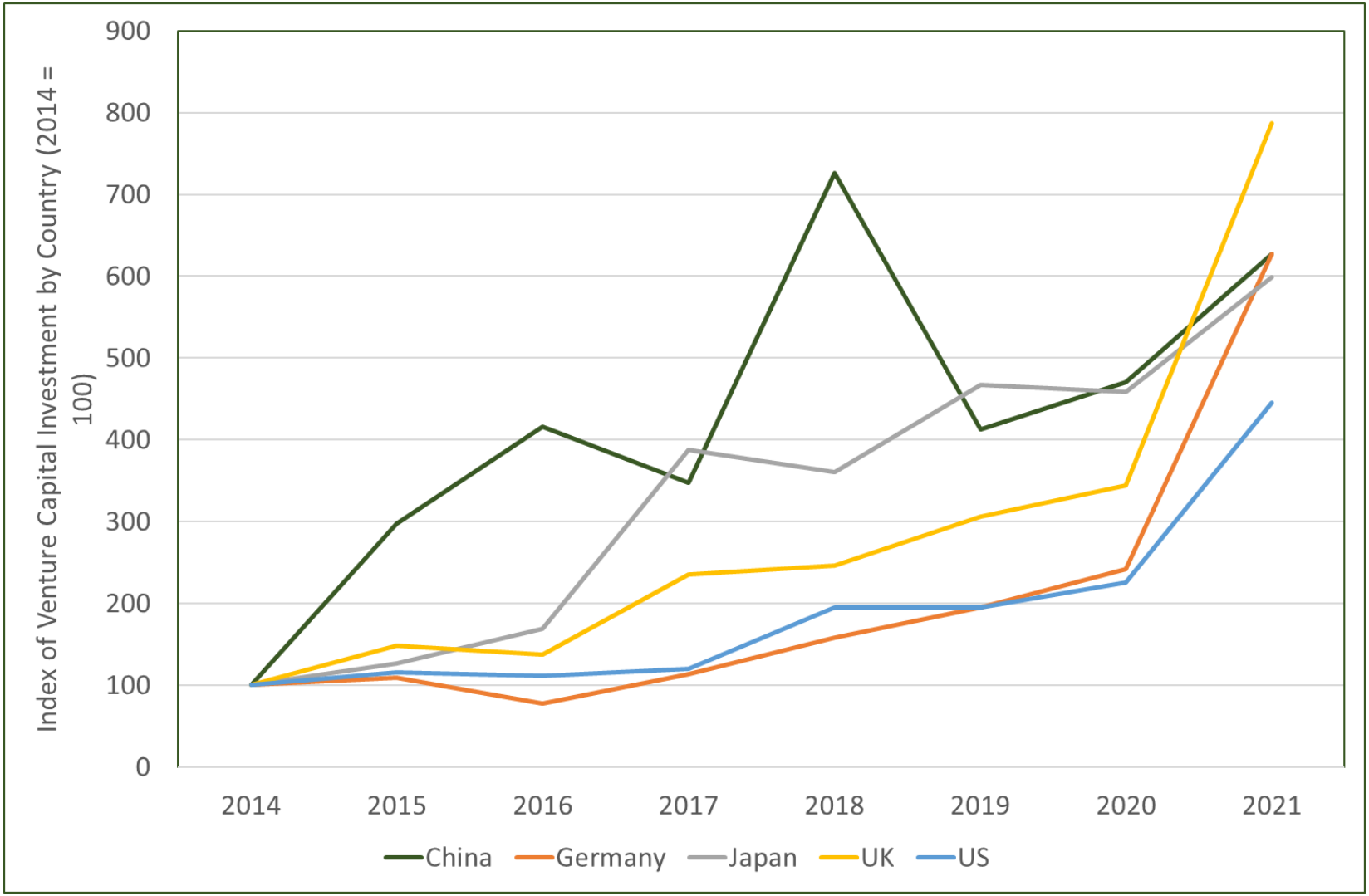
Note: Wilcoxon Paired Tests indicates a significant differences in: [a] attractiveness of Large/Global cities and Medium-sized/Second tier cities (Z = -2.405, p-value 0.016); [b] attractiveness of Large/Global cities and Small cities in close proximity to large cities (Z = -3.450, p-value 0.001); [c] attractiveness of Medium-Sized/Second-tier cities and Small cities not in close proximity to large cities (Z = -2.744, p-value 0.006); [d] attractiveness of Small cities not in close proximity to large cities and Small cities in close proximity to large cities (Z = -4.174, p-value 0.000); [e] attractiveness of Rural locations and Small cities in close proximity to large cities (Z = -3.590, p-value 0.000).

Figure 1: Stringency of Restrictions Imposed by Governments



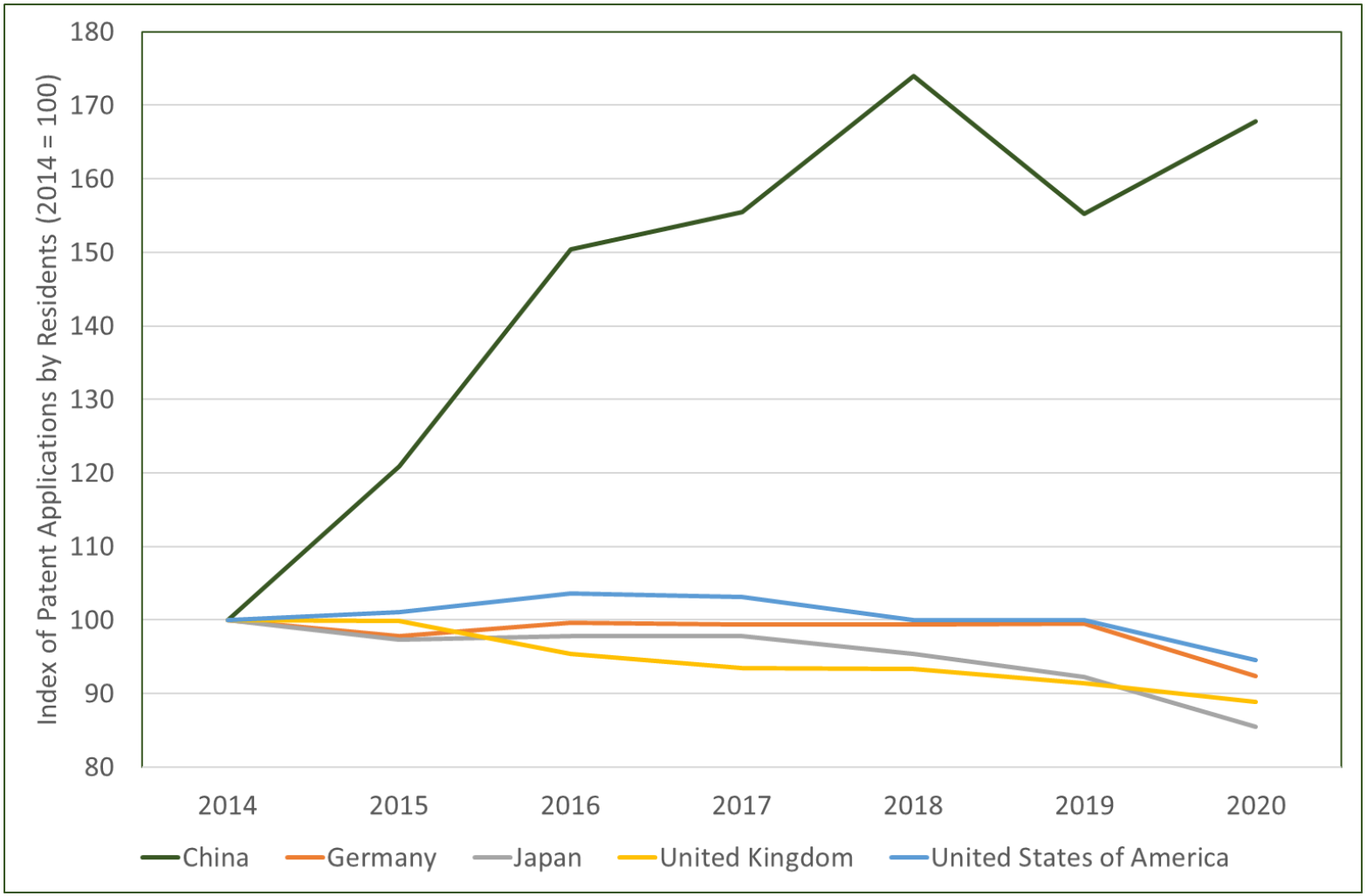
Data Source: Oxford COVID-19 Government Response Tracker (Hale et al., 2021)

Figure 2: Value of Venture Capital Investments



Data sources: KPMG (2021)

Figure 3: Number of Patents Registered by Residents



Data Sources: World Intellectual Property Organization (WIPO) statistics database

Figure 4: Location of Entrepreneurial Innovative Cities by Stage of Development