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3

Innovative Places and Regions: Implications for Technology Management

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Abstract

This chapter explores the growing evidence that cities are the nurseries for new innovation. This is anchored in a brief review of innovation theory, focusing on the literature on agglomeration, spillovers and externality. The implications of this literature are that it is increasingly important for economic competitiveness to have attractive and well-designed places. The implications of this for technology management are explored with four specific areas of concern including industrial policy, urban planning, infrastructure development and regional innovation. The chapter concludes with a discussion of data-based, place-based and technology-based strategies for researchers, companies and the public sector. The chapter concludes with an agenda for technology management that includes privacy, geospatial data and further exploration of information and computing technology as a complement for place-based strategies.

Keywords: Technology Management, Innovation Management, Cities, Regions, Regional Innovation Systems, Agglomeration Economies, Spill-Overs, Industrial Sectors, Skilled Labour, Spatial Equilibrium, Patents, Place-Based Strategy, Creative Economy

3.1 Introduction

Cities require effective engineering management and effective technology management. There are three reasons. Creating liveable, dense urban spaces is in itself a major engineering challenge. Cities are increasingly the home for the majority of the world's population. Decisions made for and behalf of cities have a major impact on human welfare and the environment. Cities are the wellspring of new technologies. Anyone interested in employment and economic development will be primarily interested in cities and their regions. Anyone interested in new technologies will be correspondingly interested in cities since they are the premier source for generating economic and technological complexity. This is increasingly valued in the world economy.

Engineering and technology managers will have a corresponding interest in cities. They will be interested in the needs and requirements of urban residents, since cities showcase many of the demanding requirements for the design, deployment and maintenance of complex infrastructures. Cities are also a primary source of the platform economy, and are propagating new trends in servitization. Many engineering and technology managers are themselves planners, managers and administrators for the world's cities. They will be interested in decision-making for urban networks and the creation of resilient networked infrastructure. Urban managers will be concerned with the challenges and opportunities of the smart city, enabled by affordable sensors, cheap data, and ubiquitous sensing platforms. Technology managers are also interested in fostering new technology, including taking advantage of externalities and spillovers. This may also entail choosing high opportunity homes for research and development laboratories, and entrepot for marketing new technologies.

There are many distinct issues therefore to address even in a survey chapter on urban technology management. The approach of the chapter is therefore as follows. The chapter begins with a broad theoretical overview of how and why cities create innovation and variety. It then turns to specific areas of urban and technological concerns. The final part of the chapter discusses place-based strategies.

3.2 Innovation Theory

There is a growing body of literature which describes cities as “innovation machines,” as “laboratories for innovation” or even as “social reactors” (Bettencourt et al. 2007, Batty et al. 2012, Florida et al. 2017). Cities foster diversity, and enable the recombination of new ideas. This in turn leads to innovation, employment and growth (Feldman and Audretsch 1999, Scott and Storper 2003, Glaeser et al. 2010, Duranton and Puga 2014). This literature or urban innovation is well-rooted in innovation theory (Marx 1867/2012, Marshall 1920). Schumpeter argues that the firm is the ultimate locus of new ideas, although he himself doubted whether small firm innovation or large firm innovation represented the most significant transformative force (Schumpeter 1934a, Schumpeter 1934b). Conversely, it is Jacobs (1969) who first rooted the locus of innovation primarily within the city rather than the firm.

The exact nature of these agglomerative benefits has been subject to some debate. The classic Marshallian view is that cities permit greater specialization of labour. This is contrasted with the Jacobian view that it is a diverse base of skill which matters most. The empirical evidence has been largely supportive of Jacobs. A similar consideration concerns whether greater spillovers are created as a matter of scale, or of density. It appears that a mix of both scale and density is likely responsible for the resultant economic benefit.

The political economy of urban innovation has been subject to considerable debate. Schumpeter credits an elite class of inventor and innovator with the wherewithal to unleash “creative destruction.” Newer theories argue that smaller, urban elite are responsible for driving economic and innovative growth (Cooke et al. 1997). These parties create the opportunities for growth by attracting funding and championing specific locales. Jacobs presents a much more pluralistic view, arguing that the variety and abundance of skills and services drives opportunity, rather than any one particular group or actor in specific. In fact, Jacobs was particularly sceptical about the entrenched leadership of her own city at the time. Florida's ideas of the creative economy (Florida et al. 2017) may represent a balance between the elite theories of urban regime, and Jacobs own highly pluralistic account of the city.

The processes which actually underlie urban agglomeration and knowledge spillover remain murky. It is possible that these are entirely human processes which are rooted in the evolutionary economic ideas of tacit knowledge and routines. Likewise the prescriptive recommendations for designing innovative cities remain obscure. A secondary literature argues that dense urban districts enable fortuitous interactions leading to enhanced creativity, innovation and growth. Prescriptions include creating urban districts that encourage mixing and chance encounters by the population. Likewise it seems clear that many cities are falling short because of a poor spatial match between employers and labour. Poor transport systems impose negative externalities on the city, and reduce the economic productivity of a region.

3.3 Specific Areas of Concern

This section addresses four specific concerns of the innovative city, where engineering and technology management have a particular role to play. The first of these areas is industrial policy. Here technology management is needed to create a long-term vision for industrial growth. The second area of concern is urban planning and administration. Here technology managers better support decision-making with new data, new models and new urban dashboards. Both these areas are of international concern. The third of these aforementioned mentioned areas of concern is in the area of urban infrastructure. Here technology management provides capabilities in project management and risk management. The final area of concern is in the space of urban innovation. Here the disciplines of scientometrics and tech mining enable the matching of technological production with engineering expertise. This matching is to the benefit of companies and regions alike.

3.3.1 Industrial Policy

Many nations are concerned with increasing economic performance and decreasing regional disparities through targeted policy efforts. There is a significant discrepancy in the capacity of regions to grow and sustain jobs and employment. Although regional specialization enables city regions to standout in a competitive international market, specialization also exposes city regions to significant downside once core industries diminish and decline. There are also significant structural differences between regions. The processes which enrich some regions may well drive away and diminish opportunities from surrounding regions. These differences persist and even grow over time, resulting in significant inequality for regions and inhabitants.

Industrial policies necessitate a range of specialized skills in technology management. This includes specialized policy analysis, the development of capability building exercises and the creation of venues which support policy learning in cities and regions (Department for Transport 2019, House of Commons Library 2020b). These are all areas of continued growth and opportunity for practitioners of technology management.

3.3.2 Urban Planning and Participation

The specific research question asks why there are substantial, geographical differences in the capability of urban regions to grow and sustain employment. Cities are called "social reactors" for a reason. Nonetheless, the structural elements of urban regions which encourage individual interaction warrant further investigation.

A network of urban decision-makers, at multiple levels, can benefit from an urban facing approach to technology management. For example, technology managers can support urban decision-making. Supporting effective decision-making means working closely with regional planning associations. Participants in these associations include participants from the public as well as the private sector. Public sector participants include city councils and enterprise companies. Public sector cooperation requires cooperation across city regions as well. Private sector participants include real estate developers as well as the chamber of commerce.

Cities learn policies from one another, particularly by copying cities which are larger or proximate (Shipan and Volden 2008). City governments are increasingly forming world-wide networks for cooperation and competition (Scott 2006). There are new actors in the governance system, as well as new technologies of governance (Swyngedouw 2005).

The planning process benefits from a collaborative process (Innes and Booher 1999). Community-based participatory research can help to address environmental and socio-spatial injustices (Ponzini and Rossi 2010, Wallerstein and Duran 2010, Wolch et al. 2014). Software supporting increased urban efficiency can enable public discussion to better focus on questions of equity (Heath 2020). Inclusive growth requires its own unique processes of planning (Visvizi et al. 2018)

The policy instruments available for enhancing growth are distributed across multiple actors and stakeholders (Cooke et al. 1997). Decision-support systems can enhance cooperation and coordination over complex decisions of land use and infrastructure investment. Technology management perspectives, such as roadmapping, can be used to benchmark local opportunities as well as to highlight specific interventions and growth opportunities. Proven patterns of growth and opportunity may then be overlaid on areas of urban interest. Roadmaps can be used for facilitating difficult discussions about equitable solutions for urban and economic growth by examining the distributional effects of regional plans.

An explicit strategy to facilitate decision-making using group-support systems and stakeholder engagement meetings is also possible. Existing urban districts can thereby be categorized and templated, and over- and under-performing regions in technology and innovation can thereby be identified. The research will produce a decision-support system for planners using these templates where a range of local "what-if" design scenarios can be proposed and tested. These digital planning efforts are part of an extended effort to create "smart cities." Some of this data-driven work enables and supports activities at the small-scale activities and processes (Visvizi and Lytras 2018). Smart city and decision-support system may in the future be supported by open-source libraries in R and Python which can be customized and replicated by other cities.

3.3.3 Urban Infrastructure

Technology managers can help address significant policy challenge through the empirical survey and analysis of infrastructural assets of cities and regions in their home nations and abroad. A significant part of the fixed factors of production that drives urban and regional capability includes installed infrastructure. Infrastructure increases the proximity of economic actors in the region. Enhanced proximity created through transport capacity enables more matches in the market for goods, services, skills and labour.

A significant class of technology policies pursue economic growth through improved physical and environmental infrastructure. There are few research exemplars of this infrastructure-led approach, despite the clear theoretical need for such explanations (Ahlfeldt and Wendland 2013, Knowles and Ferbrache 2016, Goswami and Lall 2019, Proost and Thisse 2019, Heider and Siedentop 2020). This need presents a research gap that can be addressed by using emerging sources of geospatial data concerning land use and infrastructure networks (Porta et al. 2006, Barthelemy 2011, Florida et al. 2012, Blondel et al. 2015, Thakuriah et al. 2018, Boeing 2020, Duranton and Puga 2020). Evidence-based approaches may also help to address the apparent shortcomings of public sector allocation of resources and infrastructure (Glaeser 1998). These are all significant areas for involvement by technology management researchers and scholars.

Despite the prerogative to invest in urban centres, not all infrastructural investments are equally effective. The policy processes that endow regions can and should be tested using extensive empirical evidence provided using big data approach. Plentiful existing data sources should be compiled and synthesized. Increasing resolution of data means that features at the block level of the city can be incorporated into simulation models or digital twins. These comprehensive inventories of urban assets can be used in a substantive manner for a variety of further analyses.

3.3.4 Urban Innovation

If, as suggested by the literature, cities are a primary locus of innovative activity, much more attention is needed in identifying favourable patterns of growth and development. Some of the work in this area involves modelling technological emergence. The theoretical framework acknowledges there are multiple causes of economic growth and innovation in cities. The multiple causes include the available factors of production, spatial organization, industrial organization, human factors and policy inputs. These multiple causes are explored in the literature both separately and in tandem. This suggests the extensive challenge facing innovation analysts.

Given the complexity of the problem much more work is needed in examining factors of production as well as in apprehending the spatial organization of the city. Nonetheless, elements of industrial organization cannot be neglected, since cities characterized by large firms and monopolies will perform very differently than a city composed of multiple small start-ups. Policy processes are a complicating factor. Policy processes may be conceived of as a mediating variable between urban structure and innovative performance.

This spatial turn in innovation demands new styles of analysis. This research method is based on techniques first innovated in the field of image processing. There are a number of surprising and significant parallels between images and urban data stored in a raster. These techniques enable the robust recovery of urban patterns in the presence of noise. The potential for these techniques in urban geography and regional innovation remains underexplored. The underlying models are not causal, and nor do they need to be to identify the output and operation of complex urban processes.

In particular a family of methods known as graphical modelling seems particularly valuable (Jordan et al. 1999, Roweis and Ghahramani 1999, Kschischang et al. 2001, Koller and Friedman 2009, Grace et al. 2012, Nickel et al. 2016). Despite the innocuous name, the field of graphical modelling sits aside two major traditions of machine learning (Domingos 2015). One of the two traditions is connectionism (and therefore neural network related), and uses graph theory as a formalism (Barthelemy 2011, LeCun et al. 2015, Szegedy et al. 2015). The other tradition uses Bayesian reasoning and probabilistic programming, and therefore makes use of probability as a formalism (Ghahramani 2015, Carpenter et al. 2017). Graphs are directed or undirected in character; both formalisms have their merits for modelling and analysing systems.

A highly customizable, undirected graph model known as a Markov random field seems increasingly applicable to innovation studies in the city (Cross and Jain 1983, Besag and Green 1993, Pal and Pal 1993, Roth and Black 2009). Markov random fields have been previously used as a method for reducing noise in data, downscaling the data to add credible detail and imputing missing data. Such models have even been used for the complete synthesis of new examples (Geman and Geman 1984, Besag 1986, Wang and Tang 2009, Li et al. 2016). This makes the approach highly suitable for urban data where data is noisy and complete, and where supporting human creativity is a requirement (Candy 1997, Wang and Nickerson 2017). These models have seen rich applications in image processing (Geman and Geman 1984, Besag 1986, Wang and Tang 2009) and yet remain comparatively novel in the fields of urban science and economic geography (Karantzalos 2015, Kuffer et al. 2016). Nonetheless, a model is used widely in policy-relevant research and spatial analysis (Jin et al. 2005, Sain and Cressie 2007, Sain et al. 2011).

3.4 Place-Based Strategies

This section has touched upon the importance of urban data in multiple domains. Urban data plays a role in planning infrastructure management, and in analysing urban innovation. The variety of data-smart city approaches are a testament to the increasing empirical base of the field. In the following and final section, two aspects of technology strategy are considered – a place-based approach and a technology-based approach. Prior to both, it is useful to further discuss urban and spatial data analysis, and its relationship to the practice of technology management. The section therefore discusses strategies in three distinct manners, including a strategy for the appropriate use of technological data.

3.4.1 Data-Driven Strategies

Four sources of data are particularly interesting for innovation analysts up to the challenge of exploring the geography of new technologies. Open geographical may be used to characterize the local urban fabric. Critical elements of this fabric, including access to transport networks and features of urban land use, are of particular relevance. Specific land use elements of interest include the number and density of buildings, the presence of public services, and the presence of urban parks and green space. A company should be used to examine the sectoral structure, employment characteristics and industrial organization of local firms. Financial data regarding the purchase and investment can be used to reveal the opportunity value of the land. Finally, and only once these variety of urban features have been considered, can innovative activities be considered. Patents may be used as a proxy for innovative capability and routinized production.

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The data types selected for further analysis are well-founded in urban theory. Property values are a strong indicator of alternative and competing uses for urban space (Anas et al. 1998, Bettencourt 2013, Kim and Park 2019). Transport networks at the local and regional scales are crucial for urban mixing (Holl 2004, Bettencourt 2013). Urban green space is associated with high-value land, and an important component of desirable urban density and the operation of the urban nexus (Tyrvainen 1997, Tyrvainen and Miettinen 2000, Kong et al. 2007, Landry and Chakraborty 2009, Scott and Storper 2015). Patents are a critical component of understanding urban innovation (Aghion and Howitt 1992, Almeida and Kogut 1999). Sectoral diversity and density are critical components of urban agglomeration (Harrison et al. 1996, Duranton and Puga 2000, Duranton and Puga 2005). The density of local employment is structured by economic organization, and provides an indicator of the efficient operation of local labour markets (Ciccone and Hall 1996, Scott and Storper 2003, Goswami and Lall 2019). Together these variables include necessary covariates for the research, while creating a complete portrait of the urban fabric. Taken collectively these data sources enable a variety of place-based as well as technology-driven strategies. These strategies are discussed more fully below.

3.4.2 Place-Based Strategies

A one-size-fits-all approach cannot meet all needs nor handle all urban regions (Mommaas 2004, Audretsch 2015). However, we believe that the organizational approach is now extensively explored, and newer and more comprehensive theoretical perspectives are required (Martin and Sunley 2003, Peck 2005). The research asks which patterns of urban micro-agglomeration and accessibility best foster economic growth, inward investment, sustained employment and new firm creation. There are at least two broad strategies for the systematic enhancement of competitiveness in the city (Duncan and Schnore 1959, Audretsch 2015). One of these strategies focuses on enhancing the organizational elements of the city, while the other strategy focuses on enhancing the infrastructure of the city. Example organizational tactics involve growing the creative economy of the city (Florida 2002, Asheim and Hansen 2009, Boschma and Fritsch 2009), and expanding the industrial base of the city (Porter 1998a, Porter 1998b, Porter 2000). Applying an infrastructure-based strategy requires the recognition of a fundamental trade-off made between land use and transport (Alonso 1964, Mills 1967, Bertraud 2018). Urban scale and urban density have a positive role to play in enabling urban agglomeration and increasing economic efficiency (Ciccone and Hall 1996, Anas et al. 1998, Armington and Acs 2002). Appropriate infrastructure tactics include the creation of compact urban living opportunities (Lund 2003), the development of local environmental amenities (Walmsley 2006), and the enhancement of transport options that increase connectivity and accessibility (Glaeser and Kohlhase 2004).

3.4.3 Technology-Driven Strategies

New research is increasingly demonstrating how technologies are embedded in specific times and places. This is amply demonstrated by the history of science and technology. Nonetheless, modern analyses, using patents as a proxy, demonstrate the spatial and competitive character of new innovation. Patents of particular economic value, and of unusual similarity, are contested with the patent offices. Similar inventions are disproportionately located in the same urban regions. This holds regardless of the urban region. While different technologies are located in different places, the most similar, most contested technologies are located together (Ganguli et al. 2019). This suggests that innovative firms and individuals should adopt a conscious strategy to select regions conducive to their learning, growth and competitiveness.

Some individuals are selecting cities with high concentration of urban amenities. Many of these amenities are environmental in character. Such locations are attractive to companies as well, since under spatial equilibrium, the costs of labour are likely to be higher here. This arises since individuals willingly forgo higher salaries to live in more salutary environments. In the United States particular attention is being applied to three large Californian cities where inadequate housing is available regardless of the price being paid. This lack of adequate housing results in an innovative deficit with measurable losses to the U.S. economy as a whole. In general a strategy of multicriteria evaluation is a good approach for technology-driven firms and individuals to select favourable regions. This approach enables important trade-offs to be made between various requirements for networking, access, markets, and costs in general. Another aspect of this technology-driven strategy should certainly be configurational in character. That is to say that specialized knowledge and specialized assets in science and technology depend on how such assets can be recombined into products, services, platforms and architectures (Arthur 2010). Technologies are neither fixed nor unitary in character. Those individuals best able to participate in the creation of variety are likely to be more successful in the economy as a whole. One particularly vivid decision tool is provided by the Atlas of Economic Complexity (Growth Lab 2020). This Atlas shows, albeit at the national level, areas which are particularly adept in producing products of high economic complexity. The Atlas examines patterns of sectoral growth. A fine-grained analyses may well be possible for recombining individual technologies, components or skills.

3.5 Discussion and Conclusion

Machine learning approaches increasing raise concerns because of the unique characteristics of geospatial data (Atluri and Chun 2004), and also because the firms and enterprises indirectly surveyed could be affected. As a result, technology managers must be increasingly concerned with the curation of the data in their care, and the dangers of involuntary disclosure of personal or proprietary data. As a result, technology managers in this space of innovation management will be increasingly concerned with the use of probabilistic privacy techniques to ensure the anonymity of database entries (Agrawal and Srikant 2000, Chawla et al. 2005, Aggarwal and Yu 2008, Fung et al. 2010). The data presented will be probabilistic templates (Yin and Huang 2001, Nanda et al. 2002, Grimm et al. 2005) which result from the fusion of hundreds or thousands of spatial examples.

Machine learning techniques raise significant concerns of unintentional disclosure. Such techniques have proven capabilities in imputing missing data, enhancing resolution and removing noise. Such techniques do require large datasets. Armed with such datasets these techniques excel at the isolation, identification and recombination of visual and spatial patterns. Such capabilities are a threat to the privacy of local citizens, firms and enterprises. Care will therefore be ventured to maintain the privacy of the firms and enterprises contained in the data. When using these techniques only the generalized patterns of urban performance need be revealed, while specifics of firms and their spatial embedding will remain anonymous.

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During the writing of this chapter (much of 2020), the coronavirus pandemic is underway across many parts of the world. This pandemic has been consequential in many ways, and may lead to dramatic changes in technology management, as well as practices of urban management. The information and communication technology is long underway, yet the pandemic seems to have been an important focal point for new practices of teamwork and communication. Researchers and policy-makers are working ever harder to identify sources of productivity and growth enabled by communication technology. Remote and distributed work is increasingly prominent in both large and small companies.

Despite these trends, the supposed death of the city seems dramatically overstated. The need for real people to convene in dense urban spaces to share tacit knowledge is unlikely to diminish in the near future. Communication technology is not a substitute for proximity. In fact, tantalizing new evidence suggests that communication technology is in fact a complement for dense and innovative regions. The more dense the region, the more often inhabitants make calls and reach out to other individuals in the region. This is largely in keeping with a long tradition of urban psychology that describes the rapid pace of life, and the information overload which characterizes urban inhabitants. Thus, information and communication technology will not flatten the city or its territory.

This chapter describes a particular approach to understanding technology, an approach which enthrones cities and regions as the primary locus of innovation. This suggests important new areas for technology management researchers and practitioners, in areas as diverse as planning and infrastructure management, and the spatial analysis of innovation. Technology managers will increasingly be a part of smart cities, and will call upon specific sources of urban innovative data in pursuit of technology management practices.

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