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Integrating Across Sustainability, Political, and Administrative Spheres: A Longitudinal Study of Actors' Engagement in Open Data Ecosystems in Three Canadian Cities

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Abstract:

Over the last decade, cities around the world have embraced the open data movement by launching open data portals. To successfully derive benefits from these initiatives, various individual and organizational actors need to engage with them. These actors undertake activities supporting data publication and dissemination in open data ecosystems. In this paper, we focus on enhancing the IS community's contribution to the open data movement by conducting a longitudinal, qualitative archival analysis of open data initiatives in three Canadian cities: Edmonton, Toronto, and Montreal. Combining two complementary models of open data and information ecosystems, we explore how actors engage in and across the sustainability, political, and administrative spheres to influence open data initiatives. Our findings suggest most actors operate in a single sphere but that some can operate across two or all three spheres to become ecosystem anchors. Through these sphere-spanning efforts, ecosystem anchors help to shape the way in which open data initiatives evolve. We provide a theoretically grounded explanation of processes in successful open data initiatives and suggest new directions for practice.

Keywords: Actors, Anchor, Ecosystem, Longitudinal, Open Data.

1 Introduction

Open data value refers to the range of benefits open data brings to various stakeholders including end users, community groups, public organizations, and private companies (Cabitza, Locoro, & batini, 2018). Potential open data value encompasses societal benefits, such as enhanced transparency and accountability, data-driven decision-making, and improved citizen wellbeing (Janssen et al., 2012), and economic advantages, such as efficiency and effectiveness gains and new products, services, and markets (Manyika et al., 2013). Open data represents a new and valuable raw material that stakeholders can use to spur innovation (Zuiderwijk, Helbig, Gil-Garcia, & Janssen, 2014a); however, open data's simple existence does not guarantee economic or societal value (Cabitza et al., 2018; Roy, 2014; Zeleti, Ojo, & Curry, 2016). Like other raw materials, one must extract, process, and use open data to deliver the maximum benefit. Stakeholders cannot easily create value from open data (Germano, de Souza, & Sun, 2016), which has led some observers to characterize it as a wicked problem (Zuiderwijk, Janssen, van de Kaa, & Poulis, 2016).

Researchers have used various perspectives to explain how open data initiatives achieve success and deliver benefits. One research stream has considered government capabilities around open data, such as the capabilities that the open data maturity model proposes (Dodds & Newman, 2015). Cities must invest not only in the publication of open data but also in proper administration, governance, skill development, community engagement, and data maintenance (Lee & Kwak, 2012). A second research stream has considered value creation from the perspective of end users who have different motivations for using open data (Lassinantti, Stahlbrost, & Runardotter, 2019). Findings show that open data's perceived relative advantage, platforms' familiarity and accessibility, and the data's quality positively influence the extent to which people use open data (Machova & Lnenicka, 2017; Weerakkody, Irani, Kapoor, Sivarajah, & Dwivedi, 2017). A third research stream has viewed open data value creation from an ecosystem perspective (Dawes, Vidiasova, & Parkhimovich, 2016; Welle Donker & van Loenen, 2017) where stakeholders interact to create, collect, manage, reuse, integrate, and diffuse open data (Zuiderwijk et al., 2016). To take full advantage of open data, an open data ecosystem needs intermediaries such as application developers, journalists, and researchers (Chan, 2013; Young & Yan, 2017) because individual citizens and cities may not have the skills, knowledge, and resources to fully exploit it (Gonzalez-Zapata & Heeks, 2015; Janssen, Charalabidis, & Zuiderwijk, 2012; Martin, 2014). Our research falls in this third research stream. Despite the recognition that open data initiatives require various actors to succeed, the research and practice communities still do not fully understand how these actors contribute to creating open data value. Further research is required to investigate the wider ecology of actors that can leverage open data for public interests and collective goals (Roy, 2014).

In contrast to much extant literature, we take a broad perspective of open data value creation by examining not only operational dimensions but also political and global influences on open data initiatives and the interactions between them. We build on Dawes et al.'s (2016) model of open government data ecosystems and integrate the global sustainability, political, and administrative spheres of engagement that the integrated information ecosystem (IIE) model proposes (Corbett & Mellouli, 2017). Developed in the smart city context, the IIE model applies to open data initiatives for two reasons. First, open data and government transparency represent important sustainable development objectives (United Nations, n.d.-a). In this sense, open data falls under the umbrella of investments that cities make in order to become more sustainable and "smart" (Pereira, Macadar, Luciano, & Testa, 2017; Walravens, Breur, & Balloon, 2014). Second, like many smart city initiatives, actors shape open data at multiple levels, which one can view as spheres of engagement. Spheres of engagement refer to multi-dimensional and interdependent spaces where diverse stakeholders and resources assemble to undertake activities in a specific scope of responsibility (Corbett & Mellouli, 2017). The IIE model can help researchers better understand open data initiatives because the model suggests different roles for actors in government initiatives as they engage with each other in and across spheres and take actions in practice (Corbett & Mellouli, 2017). While recognizing engagement includes both psychological and behavioral dimensions (Kappelman & McLean, 1993), we adopt a behavioral view and focus on actions and practices that shape open data initiatives. In particular, we address the following question: how do individual and organizational actors engage in and across the sustainability, political, and administrative spheres to influence the success of open data initiatives?

To answer this question, we conducted a longitudinal, qualitative archival analysis of three Canadian cities' open data initiatives. Our findings confirm previous research that has suggested that cities' open data initiatives require various actors. We further found that, while most actors operate in one specific sphere (e.g., administrative), some can operate across two spheres (e.g., administrative-political), and even fewer engage in activities that cross and connect all three spheres. Among the latter group, IS teams, the media, and community groups are well positioned to advance cities' open data initiatives by operating across spheres and serving as ecosystem anchors.

By combining the open government data ecosystem model with the spheres of engagement from the IIE model, we theoretically explain actors' behaviors that underlie successful open data initiatives. Our findings better explain how actors conduct activities across three different spheres over time in a specific city-level initiative. In so doing, we highlight the role that open data ecosystem anchors play in helping open data initiatives create value and the potential for various actors to fill that role. Beyond extending the open data scholarship, we provide tangible guidance to cities as they develop their open data initiatives.

This paper proceeds as follows: in Section 2, we present the background literature relevant to the study. In Section 3, we develop the conceptual framework. In Section 4, present our research methodology. In Section 5, we present our results and, in Section 6, discuss them. In Section 7, we describe our study's contributions and limitations, present some future research directions, and conclude the paper.

2   Background

2.1   Open Data Ecosystems

Open data refers to data "that is machine-readable, freely shared, used, and built on without restrictions" (Government of Canada, 2017). Cities have invested in open data as part of a movement toward making government data more accessible to all stakeholders and contributing to municipalities' smart city strategies (Bakici, Almirall, & Wareham, 2013; Walravens et al., 2014). In parallel with open data's growth, research has started to emerge around open data value-creation processes from the perspectives of the governments that publish the data, the citizens and other end users who use open data, and the open data ecosystem (see Table 1).

Open data simultaneously represents and requires a new type of interaction between governments and society (Walravens et al., 2014). Governments must engage in greater collaboration and strategic alliances (da Silva Craveiro & Albano, 2017) in order to create effective open data policies that provide favorable conditions for open data initiatives to succeed (Styrin, Luna-Reyes, & Harrison, 2017). Further, individual citizens or public organizations may not have the skills, knowledge, or resources to fully exploit open data (Janssen et al., 2012; Martin, 2014), which means other individuals and organizations, such as application developers and researchers, will need to make open data more useable and impactful. Based on this growing consensus that open data initiatives require various actors to succeed, we adopt the ecosystem perspective to shed new light on how diverse players contribute to value-creation processes.

Ecosystems are complex adaptive systems that comprise many elements that interact to produce a stable system (Levin, 2009; Winn & Pogutz, 2013). In organizational settings, arrangements based on ecosystem logics typically have a distributed, decentralized, and self-organizing nature (Tiwana, 2014) with the different elements simultaneously influencing and being influenced by one another. Scholars have started to adapt the ecosystem perspective to better understand open data (da Silva Craveiro & Albano, 2017; Harrison et al., 2012; Styrin & Dmitrieva, 2017). They have proposed that open data ecosystems constitute socio-technical networks that include people, practices, values, and technologies such that interactions and interdependencies can vary from one context to another (Harrison et al., 2012). A study on open data ecosystems from Mexico, Russia, and the United States (Styrin et al., 2017) suggested that open data ecosystems usually develop naturally but that their health also depends on active promotion and incentives from the government.

Table 1. Selected Research on Open Data Value-creation Processes

Perspective	Conditions for creating open data value
Government	The open government maturity model comprises five stages: 1) few or limited government capabilities, 2) data transparency (including open data), 3) open participation, 4) open collaboration, and 5) ubiquitous engagement (Lee & Kwak, 2012).
	Open data maturity comprises five levels: 1) initial efforts, 2) repeatable, 3) defined standards, 4) managed approach, and 5) optimization in six areas: cities' data management, knowledge and skills, customer support and engagement, investments, and strategic oversight, and governments' progress (Dodds & Newman, 2015).
	Open data initiatives occur in three waves: 1) publishing existing data and modifying existing structures (including laws) to facilitate open data, 2) improving the quality of open data and stimulating the use of open data, 3) driving value by seeking external input and opportunities (Nugroho, Zuiderwijk, Janssen, & de Jong, 2014).
	To create open data value, governments must evolve from traditional bureaucratic forms to embrace networked and interdependent systems (Harrison, Pardo, & Cook, 2012) that include collaboration and collective management (Walravens et al., 2014).
Citizens and end users	Positive views about the usefulness of open data, familiar platforms, and easily accessible data are positively associated with intention to use open data (Weerakkody et al., 2017).
	People perceive open data's value differently according to their preferences, skills, and contingent needs; thus, governments should personalize open data experiences for citizens and conduct user-driven assessment of datasets' social value (Cabitza et al., 2018).
	Open data users (e.g., companies, developers, journalists, NGOs, city managers) interact in five relevant social groups based on their motives: 1) exploring for creativity, 2) creating business value, 3) enabling citizen value, 4) addressing global social challenges, and 5) advocating open data agenda (Lassinantti et al., 2019).
Ecosystem	Achieving effective open data policies requires greater collaboration and alliances between government and intermediaries (da Silva Craveiro & Albano, 2017).
	Open data ecosystems occur naturally but benefit from promotion and incentives from the government (Styrin et al., 2017).
	Opening data transforms the relationship between public organizations and other stakeholders (Styrin & Dmitrieva, 2017).
	Four key processes occur in the open data ecosystem to deliver open data value: 1) publishing data, 2) searching and viewing data and licenses, 3) analyzing and enriching data, 4) interpreting data and providing feedback (Zuiderwijk, Janssen, & Davis, 2014b).
	Governments should take an ecosystem approach in planning and designing open data programs in order to evaluate existing conditions and various factors, which includes strategies, policies, and relationships that lead to desired benefits (Dawes et al., 2016)

2.2 Actors' Roles in Open Data Ecosystems

Various ecosystem processes and activities surround open data, and their successful execution requires a large number of actors (see Table 2). Governments and data end users represent prominent actors, but intermediaries—social agents who work in the ecosystem to provide open data and help other actors use open data (da Silva Craveiro & Albano, 2017)—also often play key roles. With open data, intermediaries can provide the knowledge and resources required to overcome barriers, such as poor data quality and relevance or lack of technical skills and resources, to effectively use and manipulate data (Gonzalez-Zapata & Heeks, 2015; Martin, 2014).

The extant research provides significant insight into the discreet processes and roles in open data ecosystems. Still, we do not completely understand the complex, dynamic interactions because the literature focuses on operational/technical tasks associated with open data and ignores political and global sustainability influences on open data initiatives. In Section 3, we develop a conceptual framework that integrates these dimensions to inform our investigation into open data ecosystem actors.

Table 2. Open Data Ecosystem Processes and Actors' Roles

Ecosystem processes	Actors' roles	Selected research related to processes and roles
Publishing data	Data demanders, data producers, open data publishers	Data publishers should consider nine factors when publishing open data: supporting legislation, license options, strategy, political support, government processes, collaboration, open data platforms, interoperability, and standards (Susha, Zuiderwijk, Charalabidis, Parycek, & Janssen, 2015). Media outlets have great influence in choosing what to publish, in what form, and when (Federici & Braccini, 2012).
Searching, cleansing, and aggregating data	Data extractors, data transformers, data validators, and application developers	Datasets should be both accessible and viewable to users in order to be beneficial (Welle Donker & van Loenen, 2017). Data extractors and transformers allow other actors to use open data more effectively by converting it to an appropriate format, normalizing it, and ensuring its quality by removing errors and duplicate data (Lindman, Kinnari, & Rossi, 2016). Through co-production activities (e.g., hackathons), intermediaries can transform budget data into spending stories (da Silva Craveiro & Albano, 2017).
Analysis, enriching, and visualizing data	Data analyzers and application developers	IS can contribute to how actors collect, implement, and analyze data, and researchers can actively use tools and analytics to use open data effectively (Link et al., 2017). Turning data into valuable information does not necessarily require massive data processing but involves human-interaction techniques to select the most useful information and personalize the presentation according to users' profile or preferences (Cabitza et al., 2018).
Interpreting data and providing feedback	Data communicators, data demanders, user experience providers, support service providers, and end users	Over half of open government data portals encourage feedback and discussion; simple feedback tools allow for one-way engagement, whereas community forums allow for richer discussions (Sayogo, Pardo, & Cook, 2014). Service providers may provide feedback and advice on open data release procedures, user experience enhancement, and ways to use open data (Lindman et al., 2016).
Advocacy for open data	Data demanders, transparency advocates, and open data activists	Engagement among diverse stakeholders can contribute to enhanced openness, raise awareness about community concerns, and improve the rate at which different actors adopt open data (Dawes et al., 2016)

3   Conceptual Framework

Dawes et al. (2016) have proposed one of the most comprehensive models of open government data programs by bringing together the essential processes, roles, actors, and other elements in open data ecosystems. This model identifies three main stakeholder groups: 1) open data providers (which includes political leaders and administrative agencies), 2) actors who directly use open data (which includes transparency advocates and the civic technology community), and 3) open data's ultimate beneficiaries (the consumers who consume open data products and services) (Dawes et al., 2016). These actors participate in four main processes: 1) data publication, 2) data use (includes searching, cleansing, analyzing, and visualizing data), 3) feedback and communications, and 4) advocacy. Other factors such as the community's characteristics, open data policies and strategies, and motivation for open data development influence all four processes. Collectively, these elements (actors, processes, and contextual factors) interact to help realize open data's political, social, economic, and other benefits.

While the model comprehensively identifies the key elements to consider when planning and designing an open data ecosystem, it understates the complexity that arises from the underlying subsystems that make up the ecosystem. For instance, Ubaldi (2013) proposed the existence of three interrelated open data ecosystems: an ecosystem that involves data producers, an ecosystem that relates to infomediaries and intermediate data consumers, and an ecosystem that involves open data end users. Research has also revealed that the success of sustainability-related initiatives depends on mutually supporting activities that occur in three distinct spheres of engagement: 1) the sustainability sphere, 2) the political sphere, and 3) the administrative sphere (Corbett & Mellouli, 2017). Recognizing these models' complementarily, we built

on Dawes et al. (2016) by combining it with the IIE model, which resulted in the conceptual framework that we illustrate in Figure 1.
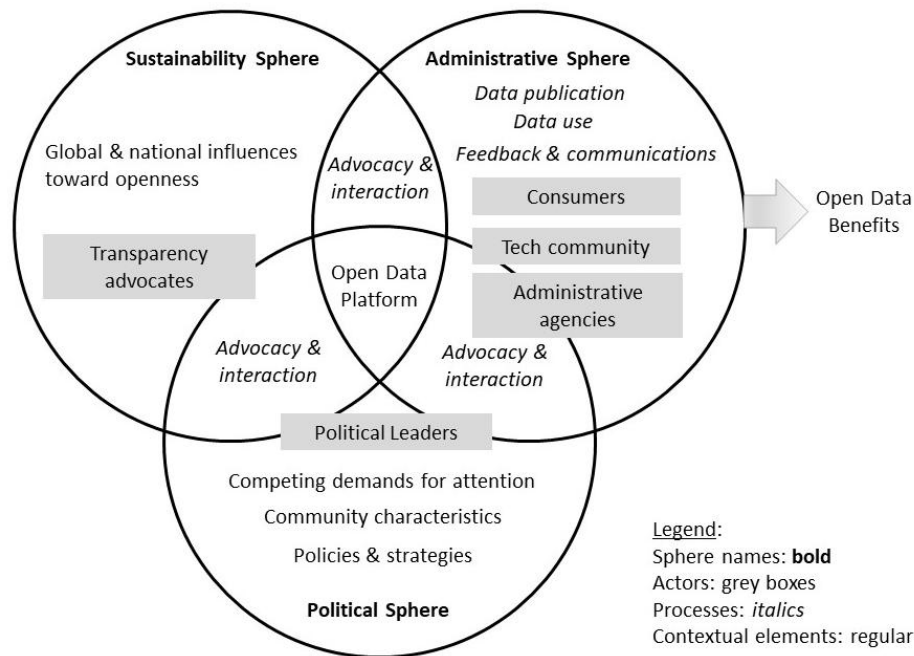

Figure 1. Conceptual Framework (Adapted from Corbett & Mellouli, 2017; Dawes et al., 2016)

According to the IIE model, each sphere of engagement has a particular focus with different information needs, activities, and actors (which we summarize in Table 3). We extrapolate from this general theory to define the three spheres of engagement relative to open data initiatives.

Table 3. Definitions of the Spheres of Engagement (Adapted from Corbett & Mellouli, 2017)

	Sustainability	Political	Administrative
Description	Space in which actors define an issue's parameters (e.g., scope, importance, threats, and opportunities).	Space in which actors negotiate city priorities and resource allocations. Such discourse serves to cultivate the political will needed to advance key initiatives and objectives.	Space in which the day-to-day work of managing cities takes place.
Information requirements	Broad range of information relevant to the sustainability issue.	Details regarding city-specific challenges, resources, goals and strategies.	Robust data and IS infrastructure platforms provide improved efficiency and quality of service to citizens.
Activities	Participating in science and fact-based discussions, which allow actors to make more informed decisions, obtain better definitions around sustainability, and identify the critical challenges for sustainable cities.	Debating and negotiating challenges set forth in the sustainability sphere in each city's context. Navigating though complex and sometimes competing economic, social, and environmental priorities. Forming perceptions of sustainability issues and setting priorities.	Responding to priorities set out within the political sphere. Turning the vision into reality. Acquiring and developing the capacities necessary to address operational challenges. These activities may also influence political and sustainability spheres by providing ground-up insights on environmental conditions.
Typical actors	Community sustainability groups, transparency advocates, government associations, and non-governmental organizations (NGOs).	City politicians and elected officials, community groups, activists, and media.	Administrative agencies, the technology community, and immediate stakeholders (suppliers, citizens, consumers).

3.1   The Sustainability Sphere of Open Data

Although cities have significant autonomy in how they develop open data programs, they do not operate in a vacuum. Cities compete for resources and must pay attention to global priorities and trends. The IIE model views sustainability in its broadest form based on the United Nations' characterization of the sustainable development goals (SDGs) as a plan for "peace and prosperity for people and the planet, now and into the future" (United Nations, n.d.-a). Thus, the sustainability sphere concerns itself with defining the major challenges and objectives around the economic, social, and environmental dimensions of sustainable development. Among the SDGs, Goal 16 calls for more effective, accountable, and transparent institutions and participatory governance (United Nations, n.d.-b). Open data constitutes an important mechanism for achieving these objectives (Corbett & Mellouli, 2017; Smith, Gerry, & Truswell, 2015). Still, the open data movement has its roots beyond the SDGs. Indeed, societal values that emphasize transparent and accountable political institutions (Manyika et al., 2013) and long-term progress in collective and citizen wellbeing (Cabitza et al., 2018) have guided the movement. The need to address global societal challenges motivates diverse open data users (Lassinantti et al., 2019), and these global and national influences help to shape how actors design open data programs in cities (Dawes et al., 2016). In addition to global actors such as the United Nations, typical actors who participate in the sustainability sphere include open data and transparency advocates (Dawes et al., 2016), such as community sustainability groups, activists, associations of governments, researchers, and NGOs (Corbett & Mellouli, 2017; Lassinantti et al., 2019). These actors interact in the sustainability sphere to define what openness means and identify the key challenges and priorities for cities at a broader level (Corbett & Mellouli, 2017).

3.2   The Political Sphere of Open Data

Actors in the political sphere negotiate city-specific priorities and resource allocations associated with open data (Corbett & Mellouli, 2017). Cities do not have unlimited resources for all potential initiatives, which results in competing demands for government attention (Dawes et al., 2016). Typically, political leaders are prominent actors in this sphere and they interact with other actors such as transparency advocates, the technology community, and city administration. These actors navigate competing economic, social, and environmental priorities; take positions on open data; and set short-term priorities appropriate to the community's characteristics. Factors such as a culture that fosters openness and innovation, the civil and private sectors' nature, and the local technology community's capabilities (Dawes et al., 2016) influence the discourse and outcomes in the political sphere. Activities in the political sphere serve to cultivate the political will needed to advance key initiatives and objectives, which are then incorporated into city's open data policies and strategies (Dawes et al., 2016). Both the sustainability sphere (in terms of the global challenges and priorities) and the administrative sphere (in terms of local-level constraints and opportunities) inform the political sphere. Likewise, the political sphere can influence debate in the sustainability sphere by elevating the questions that cities face and plays an essential role in defining the specific priorities and initiatives for the administrative sphere (Corbett & Mellouli, 2017).

3.3   The Administrative Sphere of Open Data

The day-to-day work of managing cities occurs in the administrative sphere. Activities in the administrative sphere most directly contribute to achieving the cities' sustainability goals (Corbett & Mellouli, 2017). Likewise, work in the administrative sphere most directly leads to open data use and the creation of new applications, which ultimately results in open data value. Most open data ecosystem processes studied in the literature naturally fall in the administrative sphere. To achieve open data's anticipated benefits, not only must government publish the data, but other actors must also access, process, transform, and use it. When data producers or application developers engage in processes such as publishing, cleansing, and searching data, they help to build capacities and address operational challenges that create barriers to open data use and benefits (Zuiderwijk et al., 2014b). Thus, administrative agencies in the city, the local technology community that includes application developers and intermediaries, and open data consumers must participate in the administrative sphere and communicate with each other (Dawes et al., 2016; Lindman et al., 2016; Zuiderwijk et al., 2016).

3.4   Interactions between Spheres

According to the IIE model, interactions must take place between the different spheres in order for cities to attain their desired objectives. In Figure 1, we illustrate these interactions in several ways. First, between

each sphere, we include the advocacy and interaction process, which comprises elements such as advocacy for greater openness, demand for data-driven products and services, enhanced public discourse, and consultative processes related to developing and enhancing the open data initiative (Dawes et al., 2016; Lassinantti et al., 2019). Second, although we situate the main actors (in boxes) in their primary sphere of engagement, the fact that the boxes cross different spheres' boundaries reflects the actors' ability to take actions in other spheres. Finally, the open data platform resides at the center of the model where the spheres overlap. The open data platform that comprises IT and IS artifacts, data, processes, and people constitutes the IIE model's tangible core (Corbett & Mellouli, 2017). Without the open data platform, the open data ecosystem would not exist. Different actors' interests and the cumulative decisions related to the open data initiative become inscribed in the open data platform (Orlikowski & Iacono, 2001), which then can anchor the open data ecosystem by guiding, constraining, monitoring, and legitimizing their behaviors (Robey, Raymond, & Anderson, 2012).

4 Methodology

We conducted a longitudinal, archival analysis of three Canadian cities that many recognize as open data leaders. We considered each city to be a case and relied on public documents to explore actors' behaviors in and across the different spheres and, thus, to develop new theoretical insights. When conducting longitudinal case studies, researchers must address issues related to time unit validity, time boundaries validity, time period validity, and timeline reliability (Street & Ward, 2012). We summarize the steps we took to ensure high methodological rigor when designing our research and collecting and analyzing data in Table 4.

Table 4. Measures Undertaken to Assure Rigor in the Research

Research phase	Implementation in current research
Research design	We clearly defined the research question and specified a model with constructs of interest a priori. We adopted a multiple case study design with literal replication logic. We used secondary data to ensure we could reproduce the proper sequence of events and surrounding context (timeline reliability). We defined cases as cities and described the context in detail. We analyzed data at the actor level. Multiple investigators performed different roles.
Data collection	We described our data-collection process in detail. We systematically applied search criteria for each case. We set a start date of January, 2000, to collect data to ensure we collected all relevant papers related to the initiatives (time boundary and time period validity). We consolidated data for each case into files (Word and NVivo database) for analysis.
Data analysis	We described our analytic process in detail. We used a conceptual framework as a guide to determine the spheres in which different activities and events took place. A second member of the author team conducted coding and reliability checks. We prepared data displays in form of timelines. We placed key events on a timeline as they naturally occurred to provide visibility into the natural rhythm and evolution of the open data initiatives (time unit validity). We conducted in- and across -case comparisons. We (the four authors) discussed how we analyzed each city and evaluated actors until we reached consensus. Two independent subject matter experts familiar with the initiatives validated the list of 30 key actors. We demonstrate chain of evidence with quotes. We emailed advance copies of the conditionally approved manuscript to the mayor's office in all three cities to verify the material facts in the case studies.

Recommendations based on Dubé and Paré (2003) and Street and Ward (2012)

4.1 Case Studies

We purposely chose the three Canadian cities for the cases following a literal replication logic under which we could expect similar results between the cases (Dubé & Paré, 2003). Canada has significantly invested in open data initiatives at all governmental levels and ranked second in the 2016 Open Data Barometer (Open Data Barometer, 2017). As our research focus relates to cities, we selected three top-ranked open data cities in Canada from the 2016[1] Open Cities Index (OCI): 1) Edmonton, 2) Toronto, and 3) Montreal (Public Sector Digest, 2017).

Edmonton is the capital city of the province Alberta and the fifth largest municipality in Canada. In 2016, the city had around 1.3 million people in its metropolis. The city is a major hub for the oil and gas industry

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[1] The latest year for which rankings existed when we conducted our study.

and a major economic center for Alberta. Edmonton officially launched its open data catalogue in January, 2010. During the analysis period, Edmonton claimed the top spot in the OCI rankings for three years in a row from 2015-2017, which means it ranked as the top open data city in Canada during this period.

Toronto is the capital city of the province Ontario. With a population of 2.7 million people in the city and a greater metropolitan population of 5.9 million people (2016), Toronto is Canada's largest city based on population. This multicultural city has a diversified economy and is a global center of business, finance, arts, and culture. Toronto launched its open data portal in November, 2009. From 2015 to 2017, Toronto ranked second on the OCI rankings.

Montreal is the largest city in the province of Quebec and the second largest in Canada based on population. In 2016, the city had a population around 1.7 million in its metropolis and 4.1 million people in the larger metropolitan area. The city's official language is French and most residents speak the language at home. Montreal has a diversified economy with particular emphasis in aerospace and transport, finance, pharmaceuticals, technology, arts and culture, and tourism. Montreal launched its open data portal in October, 2011, and its position on the OCI index has varied: the city ranked tenth in 2015, rose to third in 2016, and then dropped to seventh in 2017.

4.2   Data Collection

We used secondary data in the form of publicly available articles as our primary information source to develop our case studies. As Street and Ward (2012) point out, timeline reliability poses an important concern in longitudinal research because it should objectively represent past events and their relevant context. Since we focused on exploring actors' behavioral engagement in and across the three spheres over time, we needed to consider a time period that lasted almost 10 years. The three cities launched their open data portals between November, 2009, and October, 2011. As a result, many key actors involved in initially launching and developing these initiatives no longer worked on them. For the participants who still worked on them, they could have had diminished recollections about the events due to the time lapse or recall bias (Leonard-Barton, 1990). In contrast, one can access published articles through electronic databases, and they provide a permanent historical account of major events. Actors' comments in these accounts should accurately reflect their positions at that time without influence from hindsight. We also chose to use archival data since we focused on comparing experiences between cities. By drawing on secondary data from a leading archival database, we could apply a consistent data-collection approach across all cities. Finally, the media plays an important role in disseminating political information and business news as cities use news media to convey relevant news and information to their residents (Lindgren, 2015). News media can lower the price that citizens incur to access political information (Schulhofer-Wohl & Garrido, 2013) and can shape how people understand a new corporate practice (Grafstrom & Windell, 2011). Therefore, examining how the open data initiatives evolved through the lens of traditional media including local, national, and international newspapers represents an appropriate strategy and would allow another researcher looking at the same phenomenon to "uncover the same events, in the same sequence and within the same timeframes" (Street & Ward, 2012, p. 169).

We identified potential articles using the Factiva database. To do so, we combined each city's name with "open data" as key words for the period from January, 2000, to December, 2017. We used January, 2000, as the starting point to ensure we captured the first and all subsequent articles on open data in the cities (the first articles appeared only in 2009). For Montreal, we searched for articles in both English and French. For the searches in French, we used the name of the city in both French and English (i.e., Montréal and Montreal) combined with the French equivalent of open data (i.e., "données ouvertes"). From these three searches, we initially obtained 2,218 articles in total. Factiva automatically identified and removed 682 duplicates, which left 1,536 articles for further analysis. Next, we ensured the articles' relevance by verifying that they provided information that specifically pertained to the focal city's open data initiative. The articles were divided into two groups. For the first group, the first author performed the initial screening for inclusion. For the second group, the second author performed the initial screening. In both cases, the author first rapidly screened and then more thoroughly examined the articles to ensure their appropriateness for inclusion (Kitchenham & Charters, 2007; Templier & Paré, 2015). In this step, we removed 988 articles that did not specifically relate to open data in Edmonton, Toronto, or Montreal or that duplicated other articles that Factiva did not previously identify. To validate the final article set, author who had not done the initial screening reviewed the remaining papers. The two authors involved in the screening discussed any disagreements until they reached a consensus. As a result, we removed 186 additional articles, which left 362 articles in our final sample (see Table 5).
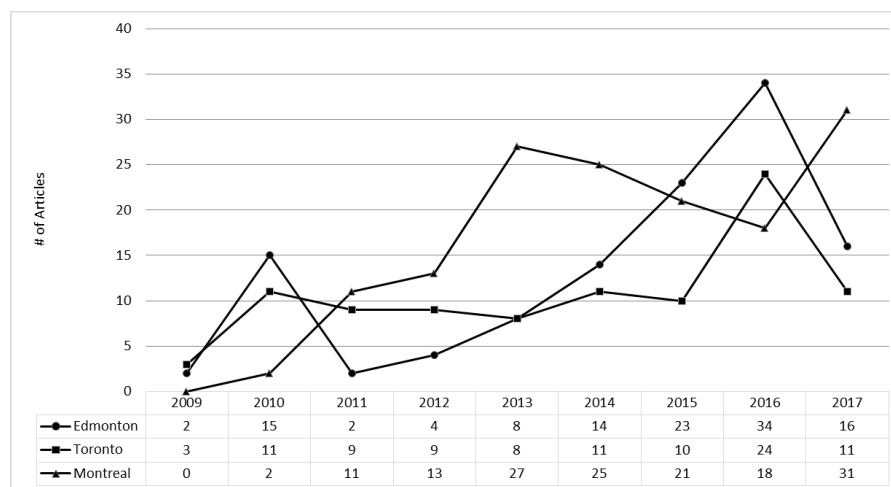
Table 5. Summary of Data Collection

	Total	Edmonton	Toronto	Montreal
Total articles retrieved	2218	461	947	810
Factiva duplicates removed	682	155	300	227
Articles removed (initial screening)	988	147	481	360
Articles removed (secondary screening)	186	41	70	75
Final sample	362	118	96	148

As Figure 2 shows, almost half (49%) of the articles targeted a local audience. A slightly smaller percentage (47%) provided national-level exposure to the cities' open data initiatives, which included articles in national news outlets and articles in a local newspaper in a different city. A small percentage (4%) of the articles appeared in outlets that offered international exposure.
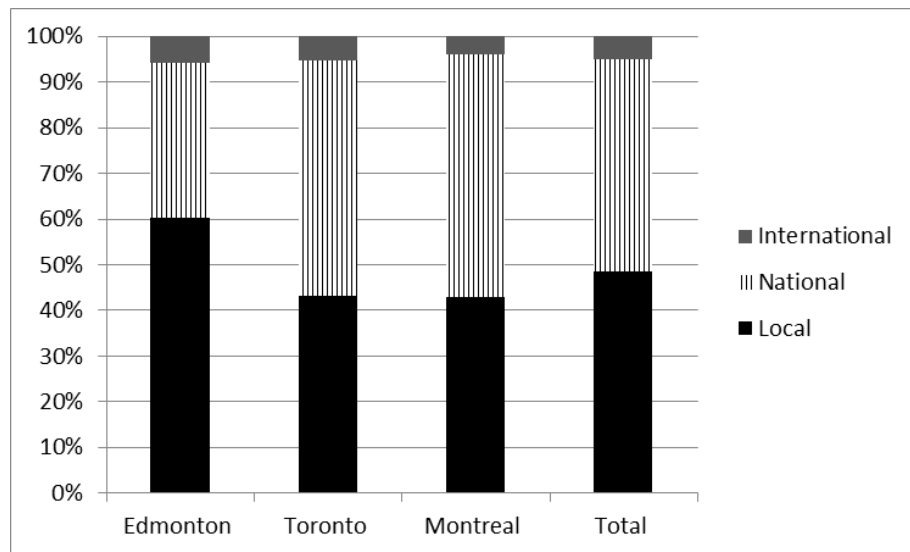
Figure 2. Percentage of Articles by Exposure Level

We show the distribution of the published articles per city according to their publication date in Figure 3.

	2009	2010	2011	2012	2013	2014	2015	2016	2017
Edmonton	2	15	2	4	8	14	23	34	16
Toronto	3	11	9	9	8	11	10	24	11
Montreal	0	2	11	13	27	25	21	18	31

Figure 3. Number of Articles Published Per Year

4.3   Data Analysis

After collecting the articles, we proceeded to analyze them in three stages as we illustrate in Figure 4. In the first stage, we conducted descriptive coding (Miles, Huberman, & Saldana, 2014) using the data analysis software NVivo. We grouped excerpts under overarching themes related to the open data initiatives' "what" (i.e., data content, value, and impacts), "when" and "how" (i.e., events, activities), and "who" (i.e., actor types). We conducted coding at the sentence level to ensure we fully captured excerpts' meaning. We coded a single data excerpt to as many categories as appropriate (e.g., to multiple stakeholders involved in a particular event). A research assistant initially coded the articles. Then, one of the authors reviewed and editing the coding. We (the four authors) and the research assistant resolved coding disagreements via discussion. We present the coding scheme in Appendix A.
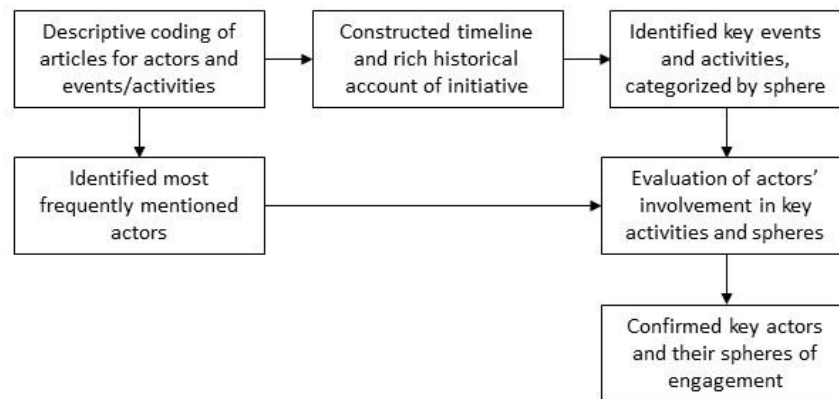

Figure 4. Steps in Analytical Process

In the second stage, we developed time-order matrices (Miles et al., 2014) for each city to investigate key events, activities, and milestones; create detailed timelines and rich historical accounts; and explore the way in which each city's open data initiative evolved.

In the third stage, we focused on the key actors and actor types that contributed to major events in each city. For each city, we began by identifying the people and organizations that played pivotal roles based on the frequency with which they appeared in the data and qualitatively gauging the extent to which they participated in an important event in the city's open data initiative. For the first criteria, we exhaustively listed all actors that we identified at least once in the data. We then sorted that list in descending order so that we ranked the most frequently mentioned actor first. From this ranking, we extracted the 10 most frequently mentioned actors from each city. To validate this list, we contacted four independent subject matter experts with knowledge of and familiarity with the open data initiatives. We gave each expert the list of 30 actors and asked them to rank the actors in order of importance or to add additional names as appropriate. Of the four experts, two responded and provided rankings, which generally concurred with our own.

For each person or organization on this list, we examined the articles that mentioned them. Using the conceptual model (see Figure 1) as a guide, we assessed whether the actors' activities took place in the sustainability, political, or administrative spheres. During this analysis, we allowed for activities and events to occur across multiple spheres depending on their nature and objectives. By conducting this detailed analysis, we could evaluate the extent to which each actor contributed to the open data initiative and whether the actors involved operated in a single or multiple spheres. In this way, we could identify whether the actors helped to integrate processes across spheres. Based on the two criteria, we did not consider people whose name appeared often (such as a mayor) as key actors if they simply lent their name to a press release. On the other hand, we considered actors with few mentions as key actors if they were involved in events or activities that we considered significant to the open data initiative. Thus, we reduced the list from 30 key actors to 15 key actors: five from Edmonton, seven from Toronto, and three from Montreal[2]. Finally, we regrouped these actors into categories based on their role, sector, or activity to provide a higher level of generalization. We discuss the detailed results in Appendix B.

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[2] We disguise individuals' names. However, we do not change organizational actors' names (businesses, community groups).

5 Results

Our results confirm that many different actors are needed to ensure the success of open data initiative. In Sections 5.1 to 5.3, we describe how each open data initiative evolved. Then, we explain how actors engaged in and across the three spheres of engagement to help the open data initiatives succeed.

5.1 Edmonton's Open Data Initiative

The first reference to Edmonton's open data initiative occurred in 2009 (see Figure 5). Prior to the open data catalogue's official launch, the city consulted with diverse stakeholders to gather the community's needs and experimented with different ways of making data available. These efforts created interest in open data and helped to solidify Edmonton's vision to use open data to improve transparency and city management. Following the portal's launch in January, 2010, Edmonton regularly published new data sets and attained 415 datasets by 2014, 700 by 2015, and about 1000 by early 2016.
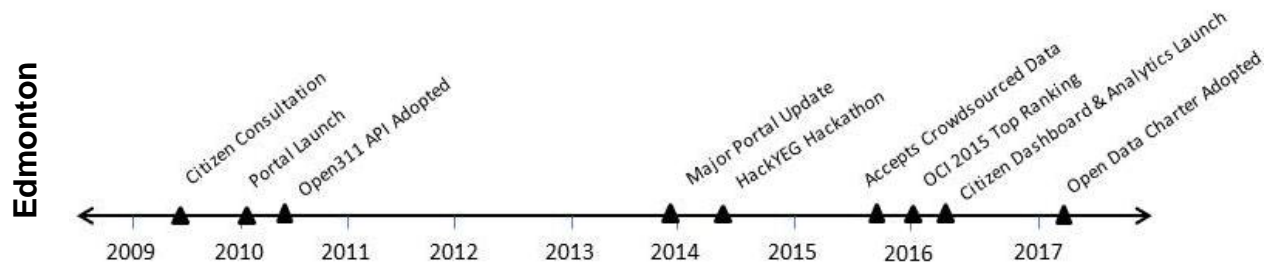

Figure 5. Timeline of Edmonton Open Data Initiative

Shortly after the launch, Edmonton worked with other municipalities to adopt the Open311 format related to service requests[3]. The city also held contests and annual hackathons to involve individuals and businesses in developing open data applications. During this time, everyday Edmontonians mostly focused on using open data in areas that directly affected their lives, such as transit, restaurant inspections, and property information. These applications validated the potential for open data and enhanced community engagement, which Edmonton recognized as being vital for success.

In late 2013, Edmonton introduced its next-generation open data portal, which included a citizen dashboard that provided real-time data on the city's activities and responses to requests. External stakeholders started to form their own communities, initiated open data events in parallel with the city, and even collected and created new data sets. Whereas the preceding years mostly involved the city's efforts to "push" open data, increased efforts from the community to "pull" data from the city began from 2014. For instance, the community group HackYEG organized its first hackathon in May, 2014. Although the event had a similar format and objectives compared to city-sponsored hackathons, as the first citizen-organized event, it represented a key milestone in Edmonton's open data evolution. As a second notable milestone, the city began to accept data from non-government sources and citizens. In May, 2015, Edmonton residents used a smartphone application to collect information on bike rack use in the city. The residents created this data set, which spanned more than six months, to not only persuade the city to install more bike parking facilities but also enrich the city's store of open data. This data's availability caused the city to rethink how it would accept, publish, and incentivize crowdsourced data because the city placed a high importance on the quality of its open data. Proponents argued that crowdsourced data would, among other things, help increase citizen data literacy, contribute to the development of impactful citizen services, and improve municipal decision making.

In January, 2016, Edmonton released an updated version of its open data catalogue with about 1,000 datasets that mostly had a machine-readable format, an application programming interface (API), and data-visualization options. In doing so, the city demonstrated both its commitment and capability to publish open data. Around this time, Edmonton received the 2015 OCI top ranking among Canadian cities. In conjunction with the new portal, Edmonton launched its Analytic Centre of Excellence's Open Analytics

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[3] In Canada and the United States, 311 calls refer to calls to municipal services of a non-emergency nature. Open311 is an open technical standard that allows cities to report, track, and share information regarding their services.

website that provided tools such as step-by-step tutorials, project showcases, and interactive data visualizations that allowed citizens to use open data and gain their own insights. With these tools, citizens without technical skills for building applications or processing raw data could more directly use open data and reduce their reliance on intermediaries.

Having worked to make an enormous amount of data available to external stakeholders, Edmonton began to recognize this data's value for the city's own purposes. Accustomed to producing siloed data, Edmonton found that it could share open data internally and that its municipal departments could use it to improve operations and services, such as reducing the driving time for turf maintenance (by combining park maintenance with road and traffic information) and addressing emergency security concerns. The city created a team that comprised data scientists and analysts in 2016 to help city staff benefit from the available data. As a result, Edmonton started using open data in operationally and strategically managing the city, such as determining healthcare needs and developing better approaches to policing and safety. Finding internal uses for the open data also contributed to improving the city's direct return on its investment. Continuing its path of leadership, in early 2017, Edmonton became the first Canadian city to adopt the Open Data Charter.

5.2   Toronto's Open Data Initiative

The Toronto media first used the term "open data" in January, 2009. At this point, the city of Toronto was just beginning to develop its vision for open data. The city took preliminary steps to open up its data: as Figure 6 shows, Toronto launched its open data portal in November, 2009. Subsequently, in April, 2010, it consulted with citizens about the potential for an open data policy. Citizens (including independent developers and the media) demonstrated their interest in open data and willingness to participate in building applications. In parallel, one of the city's main services, the Toronto Transit Commission (TTC), installed global positioning system (GPS) trackers on its streetcars and buses with a promise to make such data open and available in machine-readable formats. In December, 2010, the city held the first-ever Canadian Random Hacks of Kindness hackathon. By February, 2011, Toronto along with Edmonton, Ottawa, and Vancouver had become known as Canada's G4 of open data (Hutton, 2011).
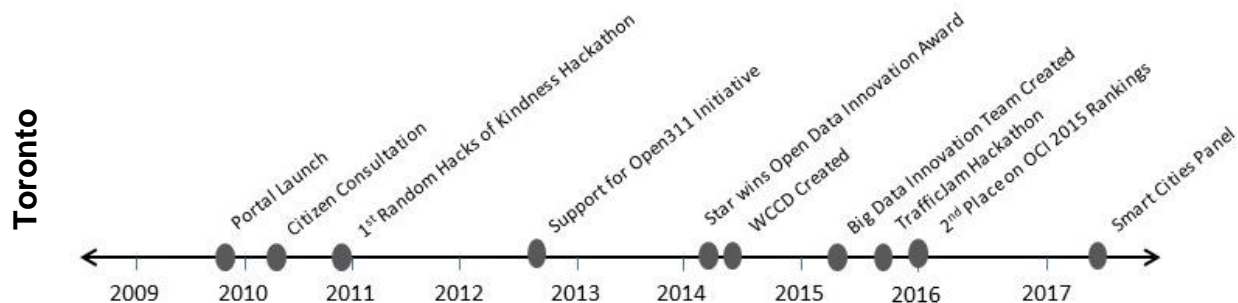

Figure 6. Timeline of Toronto Open Data Initiative

In the following years, independent developers and software companies began to rollout new applications using open data. In October, 2012, Toronto announced a plan to encourage software developers to create applications for the Open311 initiative. Three major third-party developed applications released during this phase included "What Toronto Said", which provided a more user-friendly interface for searching information from public consultations, DineSafe, and ParkInToronto. These initiatives had two common objectives: to put more information in the public's hands and to gently pressure the city to continue to publish data. Researchers and the Toronto media became more engaged in using open data to inform their activities. For instance, *The Toronto Star* used open data to analyze the number of registered lobbyists in the city, and its webpage that presented this information won the Canadian Open Data Innovation Award in February, 2014.

The 2014 municipal election campaign triggered discussions around open data as several candidates emphasized its importance, promised to increase open data publication, and suggested startup companies be paired with city departments to create new services, ideas, or applications using open data. In May, 2014, 14 organizations, including the City of Toronto, created the World Council on City Data

(WCCD). This Toronto-based organization placed Toronto on the open data world stage. Later in the year, the WCCD released standardized indicators to measure the performance of municipal services and quality of life and launched a new open data portal to help cities share information.

By early 2015, Toronto's investments in the open data initiative started to bear fruit not only via improving citizens' lives through transit and parking applications but also helping the government manage the city more effectively and improving services' quality. In April, 2015, the city announced would create a big data innovation team to find ways to improve traffic in the city, an ongoing source of discontent among city residents. Citizen dissatisfaction led to several different open data initiatives throughout 2015. In April, 2015, the media suggested Toronto should adopt an opt-out policy towards open data so all city data would be open by default. In addition, ongoing concerns regarding traffic problems in the city lead to a two-day hackathon called TrafficJam in October, 2015.

Despite continued support for open data from elected officials and the city's efforts to release additional data and applications, people frustrated with the open data's low quality and quantity criticized the city throughout 2016 and 2017. Responding to these criticisms, the city convened a panel in May, 2017, during which city officials, academics, and businesses discussed open data's benefits and challenges. Independent research that *The Toronto Star* published in October, 2017, highlighted the community's concerns and dissatisfaction: contrary to a promise to double the number of datasets available each year, they had increased by only 55% between 2014 and 2017. Despite these challenges, Toronto retained its position as the second ranked open data city on the OCI in 2016.

5.3 Montreal's Open Data Initiative

Of the three cities, Montreal launched its open data portal last (see Figure 7). Prior to the launch, pressure for open data came predominantly from community groups, such as "Montreal Ouvert" (Open Montreal). Montreal Ouvert was formed in August, 2010, and organized the city's first data hackathon in January, 2011, as a way to pressure the city to adopt the open data concept. The group primarily promoted open data's economic (e.g., growing business in the city, improving city efficiency, and enhancing decision-making) and political benefits as a means to reduce political corruption[4] through greater transparency and to improve citizen participation.
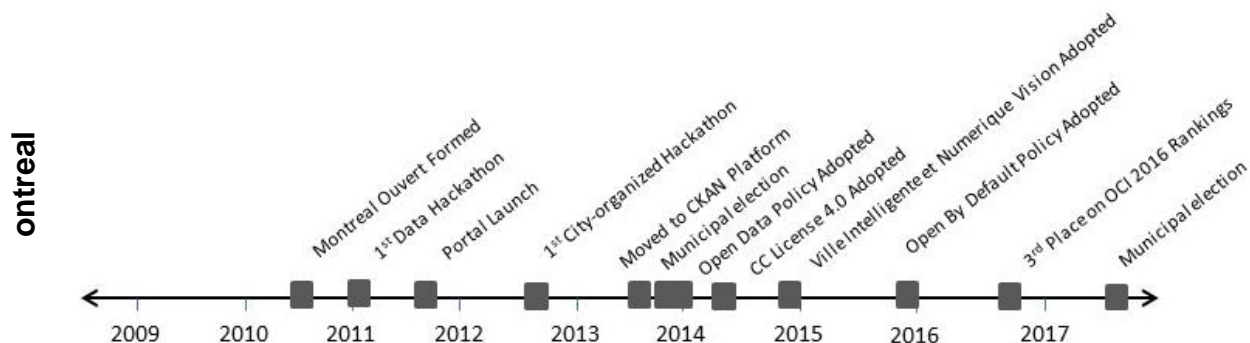

Figure 7. Timeline of Montreal Open Data Initiative

In October, 2011, Montreal launched its open data portal. Subsequently, the city incrementally improved its platform by releasing new data. The city and the development community also created new applications based on open data. City administrators emphasized that Montreal should not simply follow current trends or technology fads in its open data initiative but develop a model based on thoughtful reflection. Key actors including Montreal Ouvert who stressed the importance of creating value supported this measured approach. Various actors took steps to build the open data catalogue and foster its usage. Montreal Ouvert and other organizations (e.g., colleges and universities) sponsored hackathons with the first city-organized event taking place in May, 2012. The city used these events to announce the release of new data sets. Areas that attracted the most interest included transit, urban planning and architecture,

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[4] From 2011 to 2015, the Charbonneau Commission investigated corruption in Quebec public construction contracts. For more information, see https://www.ceic.gouv.qc.ca/ (in French).

urban agriculture, and sustainable development. To support the growing dataset catalogue, in October, 2013, the city moved to a new open-source platform called CKAN that the Open Knowledge Forum had developed. Coincidently, around this time, open data attracted substantial media attention. The city was in the midst of a municipal election campaign during which the incumbent administration received criticism for its lack of transparency. In November, 2013, a new administration entered office in part on the promise to do more to accelerate the growth of open data in the city.

Meanwhile, in late 2014, Montreal launched a new vision: "ville intelligente et numérique" (smart and digital city). This new vision situated open data not as a discrete initiative but in a portfolio of other IT projects. The city continued to improve and evolve its open data platform, released new datasets and visualization tools, and organized hackathons focused on specific subjects and concerns. As the strategic vision for Montreal as a smart city started to take prominence, discontent re-emerged. Beginning in late 2015, criticisms began to mount, which included questions about whether the open data movement had actually led to greater transparency. This topic became a hot one in the 2017 municipal election campaign. In November, 2017, a new administration entered office, which set the stage for another phase in Montreal's open data evolution.

5.4   Actors' Engagement in and across Spheres

The previous case descriptions highlight that each city followed a different path to open data success. Despite commonalities in the types of actors involved, we observed variations in different actors' importance and their participation in the three different spheres (see Appendix B). In Edmonton, we identified five key actors. Among these five, we found that the city's information systems (IS) branch led efforts to develop its open data vision. Initially, open data did not constitute a politically contentious topic, and key political leaders supported it. The city's open data strategy strongly emphasized building an external developer community; thus, Edmonton invested significant efforts in promoting open data through consultations and hackathons. Over time, the technology community accumulated expertise and began to take on a more active role. Community groups eventually formed, started to demand different types of data, and engaged in crowdsourcing to create new datasets. As the open data initiative matured, Edmonton extended its analytic capabilities to offer more value directly to data users.

Among the three cities, Toronto had the largest number of key actors (i.e., seven). Initially, a small group of open data enthusiasts in the city's IT department responsible for open data helped to define the city's vision. Other Toronto city services that endeavored to publish valuable data to users supported their efforts. As the open data initiative progressed, the developer community became more active, built applications, and pushed the city to make more data available. Dissatisfaction in the community led to greater pressure in the political sphere. In 2014, the hotly contested municipal election campaign and the WCCD's creation meant that Toronto found renewed interest in and committed more to open data. This support lasted until around 2016 when the community again began to express its discontent at the pace of improvement in Toronto's open data portal. Throughout the Toronto's open data portal's evolution, the local media played an instrumental role in publicizing new data and application releases, using the data, contributing to the political discourse, and suggesting alternative visions for open data and smart cities.

Montreal had the lowest number of key actors (i.e., three). Community groups played a central role as the primary advocates for open data. Montreal had a politically charged experience from the beginning. Open data as a means to combat political corruption constituted a major issue in the 2013 municipal election. Following this election, an executive council member took over responsibility for the smart city and open data initiatives. Under this political direction, the city's open data portal grew rapidly, which allowed it to attain the third place ranking in the 2016 OCI for Canadian cities. Subsequently, political challenges, changes in priority, and a restructured community group seemingly contributed to slowing Montreal's open data initiative's progress over the last two years.

Looking across the three cities, we found that some actors, such as city administrators and political leaders, acted principally in a single sphere (administrative and political, respectively). Other types of actors, such as entrepreneurs and developers in the technology community, spanned two spheres (most commonly the political and administrative spheres). These actors integrated capability building in the administrative sphere and shaped the discourse and priority setting in the political sphere in their respective cities. Finally, we identified three types of actors—IS teams, the media, and community groups—who engaged and interacted across all three spheres. In Sections 5.4.1 to 5.4.3, we describe how these three types of actors used different activities, events, and processes to create linkages between spheres and shape their city's open data initiatives.

5.4.1 IS Branch in Edmonton

Edmonton's IS branch played a central role in the open data initiative because it spanned all three spheres of engagement. Senior IT managers (e.g., chief information officer, chief analytics officer, and director of open data program) had high visibility in the city's open data initiative (see Appendix B). In the early years, the IS branch operated in both the political sphere and administrative spheres. In the political sphere, the CIO served as the main spokesperson for the city, and the press frequently quoted him. Prior to the portal launch, Edmonton's IS branch organized consultations with city residents to better understand what the community wanted while insisting that the requirements had to be practical (O'Donnell, 2009). This activity exemplifies the importance of engagement in the political sphere to specify the priorities for a city given its particular context and goals.

Following the portal launch, in late 2009, Edmonton invested considerable efforts in building its open data capacities and ecosystem. The IS branch organized several hackathons and app contests. In the Apps4Edmonton contest in July to September, 2010, winners received prize money and had the chance to present their work at GTEC (Canada's government technology conference). Developers could also keep the rights to their applications and sell them commercially if desired (Loyie, 2010). The Apps4Edmonton and similar events primarily served the administrative sphere by building usable and useful tools and applications. However, by promoting Edmonton's talents on the national stage, the events also reinforced a key priority set in the political sphere to establish Edmonton's leadership position in open data.

Two events in October, 2010, demonstrated the IS branch's participation in the sustainability sphere. First, the CIO participated in a GTEC panel in Ottawa where he said: "I think the problem we're trying to solve is to demystify government. It's about a different form of engagement." (Bostelaar, 2010). This comment shows that the CIO did not view open data as simply a technical exercise but as a mechanism for addressing broader societal concerns and changing patterns of communication, engagement, and governance. Second, Edmonton co-hosted the Beyond 2010 event simultaneously with Seoul, South Korea, and Birmingham, UK. The conference focused on how governments could better harness emerging technology, public information, and social media systems to engage residents in their city (Gerein, 2010). From descriptions of the event, it appears Beyond 2010 simultaneously brought together elements of all three spheres: in the sustainability sphere, the conference explored big questions about technology, data, and cities; in the political sphere, Edmonton's participation put it in elite company of other major international cities, which meant the conference supported political objectives; and, in the administrative sphere, the hackathon portion at the event offered the community an opportunity to develop applications or services to unlock the potential for open data.

Throughout 2011 and 2012, Edmonton's IS branch continued to work in and across the three spheres. These efforts were recognized in an international press article that featured Edmonton as an exemplar open data city (Brown, 2013). The following quote from the city's chief information officer related to the International Open Data Day Hackathon evidences the Edmonton's IS branch's sphere-spanning perspective:

> The 900,000 Edmontonians who are not here today are not sitting at home and saying "I wish the city would release more data". These people are part of helping us figure out what information we have that would be useful to not just them, but to other citizens…. While all of the participants are civic-minded, there is an opportunity to turn the data into dollars…. People might say, "Aren't you concerned people will take your data, make an app and make money?" And I'd say no, I call that economic development…. (Zabjek, 2014)

From this quote, we observe the importance of the administrative sphere as the CIO speaks about figuring out what information is useful to all citizens. In addition, assuming a role in the political sphere, the CIO tries to rally support for open data by turning the discussion away from personal gain to the more positive view of economic development in the city, which aligns with a more global vision of open data found in the sustainability sphere.

5.4.2 The Media in Toronto

In Toronto, we found the local media played a central role in the city's open data evolution. From 2010 to 2017, the local newspaper and online news outlet *The Toronto Star* published 32 articles related to open data and assumed various roles that spanned all three spheres.

From 2010 to the end of 2013, *The Toronto Star*'s publication activities mainly supported goals in the administrative sphere. Initially, the media outlet acted as a data user and infomediary. Journalists performed analyses and investigations using available open data. In December, 2010, *The Toronto Star* published its first article that mentioned open data. Specifically, the article analyzed open data from 311 calls to map the main complaints that the city received. A couple of years later, *The Toronto* Star used open data in investigating lobbying activity in Toronto. During that investigation, it created an application called "Lobby Watch", which received the Canadian Open Data Innovation Award for its outstanding contribution to open data in February, 2014 (Ferenc, 2014). During this period, *The Toronto Star* also served as an important data communicator via informing citizens about applications or website releases related to various aspects of their lives, such as transit and traffic issues (e.g., Rocket Radar), dining (e.g., DineSafe), and real estate (e.g., Wellbeing Toronto). *The Toronto Star* also publicized events related to open data. The articles had a positive tone and included quotes from developers that promoted these services' advantages and value. Through its journalistic activities, *The Toronto Star* contributed to democratizing data and developing capability the Toronto open data ecosystem.

Next, *The Toronto Star*'s involvement expanded into the sustainability sphere. In December, 2013, it published an article entitled "Smart Cities: Hype or Hope?" that made a compelling argument for individual developers to participate in creating innovations and building applications to allow residents to practically use open data. The article suggested advanced computer simulations and analytics could make city data valuable by revealing broad underlying patterns, optimizing city operations, and making the city "designable" (Lorinc, 2013). These types of questions and long-term visioning characterize the sustainability sphere.

The Toronto Star also became more active in the political sphere by writing about political promises and actions, community complaints, and expert opinions on open data. For instance, it reported on individual citizens' frustrations about, for example, registering for city activities through the FUNportal, insufficient available data, and relayed requests for machine-readable formats to allow developers to develop better tools. One article directly targeted mayoral candidates regarding the FUNportal and suggested candidates could win the vote from thousands of city parents with a promise to improve the system (Keenan, 2014).

The Toronto Star's influence in Toronto's open data initiative peaked in 2016 when the media outlet published eleven articles on open data. Five such articles engaged in the sustainability, political, and administrative spheres by discussing open data's impacts and how open data could contribute to the future of smart cities and improved municipal services. One article reflected on the future of policing through using new technologies (including open data and computer analytics) and presented the advantages and controversies regarding such technologies (Ballingall, 2016). Three articles discussed open data's value in the context of global sustainability issues. Finally, one article discussed how open data could change the way we live and learn and advanced the view that people have the ability to use large amounts of data in sophisticated ways for commercial purposes but that they should also use this approach to "flip the balance of power and make data a tool for public good" (Battersby, 2016).

5.4.3   Community Group in Montreal

In Montreal, the community group Montreal Ouvert played a central role in advancing the city's open data initiative as its activities provided linkages across the three spheres. The group argued Montreal should join the open data movement and mounted a public campaign to pressure the city to publish more data (Magder, 2010). Although the group ultimately wanted to make open data available to build applications (administrative sphere activity), it positioned open data as a "natural resource" (sustainability sphere activity) and tried to establish open data as a priority to potentially create jobs (political sphere activity) (Gyulai, 2010). In November, 2010, Montreal Ouvert also used competitive pressure to push for an open data policy by suggesting Montreal was falling behind other cities—"especially if Montreal is trying to position itself as a tech hub with the gaming industry and software" (Gyulai, 2010).

Throughout 2011, before and following the launch of Montreal's open data portal, Montreal Ouvert hosted three hackathons. The third one, held in November, 2011, to mark International Open Data Day, coincided with Montreal's release of new data sets related to its library, and more than 150 people attended it. Individuals developed various applications, such as ZoneCone.ca (trip planner), Resto-Net.ca (restaurant hygiene infractions), and PatinerMontreal.ca (skating rinks), during this event. According to Montreal Ouvert, the hackathon's success proved Montrealers were ready to work collaboratively with the city to improve their quality of life. These events showed that open data could stimulate citizen engagement, make services more accessible, and enable innovation (Ville de Montréal—Cabinet du Maire et du comité

executif, 2011). The efforts that Montreal Ouvert undertook demonstrated the advantages that one can obtain from integrating activities across the administrative and political spheres: building useful applications based on published data to create political support for open data. Indeed, Montreal Ouvert's co-founder said:

> The key thing for next year is to show the value of data…by continually putting out useful applications with data. It puts governments in a position where they can't cut (open-data initiatives). It's the responsibility of the movement to prevent that. (Rocha, 2011)

In February, 2012, Montreal Ouvert embarked on a new direction by founding "Quebec Ouvert" (Open Quebec), a consortium of community groups from Gatineau, Quebec City, and Montreal. This effort demonstrates how community groups can participate simultaneously in the sustainability, political, and administrative spheres. Together, Montreal Ouvert and Quebec Ouvert elevated the discourse around open data by focusing on sustainability issues, such as government corruption and transparency. In November, 2012, Quebec Ouvert organized a hackathon to tackle city corruption in Montreal. This event, which over 100 people attended, resulted in tools for identifying potential corruption as part of the administrative sphere and directly influenced the political sphere by shaping the discourse, encouraging citizen engagement, and establishing trust in the city (Shingler, 2012).

As a final notable contribution, in February, 2014, Montreal Ouvert organized various workshops that involved municipal employees, developers, and individual citizens. Many viewed this event as a key turning point in Montreal's open data initiative and a "sign of maturing relations between the city and its citizens. 'It was a clear indication to us that this administration is serious about open data'" (Rocha, 2014). Finally, it seems both elected officials and city administration had adopted open data as a priority. The change in priority corresponded with a new mayor's election, which led to subsequent investments in Montreal's smart city and open data initiatives and the appointment of an executive committee member to oversee administrative reform.

6   Discussion

The ecosystem perspective has become a valuable lens to understand open data initiatives' design, evolution, and success (e.g., Harrison et al., 2012; Styrin & Dmitrieva, 2017; Zuiderwijk et al., 2016). By exploring diverse actors' activities and roles in open data initiatives over time, we enhance this literature. Based on our results, we present a revised model in Figure 8. From the case studies, we observed political leaders will most likely engage in the political sphere and then the sustainability sphere. In contrast, employees in the city, the technology community that comprises application developers, and citizens as open data consumers will most likely participate in the administrative sphere. We can explain these natural tendencies based on the fact that most actors possess the motivation, skills, capacities, or power required for a subset of open data processes (Gonzalez-Zapata & Heeks, 2015) or roles. Nevertheless, these actors need to contribute to open data initiatives for them to advance.

We also observed that actors do not have fixed tendencies to engage and participate in certain spheres. A particular actor may take on different roles as open data initiatives evolve (as we illustrate with the grey double arrows in Figure 8). For instance, in both Edmonton and Toronto, application developers who initially participated primarily in the administrative sphere later became open data activists who operated primarily in the political sphere. Based on our data, we could not explore the underlying reasons for these transitions, but we suppose the individuals' personal interests and the open data initiatives' maturity contributed (Dodds & Newman, 2015; Lee & Kwak, 2012). Actors have dynamic roles, and, as they adjust their roles, the impacts flow down to other elements of the open data ecosystem. Thus, understanding how an open data ecosystem works depends on solidly comprehending the different subsystems and actors that interact in it (Ubaldi, 2013).

Drilling down into each of the spheres of engagement, all key actors participated, at least to some degree, in the administrative sphere. Extensive research has already examined the activities in this sphere in which data publication (Susha et al., 2015), data preparation and cleansing (Lindman et al., 2016; Welle Donker & van Loenen, 2017), data analysis (Cabitza et al., 2018), data interpretation, and feedback (Sayogo et al., 2014) constitute the main processes. This sphere plays an essential role in efforts to build the capabilities necessary for open data initiatives. However, capability-building activities extend beyond city administration and also include other ecosystem members. Edmonton, for example, emphasized building the open data technology community during the earliest stages of its open data initiative because it recognized that it could not sufficiently realize substantial long-term value just by making data available.
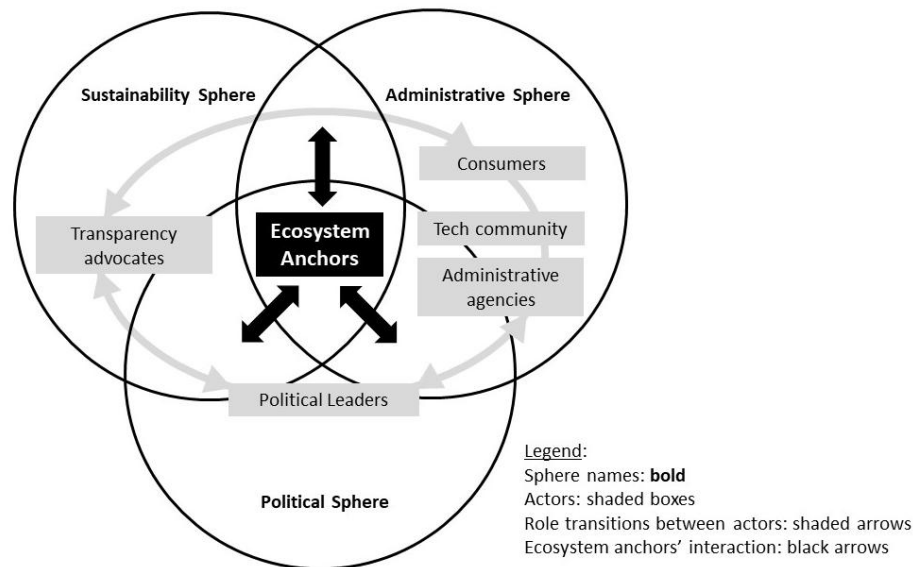
Figure 8. Ecosystem Anchors at Nexus of Three Spheres of Engagement (Adapted from Corbett & Mellouli, 2017; Dawes et al., 2016)

In contrast to the administrative sphere, the sustainability sphere had the lowest activity intensity, and no actors engaged solely in the sustainability sphere. The open data literature mirrors this practical reality; indeed, it has made only tentative steps to investigate the national and global trends that influence open data initiatives (Dawes et al., 2016; Lassinantti et al., 2019). At the international level, the United Nations has helped to promote open data and government transparency more generally through the SDGs (United Nations, n.d.-a) and international organizations, such as the Open Data Institute, Open Data Barometer, and Open Data Monitor. These organizations have emerged to direct and assess open data initiatives at a high level. Still, the extent to which the discourse in the sustainability sphere shapes and is shaped by open data initiatives at the local level remains an open question. Despite the important role cities can play with respect to sustainability (Satterthwaite & Mitlin, 2011), bringing global sustainability issues (including those related to open data) to the city level remains difficult. Historically speaking, cities have not focused on defining define sustainability issues but on implementing policies and practices mandated from higher levels, such as international organizations and national governments. The fact that fewer actors from cities participate in the sustainability sphere does not necessarily represent bad news. As we discuss below, the presence of even one actor, an ecosystem anchor, who can cross spheres may be sufficient to move open data initiatives toward successful outcomes.

The political sphere attends to the politics surrounding open data. It helps link the activities between the sustainability and administrative spheres by making the challenges associated with global sustainability issues more actionable in the administrative sphere (Corbett & Mellouli, 2017). Montreal in particular exemplified open data's political nature: its open data initiative featured three periods of intense activity in the political sphere. We also found prevalent activity in the political sphere in Toronto as open data advocates put pressure on elected officials to establish open data as a priority. Whenever a public initiative requires money, political leaders must contend with competing demands (Dawes et al., 2016). Opportunities will always exist to publish more data, to publish data in more accessible formats, to develop more applications, and to make information easier for users to extract. Thus, consumers' and other stakeholders' satisfaction will vary depending on contextual and temporal issues. Two factors simultaneously influence satisfaction expressed in the political sphere: 1) the state of open data initiatives in other cities, which shape the discourse in the sustainability sphere; and 2) local open data applications and experiments that occur in the administrative sphere. As a result, stakeholder feedback to elected officials and city administrators plays a necessary role in advancing open data initiatives (Dawes et al., 2016).

Although each sphere contributes in its own way to helping open data initiatives succeed, the spheres, as subsystems in the larger open data ecosystem, also need to work together in order for cities to reap open data's full potential benefits. In our initial conceptual framework (see Figure 1), we suggest that the open data platform serves this boundary-spanning activity. Our results further suggest certain actors, who we

call ecosystem anchors, also reside at this nexus between the spheres as we illustrate in Figure 8. The ecosystem anchor has a distinct role compared to other actors, but the role does not emerge in a vacuum. As the black double arrows in Figure 8 represent, actors from other roles may become (purposefully or by default) ecosystem anchors as they engage in sphere-spanning activities.

The ecosystem anchor concept in open data is novel, although a similar concept called an anchor tenant exists in the literature on innovation and knowledge ecosystems, such as regional technology clusters (Powell, Packalen, & Whittington, 2012). Institutional anchor tenants have strategic importance in a local community (Culkin, 2016; Malecki, 2018) and facilitate cooperation among actors to improve how well an industrial ecosystem performs (von Malmborg, 2004). These institutions, often universities, provide various resources, such as education and skill training, physical space and infrastructure, and institutional support (Malecki, 2018; von Malmborg, 2004). An anchor tenant can also be essential for building partnerships, generating knowledge, and implementing appropriate rules that help knowledge and business ecosystems grow (Attour & Lazaric, 2018). In knowledge ecosystems, anchor tenants do not normally compete with other players unlike in business ecosystems where large companies may play a dominant commercial role (Clarysse, Wright, Bruneel, & Mahajan, 2014). Although open data ecosystem anchors share some characteristics and take on some roles that anchor tenants have, they differ in notable ways. First, the ecosystem anchors we identified were not large companies or universities but moderately small groups with the interests, skills, and resources to easily move between the three spheres of engagement. Second, the open data ecosystem anchors made contributions less related to physical infrastructure, knowledge, and institutional support and more related to facilitating the dialogue and coordination across the open data ecosystem's sustainability, political, and administrative spheres.

7 Conclusion

7.1 Contributions and Implications for Research and Practice

By combining models on open data ecosystems with the perspective of spheres of engagement, we reveal the deeper complexity of interdependent subsystems that operate in open data ecosystems. The conceptual frameworks (see Figures 1 and 8) provide a new way to look at the interaction between open data stakeholders, processes, and contextual elements and extend insights beyond simply operational roles and processes. We highlight ecosystem actors' importance in building the political will necessary for favorable policies around open data in a specific city context. We also illustrate how actors can engage in the discourse in the sustainability sphere to define open data's social, economic, and environmental dimensions more broadly. Finally, by revealing and defining ecosystem anchors' critical integrating role and potential, we reinforce the socio-technical view of open data whereby both IS artifacts, such as an open data portal, and ecosystem anchors can conjointly shape and stabilize sustainable open data ecosystems.

While we drew on the smart cities literature for the IIE model, the conceptual model we propose and our findings generalize to all types of municipal open data initiatives and possibly to open data initiatives at other government levels. Cities may establish open data initiatives independent of smart city strategies, yet such initiatives still require engagement from stakeholders in the administrative sphere to operationalize open data, in the political sphere to negotiate priorities and resources, and in the sustainability sphere to define the high-level societal goals to be achieved. Further, by combining the IIE model with the literature on open data ecosystems, we contribute back to the smart cities literature by highlighting how actors, through the activities they choose to conduct, can support and span multiple spheres of engagement over time and serve as ecosystem anchors along with technological artifacts.

Our research also informs practice. Our findings reinforce the need for cities to ensure that diverse actors participate in open data initiatives across the three spheres. Cities can allow their open data ecosystems to develop naturally in a self-organizing manner (Tiwana, 2014) as evident in Toronto and Montreal. In both these cases, different actors at different times undertook activities, such as hackathons or efforts to develop applications that attracted others into the community. Alternatively, cities can develop open data ecosystems in a more top-down approach (Styrin et al., 2017). For example, Edmonton prioritized building the open data community from the very beginning, which influenced its decision to implement policies and incentives that helped it build an engaged, motivated, and sustainable open data ecosystem that included the city, external actors, and infomediaries. Those responsible for open data initiatives must leverage the potential for IS teams and external intermediaries to help build and anchor open data ecosystems.

7.2　Limitations

As with any study, our study has some limitations. First, we exclusively used archival (secondary) data. We used such data for practical purposes and because we recognized that the media has much influence in shaping how people understand new phenomena. Given the quantity and variety of articles we collected for each city, we likely captured the most essential and representative elements; however, we still may not have identified certain events or actors in the data. We tried to address this limitation by engaging independent subject matter experts and the cities themselves to review the cases. Furthermore, while the news media play an instrumental role in conveying events of public interest and providing historical accounts, they operate according to their own agendas. As we identified in this study, the news media does not only report open data initiative news but can also represent important actors in open data ecosystems. A study may have issues with research validity when the actors themselves provide the data that researchers use to analyze the actors. We hopefully mitigated this limitation by casting a wide enough net to incorporate all views and biases that exist across all different media, but the issue still remains. Lastly, although we can infer certain motivations and explanations from the data, no direct insight exists into what various actors intended as they engaged in different events, activities, and processes. In this study, we did not focus on these aspects, which refer to the psychological dimension of engagement (Kappelman & McLean, 1993). In collecting and analyzing data, we did not intend to capture actors' motivations, views, and attitudes toward the open data initiatives or toward more specific events. To address these limitations, future research could collect primary data through interviews with key actors to supplement and triangulate our results, although such research would risk recall bias given certain events happened almost a decade ago.

Second, the cases we selected represent another limitation. We chose to investigate three large Canadian cities. Although located in different provinces, the cities share a similar national context. Therefore, one must take caution when applying our results to cities with different political structures, economic systems, and urban governance practices. Future research could attempt to confirm or refine our results by investigating the open data initiatives in cities in different regions and contexts. As open data requires significant capability development, smaller cities likely face different challenges as they embark on sustainability initiatives such as open data. Thus, we suggest that future research should examine actors in open data ecosystems in both larger cities and smaller communities.

7.3　Future Research Directions

As for future research directions, an interesting avenue would involve further investigations into the sustainability sphere. We identified relatively few activities and actors in the sustainability sphere, which we may explain based on the difficulty of bringing global sustainability issues to the city level (a role that cities have not historically had). Alternatively, the possibility exists that global organizations or technological changes operating in the background may have been instrumental in shaping how the open data initiatives evolved in the three cities. The scarcity of actors may also have resulted from our analysis at the city level. To address this concern, we recommend that future research examine a national or international-level open data ecosystem that may have more elements in the sustainability sphere.

Next, among the three cities, we observed Montreal had the fewest key actors but these actors all engaged in multiple spheres to some extent. This finding might suggest a potential inverse relationship between actors' capability to integrate activities across the three spheres and ecosystem size. In other words, when actors choose to focus their activities in a single sphere, more actors need to help fill out and complete the ecosystem to make it productive and efficient. Future research could examine differently sized ecosystems and actors' motivations to engage in multiple spheres.

Third, by using longitudinal case studies, we scratched the surface of temporal issues around open data ecosystems. The model we developed, however, does not consider how these spheres' salience might change over time. For instance, in open data initiatives' early stages, activities in the administrative sphere may be important as they serve to build basic capacities. For its part, the political sphere may become more or less salient depending on other events and preoccupations in the specific city context. Finally, although the sustainability sphere plays an important role in framing open data initiatives, issues in this sphere seem to come into focus early in the process to motivate open data or once cities have achieved a certain level of success. Theoretical refinements related to the three spheres' salience over time could bring novel insights and lay the path for further investigations into open data and other city sustainability initiatives.

Finally, future research could examine the role that IT plays in supporting open data ecosystem processes as ecosystem anchors more closely. Previous research suggests IT applied in the public sector can strengthen the connection between intermediaries and governments (Löbel, Paulowitsch, & Schuppan, 2016), which also likely occurs with open data where the ecosystem plays an essential role in open data's success and value-creation processes. Drawing on the diverse expertise in the IS community, both researchers and practitioners could explore IT-enabled support for increasing collaboration and transparency in implementing open data.

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Appendix A: Descriptive Coding Guide

Table A1. Descriptive Coding Guide

First-level code	Second-level code	Description
Data content	Census (business and residents)	Census information, company register, population information
	City council information	Council meetings, donations, voting records, government budget, election data, council expenses, lobbyist information, procurement contracts
	City service requests	311 requests, complaints
	Cultural and entertainment	Festivals, art, leisure and recreational activities, food offerings, tourism
	Education	Education performance, schools
	Environment and weather	Natural environment, weather, trees, air quality
	Pets and animal control	Pet, licensing
	Policing and safety	Fire and first response, crime statistics, bylaw infractions, code enforcement violations
	Public health	Healthcare services, food inspections, safety inspections
	Real estate and housing	Property assessments, property taxes
	Transit	Public transit, transit apps, road closures, traffic, cycling trails and bike lanes, bike rentals, accidents, traffic volume
	Urban planning and development	Land usage, park inventory, institutional locations, zoning, permits, roads, public facilities and structures, construction contracts
	Waste and recycling	Waste collection and management
Events	App contest	Contests to encourage application development
	App releases	New applications based on open data by city and third parties
	Awards	Recognition of city's open data initiative
	Conferences	Conferences or workshops attended by or hosted by city related to open data
	Consultation	Public consultations, discussions with open data community
	Data release	New data set publication
	Exhibits and presentations	Marketing related activities of open data initiatives
	Funding	Budget announcements for open data initiatives
	Hackathons	Usually day-long or weekend events bringing together parties to build apps
	HW and SW acquisitions	To support open data collection, support the portal
	Partnership announcements	Between the city and other third parties
	Policy release	New policies related to open data, like open by default, adoption of new data standards
	Portal enhancements	Upgrades and enhancements to portal excluding app releases and data set releases
Value and impacts	Citizen involvement	Includes citizen participation in democratic processes, citizen engagement
	City operational efficiency	Making the city run better, reduce operational costs and inefficiencies in processes
	Economic growth	New business opportunities, economic development

Table A1. Descriptive Coding Guide

	Empowerment	More control
	Marketing benefits	Showcasing the city
	Policy development	Improving the appropriateness of policies, urban planning
	Quality of life	Improving the quality of life of citizens by offering a better living environment
	Service quality	Better, higher-quality services
	Threats	Potential negative impacts of open data (e.g., threat to privacy)
	Transparency	Openness, transparency of city decision-making
Actor types	Business	General business community
	City	The city as a collective entity
	City administrators	Civil servants, city managers
	City service providers	Police services, waste contractors, fire and emergency services, public library, transit service providers
	Citizens	Individual residents of the city, or visitors who make use of city services
	Community groups	Not-for-profit and other community organizations
	Developers	Individuals or businesses involved in IT development, apps, etc.
	IS managers	City employees responsible for the IT or IS function, open data, analytics
	Media	Journalists, bloggers
	NGO	A not-for-profit, non-governmental organization focused on a particular social or sustainability issue, typically national or international
	Other governments	Federal, provincial, agencies, other cities, non-municipal service providers
	Political leaders	Politically elected officials (e.g., mayors, councilors)
	Researchers	Academic, private research

Appendix B: Summary of Key Actors by City

Table B1. Summary of Edmonton's Frequently Mentioned and Key Actors

Actor type	Actor (mentions)	Engagement in Spheres			Highlights
		SUST	POL	ADM	
IS manager	*Chief information officer (11)	Yes	Yes	Yes	Championed the city's goal of being a leader in open data. Between 2009 and 2014, served as the main spokesperson for open data (political sphere). The IS branch organized citizen consultations, contests, and hackathons (administrative sphere). Engaged in discussions on the national and international stages, such as the Beyond 2010 event, about open data (sustainability sphere).
	Chief analytics officer (5)	No	Yes	Limited	Helped city staff from different departments to adequately use open data internally (administrative sphere). Participated in events where he presented evidence of efficiency gains delivered by Edmonton's open data initiative (political sphere).
	Director of open data program (5)	No	Yes	Limited	One of the public voices of Edmonton's open data initiative (administrative/political spheres). In 2017, she became Edmonton's CIO.
Political leader	*Elected official (10)	No	Yes	Limited	Strongly supported open data as an elected official. Prior to the launch of the open data portal, asked the city to investigate open data, which led to citizen consultations (administrative/political spheres). Passed a budget including money for open data analytics and oversaw Edmonton's adoption of the International Open Data Charter (political sphere).
Media	Postmedia (8)	No	Yes	Yes	Began using Edmonton's open data catalogue to create new content and stories in 2016 (administrative sphere). Also pushed for freedom of information via the open data portal (political sphere).
	Edmonton journal (5)	No	Yes	Yes	Reported on the open data portal since 2010 and increased public awareness regarding new open data tools. Created new content based on information pulled from the open data portal (administrative sphere). Published editorials to call for freedom of information in the public domain (political sphere).
Developer	*Developer (7)	No	Yes	Yes	Frequently cited in media. Built the YEGVotes.info site (administrative sphere). Vocally criticized applications that the city offered. Ran in the 2017 municipal election with open data figuring prominently on his election platform. Endorsed the city's plan to adopt the International Open Data Charter (political sphere).
	Developer (5)	No	No	Yes	Created and developed a website for open data mapping in Edmonton (administrative sphere).
	*Open data activist (6)	No	Yes	Yes	Assisted the media in developing an interactive chart of schools and independently created a chart showing city councilors attendance at votes (administrative sphere). Through a blog and in traditional media, he commented on open data events and promoted expansion of the city's open data initiative (administrative/political spheres).
Community group	*HackYEG (6)	No	No	Yes	Formed by citizens wanting to take a more active role in developing applications. Helped to challenge roles and foster citizen-city collaboration. Organized the first citizen-driven hackathon and challenged the city to accept crowdsourced data (administrative sphere).
* Judged as key actor considering both frequency of mentions (articles) and extent of involvement.					

Table B2. Summary of Toronto's Frequently Mentioned and Key Actors

Actor type	Actor (mentions)	Engagement in spheres			Highlights
		SUST	POL	ADM	
Media	*The Toronto Star (11)	Yes	Yes	Yes	Published 32 articles related to open data. Built awareness through advertising the open data portal and application releases. Journalists built their own analysis tools and conducted investigations using open data (administrative sphere). Influenced political debate by demonstrating the value in using open data and giving voice to citizen complaints (administrative / political spheres). Published several columns on open data impacts and contribution to the future of smart cities (sustainability sphere).
	*Journalist (3)	No	Yes	Limited	Limited direct involvement in the open data initiative. Used open data to inform his investigation into pedestrian crossings (administrative sphere). Advocated for an opt-out policy for open data and criticized the lack of technological investments that the city made (political sphere).
Political leader	*Elected official (11)	No	Yes	Limited	Pushed for the adoption of open data policies, encouraged hackathons, and made promises to publish more open data sets (political sphere). Attended a few hackathons (administrative sphere). Initially, focused on the city's traffic congestion problems.
	Elected official (7)	No	Yes	Limited	Officially launched the open data portal (political sphere). Supported the open data initiative and was present at a few hackathons, where he called for more citizen participation (administrative/political spheres).
	Elected official (3)	No	Yes	No	Campaigned to expand the city's open data initiatives (political sphere).
Citizen, Business	*Private citizen (8)	No	Yes	Yes	Continuously pushed the city to publish more data (political sphere). Quoted in media articles to draw attention to poorly developed applications and unfulfilled promised by the city regarding the pace and quality of data sets releases (administrative/political spheres).
Developer	*Web developer (2)	No	Limited	Yes	Created the website whattorontosaid.com (administrative sphere) to promote open data by showing its value and encouraging the city to publish more machine-readable open data (political sphere).
City service provider	*City manager (5)	No	Limited	Yes	Participated in organizing open data events and hackathons related to transit (administrative sphere) and promoted open data as he interacted with city officials (political sphere).
IS manager	IS manager (3)	No	Limited	Yes	Part of city's open data initiative and city Web department. Participated in the debate surrounding open data and pushed for cultural changes in the city (political sphere). Team was responsible for updating the Toronto open data portal (administrative sphere).
NGO	*World Council on City Data (WCCD) (3)	Yes	Yes	Limited	Developed high-level direction for cities and supported discussion about using open data to improve cities (sustainability sphere). Developed standardized indicators to benchmark municipal performance (political sphere). Launched its own open data portal in 2014 (administrative sphere).
* Judged as key actor considering both frequency of mentions (articles) and extent of involvement.					

Table B3. Summary of Montreal's Frequently Mentioned and Key Actors

Actor type	Actor (mentions)	Engagement in spheres			Highlights
		SUST	POL	ADM	
Political leader	*Elected official (33)	Limited	Yes	Yes	Advocated for open data and transparency. Allocated time, personnel, and resources to the initiative through his department (political sphere). Participated in government and community consultations (administrative sphere), collaborated with other cities in Quebec and provincial government (sustainability sphere). City adopted an open-by-default policy during his tenure.
	*Elected official (26)	Limited	Yes	Limited	Supported open data and pushed for citywide transparency through the use of open data (political sphere). During his tenure, Montreal adopted the creative commons license CC4.0, launched collaboration with other cities (sustainability sphere), and created a smart and digital city office (administrative/political spheres).
	Elected official (6)	No	Yes	Limited	As member of the Executive Committee, announced several data releases and open data tools available for citizen use (political sphere).
	Elected official (3)	No	Yes	Limited	As member of the executive committee, publicly launched the snow removal and the "vue sur la sécurité publique" (eye on public security) applications, which used open data (political sphere).
	Elected official (3)	No	Yes	Limited	As member of the executive committee, launched the dynamic map of the metropolitan trucking network and promoted the release of open data pertaining to transport issues (political sphere).
Community group	*Montreal Ouvert (16)	Yes	Yes	Yes	Built political will and operational capacities through organizing hackathons (administrative/ political spheres). Contributed to open data movement province-wide by forming Quebec Ouvert (sustainability sphere). Pushed for less government corruption by asking all mayoral candidates in 2013 to answer a transparency questionnaire (administrative/political spheres).
	Québec Ouvert (4)	No	Yes	Yes	Exerted pressure on politicians and city officials to release information to Quebec citizens (political sphere). Organized and co-hosted, with the collaboration of other community groups, several events and hackathons (administrative sphere).
City service provider	Société de transport de Montréal (8)	No	Limited	Yes	Public transport agency in Montreal. Participated in hackathons and events that promoted open data use and smart cities (political sphere). Released transportation data to the public in an attempt to improve services (administrative sphere).
Media	Montreal Gazette (7)	No	Limited	Yes	Created new content based on open data, especially during the 2013 election (administrative sphere). Promoted transparency via open data in politics (political sphere).
	Journal de Montréal (4)	No	No	Yes	Began using open data information for reporting in 2017. Used open data to create new content and promote citizen services (administrative sphere).
* Judged as key actor considering both frequency of mentions (articles) and extent of involvement.					

About the Authors

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