Chapter 3
Canadian Regional Science 2.0

Eric Vaz

Abstract This chapter takes a retrospective approach to the advances and contributions of regional science. It further argues that regional sciences are currently on the verge of a remarkable change resulting from the growing pressures, social, environmental, and economic felt in the Anthropocene. Regional Science, however, offers ubiquitous methods that together with economics and geography may well revolutionize the status quo of decision making and governance. The strongest aid is found in the evolution of geo-computation and artificial intelligence, which paves a new way for regional science to define itself as a fundamental field within the social sciences. The example of Canada is brought as an outstanding witness to the Zeitgeist of the regional science revolution. By framing the importance of regional science, as well as the integration of novel techniques that have strengthened the field over the recent decades, I further explore new directions Regional Science may take when considering the contributions to the present and future of times facing unprecedented challenges for humankind.

Keywords Regional science · Canada · Canadian regional science · Geo-computation · Spatial analysis · Artificial intelligence · Machine learning · Regional science 2.0

3.1 Introduction

The advent of the fifties brought the cradle of regional science as we know it today (Isard 1956). As a multidisciplinary toolkit of several methods intertwining economics, geography, and most of social science, it leveraged quickly from the need to understand space and place-based models intertwined with the rationale of

E. Vaz (✉)
Department of Geography and Environmental Studies, Ryerson University, Toronto, ON, Canada
e-mail: evaz@ryerson.ca

S. Suzuki, R. Patuelli (eds.), *A Broad View of Regional Science*, New Frontiers in Regional Science: Asian Perspectives 47,
https://doi.org/10.1007/978-981-33-4098-5_3

innovation and the growing demand of transportation efficiency for development of entire regions (Vaz 2016). The Isardian vision of transdisciplinary focus led to a natural extension of understanding spatial interactions within a consequence for economists and geographers (Isard et al. 1998). While the field significantly grew, the dominating schools of regional economic thought (Martin and Sunley 2006) leveraged the already well-established industrial allocation models (Putman 1967) to create deterministic interpretations of quantitative models for regional development (Kacprzyk and Straszak 1980). The territorial size and shape of regions, however, as well as the oftentimes homogenous distributions of policy and governance throughout geographical space, led to a set of well-established methods that allowed regional science to blossom as applied research simultaneously for many European countries (Fingleton 2013). The stronger focus in the United States of regional science within urban cores, transportation, and metropolitan areas, however (Small 1997), brought different assumptions than the European counterparts of regional development, and thus the contribution of integrating transportation efficiency into the discourse of regional science created a growing field in the eighties and nineties of a ubiquitous approach of testifying the future of development of regions. Regional science grew leaps and bounds in the last couple of decades, and created as a consequence a field that extends from planning and urbanization to economics and geography, without failing to integrate sociology and finally, addressing the complex structures of local governance and government (Stimson 2019). For that reason perhaps, did the very father of regional science consider in his later years to advent his work further into peace science instead (Isard et al. 1998).

Regional science reached its height of optimism along the fringe of its development in the mid-1990s to early 2000 (Isserman 1993). The growing economies of Europe and America, the consolidated industrial models peaking in growth before the several economic recessions (Martin 2011), made regional science and regional economics the new standards allied to the upcoming computational methods to better explore the robust quantitative frameworks of industry, governance, and economic development (Fischer and Getis 2009). In fact, computation of the 1990s and early-2000 create a relationship of reconsidering interacting and relations of spatial decision, enhancing the scope of location analysis to regional analysis with pervasive methods for interpreting the value of territorial decision making (Wilson 2014). Regional problems became the centerfold of governance and policy ideation, and the new hope of future sustainable regional development (Field 2018). By 2007, however, with the downturn of several economies throughout the world, territories became fragmented, and the asymmetries at national boundaries led to misinterpretation of regional understanding having a profound impact on the economy and thus an underlying skepticism concerning adequate governance (Hadjimichalis and Hudson 2014). The once robust methods within regional science became questioned, and fields such as geography, sociology, and economics witnessed a rebirth of their non-multidisciplinary framework for social sciences since (Stimson 2019). In recent years, however, largely due to the availability of large data structures within social sciences (Snijders et al. 2012), an astonishing regrowth within the regional science has taken shape (Lohr 2012). New paradigms, beyond industrial allocation, focusing on hybrid models and significantly smaller scales of interaction have started to emerge (Vaz and Aversa 2013). Regional science is thus changing into a new accord of reinventing itself as a multidisciplinary field that substantiates the integration of sociology, geography, economics, and planning (Massey 1979) within highly robust computational (and geo-computational) models brought forth from the advances of spatial science and artificial intelligence coupled with spatio-temporal resolutions that answer regional issues. (Rey and Janikas 2006). This paper attempts to better understand the development of regional science within the Canadian context, and define an upcoming definition for regional science that considers the technological innovation brought by big data and artificial intelligence—defined as regional science 2.0. Canada benchmarks a unique opportunity to address large data and offers an ideal laboratory for the development of modern regional science given its data availability, intrinsic regional dimension, and territorial differences throughout the importance of structured governance and divergent provincial decision making (Polèse 1999). While the data is out there to be assessed, the challenges of applying regional science in the context of Canada are an important driver for its future sustainability (Vaz and Arsanjani 2015), and an opportunity for the advent of Regional Science 2.0.

3.2 Regional Science and Artificial Intelligence

During a similar timeframe as regional science itself, in the mid-1950s, the interest in developing self-sufficient models by means of computation nested the birth of artificial intelligence (Norvig 2012). The integration of the component of machine learning (Michie et al. 1994) led to a fundamental growth of understanding conceptually at the time the possible complexity of offering large scale territorial solutions (Gahegan 2000). The computational capabilities, which we are, however, reaching only at the present, were not available to the extent of much of the theories developed during the extend of the 1960s to the 1980s could leverage the field and make artificial intelligence an applied research stream beyond the fiction ideas of science fiction. With the advent in recent years, however, of artificial neural networks (Fischer 1992), clustering techniques (Murray and Estivill-Castro 1998), and agent based models (Gimblett 2002), the classic machine learning theories are now capable of rewiring the very core of application of computational science. This has as such become the first generation of applied artificial intelligence, where the integration of big data into novel views of understanding the world around us, and reshaping several scientific fields Vaz and Noronha (2020). Artificial intelligence as such, has developed beyond the Asimovian idea of a competing robot (Haddadin 2013), into a leveraging technique of competitive science where the goal of artificial intelligence now relies in robust models to address the complexity of decision making, a much needed avenue in a rapidly changing world where regions are an important aspect of future development dynamics The increase of computational capacity and the integration of learning algorithms, for instance, mimic nicely unpredictable behaviors, particularly when enriched with big data, and leading to optimal solutions for territorial governance. Artificial intelligence, somewhat explored in recent years in spatial sciences, has seldomly been explored in the field of regional science and governance. This is, however, a natural evolving step from the tradition of the growth of the discipline of social science (King 2011). Fostered by the availability of specific data sets, neatly hosted within open data structures, for the first time in human history, we have the opportunity to assess multi-temporal standardized data structures that show demographic, geographical, and economic evolutions over periods of time that allow us to assess the evolution of patterns leading to predictive and scenario based modelling (Vaz et al. 2012). The increment of neural networks and the capacity of geo-computation is leveraging the territorial interpretation of these findings (Hewitson and Crane 1994), lending the explicitly spatial driven characteristics of regional models to answer territorial divergences that allow the very same calculated optima to be applied for governance and industrial allocation decision (Tang et al. 2018). The advent of artificial intelligence as such, is remitting to a new hope for the evolution of regional science Vaz (2018), in its multidisciplinary convergence as a structure field of knowledge and contributor for modern regions throughout the world (Brunette et al. 2009).

3.2.1 Geo-computation and Artificial Intelligence

Spatio-temporal dynamics, particularly when assessing regional change have gained a significant amount of attention in recent years due to its inherent complexity, resulting from the interaction of environmental and economic interests, as well as the need for consequential sustainable development (Arsanjani et al. 2013). The existence of different data sets that depict economic, environmental, and social phenomena have led to growing amount of data infrastructures that support multiple scales of regional analytics. Regional sciences, as such, have challenged the status quo of conventional computation techniques to address transdimensional data to assess regional problems. The territorial nature of these tools have led to the integration of geospatial and spatial analytical toolboxes within the field of geo-computation that (1) leverage the understanding of static modelling of territorial interaction (Vaz and Bandur 2018), (2) demonstrate the capability to assess past behaviors to integrate governance and policy opportunity costs (Vaz 2014), and (3) predict the future changes and impacts at regional based on past and present territorial decision (Vaz and Nijkamp 2015; Vaz 2020). The integration of spatial sciences, regional modelling, computational technologies, as well as the stochastic opportunity to model time as well as geographical extend, has leveraged what can be defined the field of geo-computation, with a direct impact on the way we handle and monitor regional change. The opportunity of regional data storage systems at different scales throughout has made particularly in the last couple of years the existing data sets inherently rich, and multi-temporal, maximizing the prospect of multi-temporal analysis within the predictive spatial frameworks of regions. These instruments can nowadays be applied for decision making through Geographic Information Systems interfaces, where visualization of prospected regional data, as well as results of direct prediction ease the integration of strategy as well as community knowledge transfer of regional decision processes. The advent of geo-computation is further fueled by the capacity of volunteered data integration from the community itself, where criteria of data satisfaction and system integration satisfaction permits to establish knowledge transfer where regional toolboxes for governance decision become more society-centric as we advance towards smarter regions. Both the data richness (in terms of spatial and temporal resolution) as well as the community integration of quality assurance directly contribute towards the potential of artificial intelligence to have a determinant role in several fronts of regional geo-computation Vaz et al. (2020).

3.2.2 Machine Learning for Regional Sciences

One of the key aspects where regional geo-computation benefits mostly from artificial intelligence is the growing demand of machine learning algorithms to prospect the ever increasing data sets and gear towards robust predictive models of classification techniques as is the case of the contribution of global data sets of land use and land cover, that would have been unthinkable a decade ago with similar coverage and resolution. Expanding machine learning towards the incorporation of artificial neural networks, such as self-organizing maps, idealizes a new perception of integrating strategic decision and enables spatial planning to rethink the role of spatial interaction between communities, cities and even the efficiency of transportation. The remarkable contributions of such tools allow to assess big data as well as understand spatial interaction for large to very large geographical extents. This particular field of advances within machine learning has allowed the integration of a geographical perspective into the governance and policy application framework. The territorial heterogeneous nature within regional systems can largely benefit from the taxonomy of spatial autocorrelation that assesses at a fine level of granularity different spatial and remote sensed data. This permits the foundation for artificial intelligence and machine learning to blossom in the multidisciplinary field of regional science where the convergence of high resolution data is incrementally relevant for fine resolution governance issues. A growing body of literature is dominating the spatial science ecosystem with such methods. From classification of land use at finer scales, to the possibility to predict commuting times for transportation, has direct impacts on the regional sphere of our cities, vulnerable ecosystems, and the aesthetics of our landscape. The final operability of such methods lies in the positioning of governance structures utilizing novel geoinformatics for regional decisions. It is necessary thus that regional scientists think holistically, and consider geography, economics, as well as the skyrocketing advances of machine learning into the frameworks of regional decision and monitoring. Machine learning is a promising contribution which fits very well in the application of spatial data, and leverages traditional statistical models to a new dimension of spatial understanding within the regional perspective. The exploration of social, economic, and territorial dimensions within a regional system allows to address complex questions that otherwise would be impossible to assess. Issues such as (1) industry location, (2) corporation dynamics, (3) land use transitions, (4) endogenous growth and specialization, (5) social impact, (6) urban and rural interactions, and (7) innovation and invention dynamics, are all issues that may be tackled within a regional complexity science framework and largely benefit from instruments found in artificial intelligence. It is the geographical scalability that allows for a mixed science approach and a convergence of multidisciplinarity. Within the structure of policy and governance, the role of computational methods holds the potential to (1) monitor, (2) assess, (3) predict, the current state of complex regional interactions, that otherwise would be impossible to measure. In this sense, the future development of regional science will use the significant advances of computational and geo-computational methods. Fundamentally, regional science is an open science, where despite its tradition, a central methodological framework has to be defined as to create an epistemology for its field. The dispersal of regional science as a field in itself is a result of the growing literature in other more traditional fields such as sociology, geography, and economics. It should be noted, however, that regional science has a tremendous potential when considering the Anthropocene, and it can well be expected that it will continue to grow in the next decades, as we face increasingly complex problems that intertwine computational decision systems with governance and policy integration. The availability of spatial (and not so spatial) data and particularly, the advent of high-granularity data, responds well to the growth of regional science as a field. As the subject data become available for more precise (or local) decisions, one can consider the articulation of the field as a macro-regional science 2.0 and a micro-regional science 2.0. Where the field will leverage new scales to address regional issues, from perspectives that otherwise, without the computational aspects of data availability, would not be achieved.

3.3 The Opportunity for Canada

Canada presents quite a unique challenge in regard to its regional understanding. Its significant geographical extent makes the country hold a unique complexity formed by cultural, physical, and economic characteristics. While there is a single Canadian identity, at provincial level economic, historical, and policy characteristics are very distinct. This grants Canada a unique profile of richness and diversity, which leads to differentiated sectors of economic activity to blossom in different provinces. This is a result of the historic path tendency tied to the traditional production circuits of provinces, but also to the availability of natural resources given the heterogeneous profile of the spatial unit of Canada itself. Six geographic regions can be distinguished for regional purposes: (1) Atlantic Canada, (2) Quebec, (3) Western Canada, (4) British-Columbia, (5) Territorial North. The remarkable variation on key variables such as population concentration and economic activity (both the industry and the service sector) make Canadian provinces a highly interesting regional proxy. Southern Ontario, for instance, where population density is one of the greatest in Canada, shows a substantially low population density in northern Ontario. A crucial example is the unavailability of certain demographic and land use indicators in the less population dense regions. Canada's spatial data structure, and geographical information—despite the significant investment in technological integration and data in the recent decades as well as the fact that Canada has been the pioneer for geoinformation—presents some significant gaps when outside the population dense regions. Added to this, the regional challenges of population dynamics, with immigration playing a key role on the distribution and redistribution of spatial interactions of the economy, applied politics, and governance initiatives, lead to a regional dynamic structure for Canada's geographical regions and provinces. These transitions throughout regional space as well as the emergence of large urban cores that function as economic hubs for Canadian economies continuous growth, leverage the importance of regional models that handle large data, and understand the spatial interaction from a spatio-temporal perspective. This is the unique opportunity that Canada has to merge novel regional spatial methods in its forum of current monitoring techniques. While governance structures largely recognize monitoring of regional dynamics as one of the most relevant aspects for sustainable decisions in line of an increasingly vulnerable environment, it is the added territorial complexity of (1) size, (2) economy, (3) land use, that makes Canadian provinces benefit greatly from the upcoming regional methods such as machine learning and artificial intelligence in its planning structure.

3.4 Regional Science 2.0 in Canada

In its long tradition, regional science has become a beacon for development in a globalized world, where issues such as land use change, fresh water resources, immigration, and sustainable development are critical factors for guaranteeing a sustainable future. Regional science has reached its septuagenarian existence, and with the ongoing trends of globalization, where immigration, heritage, environment, and urbanization gain a new dimension, regional science boasts yet again, the charm and youth of a teenager. The reinvention of regional science has mostly been brought forward with the advances of computation and technology, where never like before, toolsets become available to end-users (both from science as well as from the community) to dwell in the questions of regional dynamics. The open source community enabling methods, tools, and techniques in forums and discussion boards alike, have allowed through open source software such as Geoda, GWR4, and QGIS, to name a few, to establish a new network of multidisciplinary communities that enable the continued success of major conferences such as the RSAI, ERSA, and NARSC to flourish. The incremental amount of workshops that are offered in such conferences are far from different than the 1954 call for an association of regional scientists, that stood still well-established in the ivory tower. It has been the evolution of this great regional scientist, and later the quasi-evolution of computing, that allowed brick-and-mortar scientists to become the second generation of innovative and creative thinkers of regional science. It was the generation of well-established academics in the 1990s, that through inquisitive minds, and still active nowadays as the legacy passes on to the next generation of regional scientists, laid the cumbersome task of creating the digital divide, when computational processes in the mid-1990s still presented from a programming and geo-computational standpoint several hardware and software implementation challenges. Far from the original blackboards from the Isardian vision of contemplation of geography and regions, the 1990s so bustling challenges of computation and contribution to more extensive data dealing with firm allocation, and the sentient and rapid transformation of the urban landscape and firms allocation. I would consider that we are now in the third paradigm of Regional Science. The Regional Science 2.0, standing in the shoulders of giants, regional science stands now as a renewed frontier of understanding the contexts of the startling absence of geographical space for commercial activity, the ethereal nature of services through sharing economies, and the frontier of verticalization of cities in the urban divide. These issues are becoming inquisitively explored by a new set of scientists and research toolkits, that find contemplation far beyond the blackboards from the 1950s, the conference rooms from the 1990s, but in the short posts of Facebook, the witty lines of Twitter, and the encompassing forums on Reddit. Regional science is witnessed unprecedented growth in the potential to address new paradigms that aid in understanding the complexity of territories and land use interactions. As the rumors of fractal cities travel farther along the dissonant walls of cyberspace, we ask ourselves the question if regional science extends to complex systems, and if our models are not a reflection of a single scale of a much more complex and naturally forming systems. Is the urban footprint similar to the mutation of cells biological systems are transportation networks that different from a nervous system. The new generation of regional scientists will be engaged in working further with complex computational models that set up through quantum computing an integrative vision of macro, microeconomics. While Regional Science will continue to be a not so well definable discipline, it will continue to flourish through the many multidisciplinary realms it can integrate. The geographical dimension remains thus, the next frontier as our digital data elaborates further on the complexity of territorial and multi-scale integration of spatially-explicit frameworks that only regional science allows to further to have a positivist truth within a framework of regional intelligence.

Acknowledgments The author would like to thank the reviewer for the constructive comments.

References

Arsanjani JJ, Helbich M, de Noronha Vaz E (2013) Spatiotemporal simulation of urban growth patterns using agent-based modeling: the case of Tehran. Cities 32:33–42

Brunette ES, Flemmer RC, Flemmer CL (2009) A review of artificial intelligence. In: 2009 4th international conference on autonomous robots and agents, IEEE, pp 385–392

Field B (2018) Forecasting techniques for urban and regional planning. Routledge, New York

Fingleton B (ed) (2013) European regional growth. Springer, Berlin

Fischer MM (1992) Expert systems and artificial neural networks for spatial analysis and modelling: essential components for knowledge-based geographical information systems. Inst. für Wirtschafts- und Sozialgeographie, Wien

Fischer MM, Getis A (2009) Handbook of applied spatial analysis: software tools, methods and applications. Springer, Berlin

Gahegan M (2000) On the application of inductive machine learning tools to geographical analysis. Geogr Anal 32(2):113–139

Gimblett HR (ed) (2002) Integrating geographic information systems and agent-based modeling techniques for simulating social and ecological processes. Oxford University Press, Oxford

Haddadin S (2013) Towards safe robots: approaching Asimov's 1st law, vol 90. Springer, Berlin

Hadjimichalis C, Hudson R (2014) Contemporary crisis across Europe and the crisis of regional development theories. Reg Stud 48(1):208–218

Hewitson BC, Crane RG (1994) Neural nets: applications in geography: applications for geography, vol 29. Springer, Dordrecht

Isard W (1956) Regional science, the concept of region, and regional structure. Reg Sci 2(1):13–26

Isard W, Azis IJ, Drennan MP, Miller RE, Saltzman S, Thorbecke E (1998) Methods of interregional and regional analysis. Routledge, New York

Isserman AM (1993) Lost in space? On the history, status, and future of regional science (presidential address, April 4, 1992). Rev Reg Stud 23(1):1

Kacprzyk J, Straszak A (1980) Application of fuzzy decision-making models for determining optimal policies in "stable" integrated regional development. In: Fuzzy sets. Springer, Boston, pp 321–328

King G (2011) Ensuring the data-rich future of the social sciences. Science 331(6018):719–721

Lohr S (2012) The age of big data. *New York Times*, p 11

Martin R (2011) Regional economic resilience, hysteresis and recessionary shocks. J Econ Geogr 12(1):1–32

Martin R, Sunley P (2006) Path dependence and regional economic evolution. J Econ Geogr 6 (4):395–437

Massey D (1979) In what sense a regional problem? Reg Stud 13(2):233–243

Michie D, Spiegelhalter DJ, Taylor CC (1994) Machine learning. Neural Stat Classif 13

Murray AT, Estivill-Castro V (1998) Cluster discovery techniques for exploratory spatial data analysis. Int J Geogr Inf Sci 12(5):431–443

Norvig P (2012) Artificial intelligence: early ambitions. New Sci 216(2889):ii–iii

Polèse M (1999) From regional development to local development: on the life, death and rebirth (?) of regional science as a policy relevant science. Can J Reg Sci 22(3):299–315

Putman SH (1967) Intraurban industrial location model design and implementation. In: Papers of the Regional Science Association, vol 19. Springer, Philadelphia, pp 199–214

Rey SJ, Janikas MV (2006) STARS: space–time analysis of regional systems. Geogr Anal 38 (1):67–86

Small KA (1997) Economics and urban transportation policy in the United States. Reg Sci Urban Econ 27(6):671–691

Snijders C, Matzat U, Reips UD (2012) "Big data": big gaps of knowledge in the field of internet science. Int J Internet Sci 7(1):1–5

Stimson RJ (2019) Challenges for regional science research: past and present. Spat Econ Anal 14 (2):133–152

Tang W, Feng W, Deng J, Jia M, Zuo H (2018) Parallel computing for geocomputational modeling. In: GeoComputational analysis and modeling of regional systems. Springer, Cham, pp 37–54
Vaz E (2014) Managing urban coastal areas through landscape metrics: an assessment of Mumbai's mangrove system. Ocean Coast Manag 98:27–37
Vaz E (2016) The future of landscapes and habitats: the regional science contribution to the understanding of geographical space. Habitat Int 51:70–78
Vaz E (2018) Regional intelligence: a new kind of GIScience. Heidelberg, Springer
Vaz E (2020) Archaeological sites in small towns—a sustainability assessment of Northumberland County. Sustainability 12(5):2018
Vaz E, Arsanjani JJ (2015) Predicting urban growth of the greater toronto area-coupling a markov cellular automata with document meta-analysis. J Environ Inf 25(2):71–80
Vaz E, Aversa J (2013) A graph theory approach for geovisualization of anthropogenic land use change: an application to Lisbon. J Spat Org Dyn 1(4):254–264
Vaz E, Bandur D (2018) Merging entropy in self-organisation: a geographical approach. In: Resilience and regional dynamics. Springer, Cham, pp 171–186
Vaz E, de Noronha T (2020) Regional opportunities in Southern Europe. In: Sustainable development in Southern Europe. Springer, Berlin, pp 23–36
Vaz E, Nijkamp P (2015) Gravitational forces in the spatial impacts of urban sprawl: an investigation of the region of Veneto, Italy. Habitat Int 45:99–105
Vaz E, Nijkamp P, Painho M, Caetano M (2012) A multi-scenario forecast of urban change: a study on urban growth in the Algarve. Landsc Urban Plan 104(2):201–211
Vaz E, Shaker RR, Cusimano MD (2020) A geographical exploration of environmental and land use characteristics of suicide in the greater Toronto area. Psychiatry Res:112790
Wilson AG (2014) Complex spatial systems: the modelling foundations of urban and regional analysis. Routledge, New York