Factors for Collaboration Among Smart City Stakeholders: A local government perspective

Abstract:

A collaborative ecosystem of diverse stakeholders is seen as critical in smart cities for solving complex public problems and overcoming socio-technical hurdles. However, little is known about the factors that may increase collaboration among smart city stakeholders. Through a digital government lens, we first elaborate the nature of multi-stakeholder collaboration in the smart city. Then, we adopt a contingency approach to unpack the factors that affect the intensity of collaboration between the stakeholders in the smart city ecosystem. To characterize the ecosystem, we use the quadruple-helix framework. Through the perspective of the local government, we derive hypotheses on whether certain factors lead to more intensive collaboration, which are tested on a sample of Belgian municipalities. Our findings reveal the importance of smart city strategies for intensifying collaboration between the local government and stakeholders in the ecosystem. Moreover, we also find that for large ecosystems, a smart city manager or department may facilitate collaboration amongst stakeholders. Taken together, our findings indicate that there are certain configurational approaches to increasing collaboration in smart cities, which will depend on the context of a city.

Key words:

collaborative ecosystems, smart city, local public administrations, digital government, contingency theory, quadruple-helix framework

1. Introduction

There is currently a high interest in public administrations for providing smart city solutions (Haarstad & Wathne, 2019), which are broadly defined as "investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure [that] fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance" (Caragliu et al., 2011: 70). In this line, smart city initiatives are relevant for local public administrations as they can be used to manage pressing urban challenges and support a variety of stakeholders in the local area (Wirtz et al., 2020). Moreover, smart city initiatives can bring urban sustainability (De Guimarães et al., 2020; Desdemoustier et al., 2019), support socio-economic development (Komninos et al., 2019), and more broadly improve the quality of urban life (Appio et al., 2019). Information technology use in government is a part of a dynamic socio-technical system that works toward more efficient operations and greater public value (Dawes, 2009; Neumann et al., 2019). It is therefore important to understand the building blocks of smart cities and what drives their successful initiatives.

Collaboration between stakeholders is emphasized in the literature as one of the necessary components of the successful development of smart cities (Komninos et al., 2019; Snow et al., 2016). In line with this, municipalities engaged in smart city initiatives seek to develop 'collaborative ecosystems', which create "linkages among citizens, government, business, and educational institutions" (Appio et al., 2019: 2). This aligns well with the idea that solving public challenges requires cross-sectoral collaboration, which can be defined as "partnerships involving government, business, nonprofits and philanthropies, communities, and/or the public as a whole" (Bryson et al., 2006: 44). Collaboration is moreover suggested as useful for overcoming socio-technical hurdles in digital government contexts (Ku et al., 2016), such as smart city ecosystems led by local governments. In smart cities, collaboration may also lead to increased performance (Appio et al., 2019; Komninos et al., 2019; Snow et al., 2016) or smarter solutions, as it is recognized that it is difficult for one organization to solve public problems alone (Chen et al., 2019). As a smart city ecosystem compiled of several stakeholders is challenging to organize (Angelidou, 2014), understanding the factors that lead to increased collaboration in smart city ecosystems will advance both the smart city literature and practice by unpacking ways to improve performance.[1]

Thus, we analyze collaboration among stakeholders and look at facilitating factors. In this context, we recognize that the related smart city technologies themselves may promote exchanges amongst stakeholders, and thus enhance collaboration. In this line, we call on literature from the field of digital government. Studies in this domain have recently connected the role of local government in managing smart city ecosystems within a digital government framework and this approach has implications for collaboration in smart city ecosystems (Reggi & Gil-Garcia, 2021; Sancino & Hudson, 2020). The literature on digital government therefore offers a useful perspective to understand collaboration within the smart city ecosystem. This literature has engaged with the question of collaboration between stakeholders, suggesting several features to facilitate collaboration, such as executive support, leadership, and trust (Chen et al., 2019). Digital government scholars have also explored phases of evolution, whereby each phase engages stakeholders more intensively (Janowski, 2015). In this context, we aim to understand what factors in particular will contribute to more intensive

[1] To the best of our knowledge, while case studies and theoretical propositions exist (Appio et al., 2019; Komninos et al., 2019; Snow et al., 2016), no empirical evidence supports the assumption that collaboration leads to smarter solutions. Moreover, using the data and sources described in Section 4, we find a positive correlation between a measure of the smartness for municipalities and our proxies of collaboration between the local government and the other stakeholders (all based on the evaluation of a well-informed public official). Although this provides evidence to support this assumption, further research is clearly required to unveil the relation between collaboration between stakeholders and the advancement of smart city initiatives.

collaboration among stakeholders in the smart city context. While the smart city literature extensively discusses collaboration, as noted above, no literature was found that identifies such contingency factors.

We thus aim to address this gap in the literature and complement the digital government literature by adopting contingency theory (Arellano-Gault et al., 2013; Donaldson, 2001) to unpack the factors that influence collaboration in smart city ecosystems. The premise of contingency theory is that there is no singular way to manage an organization, as organizations face different environmental and contextual circumstances (Katz & Kahn, 1978; O'Toole & Meier, 1999; Walker, 2008). There thus, based on contingency logic, emerge certain organizational configurations, whereby similar firms or public organizations will have similar results (Andrews et al., 2016; Doty et al., 1993). Contingency theory is used to explain, given these configurations, how moderating factors may lead to a certain outcome (Luo, 2002). We evaluate three contingency factors widely discussed in the literature (Donaldson, 2001) – smart city *strategy*, collaborative ecosystem *size*, and *environmental* factors – to examine if and how much they have a moderating role between local government and ecosystem collaboration.

As the local government is often shown to be the key actor in developing the smart city (Brorström et al., 2018; Estevez et al., 2016; Visnjic et al., 2016), the perspective of the municipality is adopted. Using this lens, this paper focuses on how different smart city contingency factors influence the intensity with which a local government collaborates with the different stakeholders in its collaborative ecosystem. Put simply, we aim to assess which factors lead to more collaboration amongst the local government and other smart city stakeholders. Taken together, our approach enables us to provide insight about how local governments may increase collaboration amongst their smart city ecosystem.

We derive a set of hypotheses about the effect of contingency factors on the intensity of local government collaboration with other stakeholders. We then empirically test them using a sample of 40 Belgian municipalities engaged in collaboration with smart city stakeholders. While the smart city literature has discussed factors that may influence relations between the local government and citizens (Simonofski et al., 2021), this paper goes further to understand how the local context and environment can influence collaboration between local government and a broader set of stakeholders: citizens, but also businesses and academic institutions. Previous research has analyzed case studies, providing insight into collaboration amongst actors in smart cities studies (Baccarne et al., 2014; Mora, Deakin, & Reid, 2019; van Waart et al., 2016). Our paper aims to complement this literature by providing evidence from regression estimates that shows the impact of each contingency factor while controlling for that of the others. Our findings reveal the importance of strategies, and for large collaborative ecosystems, smart city managers or departments. Moreover, theoretically we contribute to the smart city field, since previous literature stresses the importance of collaboration, but not which factors determine it. In response, we use the digital government literature to frame how local government may collaborate with their smart city ecosystem and contingency theory to pinpoint which factors matter for collaboration.

The rest of the paper is organized as follows. Section 2 discusses the previous literature on collaboration in smart cities, paired with insights on collaboration from the digital government field. Section 3 presents the theoretical framework and hypotheses. Section 4 covers the data used in this study. Section 5 shares the empirical results. Section 6 discusses the results, giving their implications and Section 7 provides the final conclusions.

2. Literature Review

The ecosystem of a smart city incorporates the main actors active in the development of the smart city (Angelidou, 2014; Ooms et al., 2020). We conceptualize the smart city collaborative ecosystem through the quadruple helix framework based on literature that suggests four key stakeholders comprise this system: local government, industry, universities, and civil society (Baccarne et al., 2014; Mora, Deakin, & Reid, 2019; Tatar et al., 2020). While other research has suggested a triple-helix model for smart cities (see, for instance, Leydesdorff and Deakin, 2011), it has been argued that as this type of ecosystem is influenced by the public it is important to incorporate this stakeholder as a fourth helix in the framework (Kummitha and Crutzen, 2019; van Waart et al., 2016).

Collaboration among stakeholders varies in intensity, and can be viewed along a scale (Bryson et al., 2006). At one end of this scale, stakeholders do not interact with one another to solve complex problems. For the smart city, while an example of the complete isolation of stakeholders is rare, critiques of Songdo have emerged due to a sharp top-down strategy that lacked the involvement of stakeholders, most notably civil society (Yigitcanlar et al., 2019), thus privileging an elite class (Shwayri, 2013; Viitanen & Kingston, 2014) and certain unrealized stated objectives (Hajer, 2016). At the other end of the scale, stakeholders come together into one unit to solve problems. The Amsterdam Economic Board can be likened to this case in the smart city context as it is an independent collaborative platform that coordinates Amsterdam Smart City (Mora, Deakin, & Reid, 2019). We propose that collaborative ecosystems composed of stakeholders within the quadruple-helix framework in smart cities operate within this scale, with more intensive collaboration leading to a higher performance of smart cities (Appio et al., 2019; Komninos et al., 2019; Snow et al., 2016).

In an attempt to open up the black box of the collaborative ecosystem, we follow previous literature (Tatar et al., 2020) and conduct the analysis through the lens of the local government. This is because the nature of collaborative solutions calls for governments to embrace a harmonizing role to ensure that there is a guiding force to steer the interactions in the ecosystem (van Waart et al., 2016). As such, while the quadruple-helix framework implies no one actor is in charge of the overall collaboration, in the smart city context, local governments are often cited as playing a significant role (Brorström et al., 2018; Estevez et al., 2016; Mora, Deakin, & Reid, 2019).

For example, in Vienna, the city government has been cited as the primary organizer of the smart city ecosystem (Visnjic et al., 2016), while in Gothenburg, the local government is in charge of implementing their smart city strategy (Brorström et al., 2018). In the Belgian context, Wayenberg et al. (2017: 123) conclude that, although the regional governments of Brussels, Flanders, and Wallonia have key competencies (for example, in housing, transport, and spatial planning), "local governments [have] considerable leeway to decide on specific ways of working when dealing with the needs and desires of its environment and citizens". More generally, Mora, Deakin, Reid, et al. (2019) find that local government has a strong role in smart city collaboration. Building on the wealth of evidence across the smart city literature, we therefore agree with Sancino & Hudson (2020: 716), who conclude that there is a "key role of the local government leadership in making smart cities happen". As the local government is such an influential actor in the smart city, how much they collaborate with other stakeholders will influence the performance of the smart city.

Governing a smart city is understood here as a type of digital governance paradigm operating in a socio-technical system (Dawes, 2009). Specifically, the digital government framework has been used to consider collaboration in smart city ecosystems (Reggi & Gil-Garcia, 2021; Sancino & Hudson, 2020). Moreover, certain types of collaborative relationships within smart city ecosystems are influenced by practices found within digital government initiatives (Mills et al., 2021). Thus, we call on the digital government literature to better explain local government collaboration with its smart city ecosystem. Digital government is defined as "the use of digital technologies, as an integrated part of governments' modernisation strategies, to create public value" (OECD, 2014: 6). Like the smart city concept, digital government is also seen as a way to promote sustainability and empower citizens (Janowski et al., 2018).

Our topic of interest is moreover complementary to the literature on digital government, as there are similarities between governing a smart city and the concepts presented in this field. Notably, digital government implicates an ecosystem made up of the following stakeholders: government actors, citizens groups, private businesses, and other non-government entities. In the final phase in digital government evolution, the contextualization stage, a new governance paradigm emerges that engages these stakeholders in collaboration (Janowski, 2015). The contextualization stage of digital government aligns with the notion of the government playing an orchestration role in achieving public goals, but with stakeholders actively collaborating (Janowski et al., 2018).

Leveraging the digital government literature allows us to frame the local government as an orchestrator in the smart city ecosystem, providing tools and collective action mechanisms, but not in control of the stakeholders, who remain autonomous. While this provides the underpinning structure of how stakeholders may balance their roles during collaborative processes, it does not describe what factors may encourage the local government to collaborate in the first place. To address this gap, we consider a contingency approach.

3. Theoretical Framework

Many different approaches have been used to study collaboration across stakeholders, such as Actor Network Theory (Aka, 2019) or stakeholder theory (Goodman et al., 2017), amongst others. However, the purpose of this paper is to improve the understanding of what factors lead the local government to collaborate more intensively with its stakeholders, thus increasing smart city performance. As our research problem can be framed as understanding factors for optimizing performance, we adopt contingency theory. In essence, contingency theory suggests that organizations aim to fit their structure to a variety of factors, or contingencies, that characterize the situation of the organization. This is relevant for our case, as research suggests that each collaborative organization or ecosystem should be tailored to its setting (Imperial, 2005). Aligning the fit of organizational characteristics to contingencies leads to high levels of effectiveness and organizational performance.

Contingency theory, while originally developed for the firm level (Donaldson, 2001; Pennings, 1987), has since been extended to consider the public sector (Andrews et al., 2016). This approach has moreover been used to understand collaboration. Luo (2002) investigates international and cross-cultural collaborations to understand the organizational and environmental contingency factors that mediate between trust and performance. Similarly, scholars in Public Administration have used contingency approaches to study collaboration. For example, Ansell and Gash (2008) adopted a contingency approach to understand what contextual conditions facilitate or hinder collaborative governance. In a different study, Span et al. (2012) highlighted that different ways of collaborating with actors at the local level will be affected by a given set of contingencies. In this context, collaborative ecosystems are viewed as enablers for smarter solutions. Increased collaboration in the ecosystem, therefore, leads to a smarter city. We thus derive three hypotheses using contingency theory on the expected influence that size, strategy, and the environment may have on the level of collaboration between a local government and its ecosystem. These contingency factors are chosen due to their marked role in the literature (Donaldson, 2001).

In contingency theory, well performing large organizations, whose size is characterized by having a higher number of employees, tend to standardize operations and delegate decision-making to lower levels of the company to maintain performance. Large organizations have developed standardized procedures in order to avoid the high costs and level of effort associated with tight control across an extensive organization. These procedures enable a higher organizational performance (Child, 1975).

The situation is however different in the case of smart cities. The smart city collaborative ecosystem involves many public and private stakeholders. While this ecosystem may benefit from orchestration from the local government (Janssen & Estevez, 2013), the partnership nature of quadruple-helix collaboration suggests that the local government cannot fully standardize procedures and ways of interacting across all stakeholders. For the case of smart cities, more collaboration leads to a higher operational performance, indicating a positive size effect. However, as the local government has a limited set of resources at its disposal to manage the ecosystem, it is predicted here that there will be increased collaboration only up to a certain point. After this threshold, since the local government is unable to standardize dynamics in the collaborative ecosystem, diseconomies are likely to arise. This is moreover supported by research investigating contingency factors for collaboration, which finds that collaboration with more stakeholders can increase coordination costs (Danese, 2010), and research on small-size ecosystems, which enjoy close collaboration with the relevant stakeholders in their territory as they are easier to identify and engage (Ruohomaa et al., 2019; Simonofski et al., 2021). As a result, it is predicted that smaller ecosystems may facilitate collaboration, while it will become more difficult for the local government to collaborate with its stakeholders as their numbers grow past a certain point in the manner of an inverted-U relationship. Here we thus consider the size of the ecosystem, as defined as the number of stakeholders in the ecosystem. This suggests the following hypothesis:

Hypothesis 1: *A local government will collaborate more intensively with its smart city ecosystem the larger it is up until a certain point. After this threshold is passed, the local government will collaborate less.*

For the strategy factor, we consider the strategy followed by stakeholders, notably the municipality. Contingency theory suggests that operational performance is linked to whether the structure of an organization fits its strategy (Donaldson, 2001). Collaboration in the smart city should therefore fit its strategy. If the municipality has a formal smart city plan, then the government has increased reason to collaborate with different stakeholders in order to complete smart city projects and meet the defined objectives. This is reinforced by Public Administration literature that tells us collaboration in public settings is supported when there is a clear vision and purpose for collaboration (O'Leary & Vij, 2012), as well as previous contingency approach studies that suggest the objectives of the collaboration can affect collaboration levels (Danese, 2010). This suggests the following hypothesis:

Hypothesis 2: *A local government will collaborate more intensively with its smart city ecosystem if it has a defined smart city strategy.*

In the original formulation of contingency theory, environmental factors are referred to as external circumstances that impact the organization of a private firm (Child, 1975). In order to characterize environmental contingency factors of the smart city, we follow a model presented by Appio et al. (2019), which places the collaborative ecosystem at the center of the smart city and further suggests four external smart city factors that may influence the ecosystem: Smart Environment, Smart Mobility, Smart Governance, and Smart People. This model is used to emphasize that place and infrastructure underpin smart city projects. It is stressed, however, that their role in the smart city is a means to achieve more collaborative ecosystems that lead to smarter solutions and a higher quality of life.

By additionally including the related smart city domains established in Giffinger et al. (2007), the model is further characterized by smart city elements. Smart Environment describes natural conditions of a city, such as its climate or green spaces. Smart Mobility pertains to accessibility, transport, and information and communication technologies. Smart Governance concerns political participation and citizen services. Finally, Smart People speaks to education levels and social interactions amongst citizens.

As such, this model suggests that Smart Mobility and Smart Environment provide foundational support for collaborative ecosystems. Moreover, this model proposes that collaborative ecosystems are further influenced by Smart People and Smart Governance. Taken together, this suggests these four smart city elements proposed by Giffinger et al. (2007) will affect the collaborative ecosystem.

The relationships suggested by this model can be found throughout the smart city literature. Components within Smart Environment and Smart Mobility have been suggested as factors that encourage collaboration between stakeholders (Albino et al., 2015; Snow et al., 2016). In detail, Snow et al. (2016) highlight both the tradition of stakeholder engagement to protect the natural environment as well as strong broadband and other digital infrastructures as foundational aspects of collaboration in the smart city context. In relation to Smart People and collaboration in the smart city, high levels of human and social capital can help solve complex urban problems through supporting the creation of smart solutions with other stakeholders (de Wijs et al., 2016). Specifically speaking to Smart Governance, the smart city literature emphasizes the role of citizens, underscoring the importance of public participation in collaborative processes (De Guimarães et al., 2020; Meijer & Bolívar, 2016; Silva et al., 2018).

Contingency theory states that for an organization to be successful, there should be a high goodness of fit between its structure and environment (Pennings, 1987). An organization therefore attempts to implement a structure to achieve goodness of fit in order to have higher performance. In the case of the local government, it will try to fit the intensity of its collaboration in the collaborative ecosystem to the environment.

In the smart city, four environmental factors impact collaborative ecosystems: Smart Environment, Smart Mobility, Smart People, and Smart Governance (Appio et al., 2019). Infrastructure, including Smart Environment and Mobility, is the foundation for creating collaborative ecosystems (Albino et al., 2015; Snow et al., 2016). Subsequently, these ecosystems are based on human and social capital, represented through Smart People, (de Wijs et al., 2016) and benefit strongly from coordination arising from public participation, or Smart Governance (De Guimarães et al., 2020; Meijer & Bolívar, 2016). These environmental factors are then all expected to be positively related to how intensively a local government collaborates with its smart city collaborative ecosystem. This suggests the following hypotheses:

Hypothesis 3: A local government will collaborate more intensively with its smart city ecosystem the higher the smart city environmental factors.

Since we look at four environmental factors (Smart Environment, Smart Mobility, Smart People, and Smart Governance), Hypothesis 3 can be unpacked into the following sub-hypotheses:

H3a: A local government will collaborate more intensively with its smart city ecosystem the higher the Smart Environment factor of an ecosystem.

H3b: A local government will collaborate more intensively with its smart city ecosystem the higher the Smart Mobility factor of an ecosystem.

H3c: A local government will collaborate more intensively with its smart city ecosystem the higher the Smart People factor of an ecosystem.

H3d: A local government will collaborate more intensively with its smart city ecosystem the higher the Smart Governance factor of an ecosystem.

Figure 1 situates the contingency factors into the framework. Environmental contingency factors are external to the ecosystem, while contextual contingency factors are those that depend on the context of the ecosystem. The contextual contingency factors are therefore size and strategy. The above hypotheses are derived using a contingency approach to evaluate the expected influence that size, strategy, and the environment may have on the level of collaboration between a local government and its ecosystem.

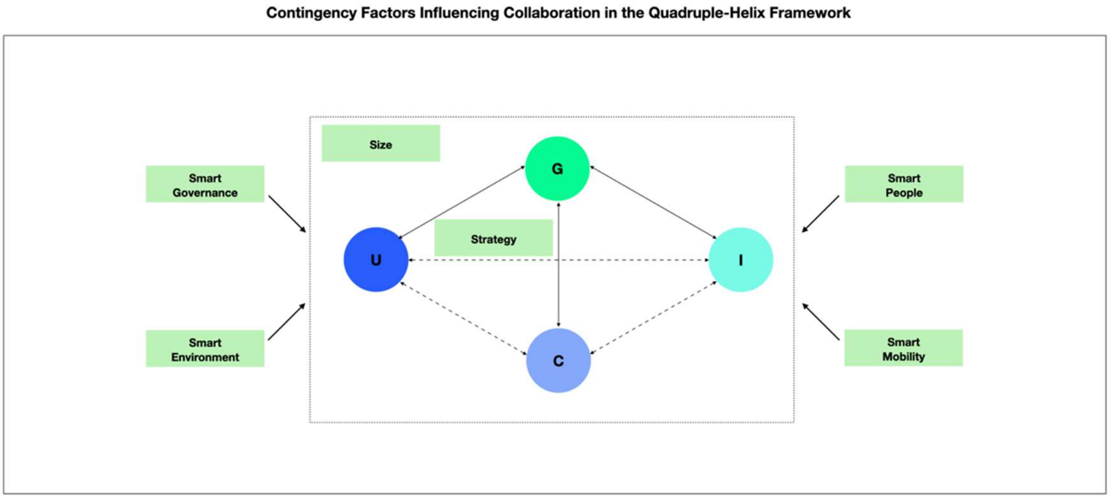

Figure 1: Graphical representation of the contingency factors affecting the smart city collaborative ecosystem – G: government, U: universities, C: civil society, and I: industry. From the perspective of local government in the quadruple-helix framework, the dashed lines indicate that collaboration between two stakeholders may occur, while the solid lines indicate that collaboration between two stakeholders is observed. Within the rectangle we have contextual factors (size and strategy) and outside the rectangle we have environmental factors (Smart Governance, Smart Environment, Smart People, and Smart Mobility). Source: Authors' own elaboration.

4. Data and Empirical Analysis

We use data from a sample of Belgian municipalities to test the validity of Hypotheses 1 to 3. The Belgian case is interesting because several policies have been launched in recent years to support the development of 'smart initiatives' at different administrative levels. Mentionable examples include 'Digital Belgium' at the federal level, 'Smart Flanders' and 'Digital Wallonia' at the regional level, and the smart city projects of Antwerp, Brussels, and Namur at the local level. Also, smart city initiatives at the local level are developed within a regional legal setting that "opens up the local governance to the citizens and civil society" (in Wallonia) and explicitly "underlines the importance of local participation" in local planning (in Flanders). However, the role of the regional government with respect to the participation of different stakeholders in local planning differs. While in Flanders the regional government may require a “local government to account for the involvement of specific local stakeholders”, the Wallonia regional government does not have such a prerogative (Wayenberg et al., 2017: 114, 117). Moreover, Belgian regions have control over certain competences, such as regional planning and environmental policy. As a result, this leads to particular modes of internal organization across the different regions. As previous research has noted that institutional differences for smart city development are found across the three Belgian regions (Desdemoustier et al., 2019), we will account empirically for these here.

In particular, we use regression analysis to assess which contingency factors are statistically correlated with the intensity of collaboration between the local government and the other stakeholders involved. The variables to measure collaboration between the local government and the other stakeholders are proxied using information extracted from a survey carried out between February and May 2019 by the Smart City Institute (SCI) of the University of Liège (Bounazef, 2019). The purpose of the survey was to take stock of smart city approaches in Belgium, and in particular evaluate the strategic stakeholders in smart city initiatives, the actions developed in smart city approaches, and what factors to prioritize to strengthen the smart city dynamic across municipalities. The survey targeted all 589 Belgian municipalities and was sent to local public officials “responsible for the projects associated with the phenomenon of the smart city in the municipality” (see also Ching and Ferreira, 2015). In particular, the survey was responded to by a local public official in charge of the projects associated to the smart city in a given municipality (Djida Bounazef et al., 2018). As a result, while we do not suggest that all municipalities in Belgium can be labelled as matured smart cities, those municipalities who indeed responded indicate they are engaged in the smart city.

The response rate of the survey was 93 municipalities or nearly 16%. The sample is representative of the nature of the municipalities (urban or rural character) and the Belgian provinces, which have been shown as useful characteristics to gauge representativity in other studies on Belgium (Desdemoustier et al., 2019). There were however missing responses. In total, 79 municipalities answered our questions of interest, but 39 responded with 'I do not know / not applicable' for some of the questions. Therefore, we have 40 municipalities that responded to all the questions used in this study to construct the dependent variables. This gives us a comparable sample, indicating that all municipalities in our study engage with stakeholders in the smart city collaborative ecosystem to a certain extent. Despite focusing on these 40 municipalities for the main study, we also ran tests on the set of 79 municipalities to see if our results hold (see footnote 3 in the Results section).

The variables considered are: 'Intensity of general collaboration', 'Intensity of partnerships with firms', 'Intensity of partnerships with universities', and 'Intensity of partnerships with citizens'. Intensity is measured along a scale, and the variables used take values between 1 and 10 to measure how actively stakeholders collaborate, which are the lowest and highest values meaning 'Low and/or Non-existent' and 'Very developed' collaboration or partnership, respectively. These four variables are constructed from the answers to the following questions, respectively: "With respect to the development of smart city projects, i) The public, private, and civil society actors are invited to actively collaborate; ii) Partnerships with companies located in Belgium are developed; iii) Partnerships with universities, research centers, and students are developed; iv) Partnerships with citizens, associations, and neighbourhood associations/committees are developed". The survey and the resulting variables are based on the notion that stakeholder involvement in participatory processes varies on a scale of intensity (Arnstein, 1969).

In effect, these four dependant variables measure, according to the public official who answered the survey, the intensity of collaboration between the municipality and different stakeholders in its ecosystem with respect to smart city approaches and projects. This accounts for collaboration in the general collaborative ecosystem, as well as bi-lateral collaboration between the local government and each respective stakeholder found in the quadruple-helix framework. This gives us the required data to test our hypotheses on the intensity of collaboration between the local government and the other stakeholders in the collaborative ecosystem. As the local government is taken as the key stakeholder in the smart city, how intensively it collaborates with certain stakeholders will influence the collaboration in the overall ecosystem, and thus the performance of the smart city.

Descriptive statistics reported in Table 1 indicate that, on average, the higher levels of collaboration are found in the 'Intensity of general collaboration' and 'Intensity of partnerships with citizens' variables. It is also noteworthy that a score of one is the highest frequency value of the variables 'Intensity of partnerships with firms' (in 10 municipalities) and 'Intensity of partnerships with universities' (in 15 municipalities). That is, one out of four and three out of eight municipalities consider the degree of development of partnerships with firms and universities 'Low and/or Non-existent', respectively. Also, the variables generally score higher in the 17 Flemish municipalities, with the only Brussels municipality taking values somewhere in between to those of Flanders and Wallonia. The data therefore suggest that the smart city ecosystem for a municipality in Belgium largely falls into one of two types: 1) a collaborative ecosystem with very strong linkages between local government and civil society and a strong overall collaboration between the local government and the general ecosystem; or 2) an ecosystem with observed, but not strong, linkages between the local government and its different stakeholders, particularly firms and universities.

Table 1: Descriptive Statistics

		Source	Mean	St. Dev.	Min	Max
Dependent Variables	General collaboration	SCI survey	5.97	2.57	1	10
	Partnerships with firms		5.00	3.18	1	10
	Partnerships with universities		4.33	3.21	1	10
	Partnerships with citizens		6.00	3.00	1	10
Regressors						
Size	# Firms	Bel-first	5375.95	10585.78	449.00	61867.00
	Population (in thousands)	Statbel	81.75	52.57	32.45	303.82
	# Universities	Regional websites	0.17	0.50	0	2
Strategy	Smart strategy implementation	SCI survey	2.40	1.39	1	5
Smart Environment	Share of woodland	Belfius (2018)	0.15	0.17	0.00	0.66
	Share of parks and gardens	Belfius (2018)	0.02	0.02	0.00	0.12
	Sunshine hours	RMI	4.38	0.15	4.00	4.70
Smart Mobility	Trains	NRCB	0.45	0.50	0.00	1.00
	# Traffic accidents	Statbel	166.62	407.77	6.00	2492
	Internet	BIPT	0.89	0.23	0.01	1.00
Smart People	Share of pop. with univ. degree	Belfius (2018)	0.06	0.04	0.02	0.21
	Share of foreign population	Belfius (2018)	0.06	0.07	0.01	0.32
	Voters' turnout (%)	Regional websites	90.66	3.64	80.28	97.79
Smart Governance	# Political parties	Regional websites	5.10	2.17	2.00	11.00
	% Of female city representatives	Regional websites	46.33	3.38	38.62	50.00
	Share of children in day care	Belfius (2018)	1.17	0.20	0.77	1.87

Note: Our sample size is 40 municipalities. Definitions and statistical sources for all the reported variables can be found in Section 4. RMI stands for Royal Meteorological Institute, NRCB stands for the National Railroad Company of Belgium, and BIPT stands for the Belgian Institute for Postal services and Telecommunications. The source Regional websites indicates a variable came from the official web pages of the regional governments of Brussels, Flanders, and Wallonia.

As for the regressors, they consist of variables that approximate the contingency contextual and environmental factors that, according to the theoretical framework developed in Section 3, shape collaboration within the smart city ecosystem. The contextual factors include the size of the smart city collaborative ecosystem and the existence of a smart city strategy in the municipality, whereas the environmental factors refer to the relevant smart city characteristics proposed by Giffinger et al. (2007). Next, the variables and statistical sources used to proxy these factors are described. Their descriptive statistics are reported in Table 1.

First, we consider the size of the smart city collaborative ecosystem. To approximate this ecosystem, we use the number of existing firms in the 2013 to 2018 period, the number of universities, and the number of residents. We moreover include the square of size, as we previously predicted an inverse-U relation in Hypothesis 1. Thus, we use a quadratic approximation to account for both the positive and negative effects of size.

Then, to evaluate whether a municipality has a smart city strategy, we use a variable from the SCI survey based on the question: "Has your municipality implemented a smart city strategy (or objectives) following the 2018 local elections?". We proxy the existence of a smart city strategy using the responses, which are answered along an integer scale between 1, meaning 'Totally agree', and 5, meaning 'Totally disagree'.

Finally, we adopt a selection of the smart city indicators proposed by Giffinger et al. (2007) to account for the environmental factors. These indicators were developed to approximate the smart city characteristics using a hierarchical three-level structure. The variables are taken from a selection of datasets, indicated in Table 1. Following the Giffinger framework, the top level has six characteristics (namely Smart Environment, Mobility, People, Governance, Living, and Economy). In the second level of the framework, each characteristic has a number of factors associated (for example, the characteristic Smart Environment is composed of the following factors: Attractivity of natural conditions, Pollution, Environmental protection, and Sustainable resource management). In the third level, each factor is described by a number of indicators (for example, the factor Attractivity of natural conditions involves the following indicators:

Sunshine hours and Green space share). Table A in the appendix, derived from Giffinger et al. (2007), shows the variables we use in our study. These variables correspond to the indicators for which data were available for the Belgian municipalities, representing approximately one out of four indicators proposed by Giffinger et al. (2007). Although many factors have been used in the literature as smart city indicators, the indicators proposed by Giffinger et al. are viewed as seminal references by both academics (for example, Sharifi (2019)) and practitioners (for example 'Brussels Smart City'). As a result, these indicators are deemed appropriate for our study.

In particular, to approximate the Smart Environment, we use the share of woodland areas and the share of parks and gardens in 2015, along with the average sunshine hours per day in the 1981 to 2010 period. We use a dummy variable that indicates whether inter-city trains stop at the municipal train station, the number of traffic accidents in 2018, and the share of population covered with an access to 200MB internet speed over the landline to approximate Smart Mobility. We use the share of population with a university degree in 2011, the share of foreigners in the population, and the voting turnout at the 2012 local elections to approximate Smart People. Finally, we use the number of political parties presented and the share of female city representatives at the 2012 local elections, as well as the share of children in day care in 2015 to approximate Smart Governance.

Lastly, because of the (ordered) nature of our dependent variables, we use a log-linear and ordered probit model to test the validity of Hypotheses 1 to 3 (Wooldridge, 2010). Also, because of the large number of explanatory variables relative to the sample size (including the squares of the size variables and a constant in the model results in 20 explanatory variables), the largest eigenvector obtained from a principal components analysis of certain variables is used to avoid the substantial loss in the degrees of freedom (Jackson, 2003). Thus, the explanatory variables are the largest principal component of the variables that approximate the size of the smart city ecosystem and its square, the strategy variable, and the largest principal component of the variables that approximate each of the smart city characteristics (Smart Environment, Smart Mobility, Smart Governance, and Smart People).[2]

5. Results

Table 2 reports the following two estimates for each dependent variable: OLS log-linear estimates and maximum likelihood (ML) ordered probit estimates. Despite the different specifications, the two sets of estimates essentially show the same sign and significance in the (common) coefficients. More importantly, the results largely support the validity of the hypotheses derived in Section 3.[3]

This means that size, strategy, and the smart city characteristics are factors that tend to be correlated with the intensity of collaboration between the local government and the other stakeholders involved in the Belgian smart city ecosystems. In particular, size and its square show the expected signs in almost all the cases considered and are statistically significant for the 'Intensity of partnerships with firms' and 'Intensity of partnerships with universities'. These results partially support Hypothesis 1, which suggested an inverted-U relation between size and collaboration. This indicates that a larger collaborative ecosystem is positively related to the intensity of local government collaboration with their ecosystem, or at least the firms

[2] The percentage of variance accounted by these components was the following: 89% (size), 54% (Smart Environment), 51% (Smart Mobility), 43% (Smart Governance), and 58% (Smart People).

[3] As a robustness test, we also estimated a Heckman selection model in which the probability of not responding (which corresponds here to the answer "I do not know / Not applicable") was explained by dummies for the category of the respondent (where the possible categories are: Mayor (or member of their cabinet), Alderman (or member of their cabinet), Local Councillor, Municipal Administration member, or 'other' with a precision of who responded) and socioeconomic characteristics of the municipality (density and unemployment rate). However, results from a sample of 79 municipalities largely concur with those reported in Table 2. These are not reported to save space but are available from the authors upon request.

and universities in the ecosystem, up until a certain point. When stakeholder numbers in the ecosystem are very large, there are diseconomies of collaboration for the local government.

Table 2: Estimates

	GC (OLS)	GC (ML)	PF (OLS)	PF (ML)	PU (OLS)	PU (ML)	PC (OLS)	PC (ML)
Size	0.1182 (0.1628)	0.2519 (0.2797)	0.5273** (0.2171)	0.7598** (0.3353)	0.5430** (0.2550)	1.0862*** (0.3146)	-0.0235 (0.2154)	0.0425 (0.3057)
$Size^2$	-0.0269 (0.0173)	-0.0618* (0.0344)	-0.0652** (0.0260)	-0.0950** (0.0433)	-0.0605* (0.0307)	-0.1186*** (0.0421)	-0.0109 (0.0237)	-0.0354 (0.0371)
Strategy	-0.2016** (0.0851)	-0.4423*** (0.1695)	-0.2889*** (0.0842)	-0.4499*** (0.1353)	-0.0962 (0.0979)	-0.1236 (0.1357)	-0.2336*** (0.0830)	-0.4852*** (0.1575)
SE	0.0507 (0.0559)	0.0845 (0.1163)	0.1045 (0.0756)	0.1282 (0.1088)	-0.0713 (0.1188)	-0.0311 (0.1270)	0.1674** (0.0613)	0.2478* (0.1315)
SM	0.0673 (0.1324)	0.1479 (0.2525)	0.0514 (0.1865)	0.0200 (0.2466)	-0.0033 (0.1637)	-0.0775 (0.1992)	0.1182 (0.1528)	0.1836 (0.2436)
SP	-0.0703 (0.1054)	-0.0896 (0.2340)	-0.0869 (0.1402)	-0.0206 (0.2525)	-0.0274 (0.2028)	-0.0051 (0.2739)	-0.1068 (0.1224)	-0.1421 (0.2121)
SG	0.1234 (0.0981)	0.2930 (0.2262)	-0.1258 (0.1393)	-0.1510 (0.2314)	-0.0093 (0.1489)	-0.0297 (0.1901)	0.2374* (0.1264)	0.4580* (0.2357)

Note: The dependent variables are 'Intensity of general collaboration' (GC), 'Intensity of partnerships with firms' (PF), 'Intensity of partnerships with universities' (PU), and 'Intensity of partnerships with citizens' (PC). Columns (OLS) correspond to log-linear OLS estimates whereas columns (ML) correspond to ordered probit estimates. SE stands for Smart Environment, SM for Smart Mobility, SG for Smart Governance, and SP for Smart People. The asterisks denote statistically significant coefficients at the 1% level (***), 5% level (**), and 1% level (*). Robust standard errors in brackets.

For the second hypothesis on strategy, the results show that for the intensity of collaboration with the general ecosystem, collaboration with firms, and collaboration with civil society there is a significant, negative relationship. Given the way this variable is coded, its negative sign largely supports Hypothesis 2. The results, therefore, indicate that having a defined smart city strategy leads a municipal government to collaborate more intensively with its smart city ecosystem.

In fact, the existence of a smart city strategy stands as the most important factor across the measures of collaboration considered, since it is only not statistically significant for the 'Intensity of partnerships with universities', which incidentally is the group of stakeholders that has the lowest levels of collaboration in our sample. This may be explained by the fact that in Belgium, universities are very concentrated in certain municipalities. They may be important in these municipalities, but the effect of universities does not show up in the overall study.

The third hypothesis concerned environmental factors. Smart Environment, Smart Mobility, Smart People, and Smart Governance were evaluated to see how identified external factors influence the intensity with which a local government collaborates with their smart city ecosystem. Across the different specifications, the environmental factors do not show up as having an impact on the level of local government collaboration. An exception for this finding is for local government collaboration with civil society. Smart Environment and Smart Governance have a positive and significant relation to the level of collaboration between local government and the public, which will support H3a and H3d, respectively.

As an extension to our analysis, we also model regional effects. We included a Flemish municipal dummy variable and found, as expected from the descriptive analyses, that it shows a positive and statistically significant coefficient (results available upon request). Also, the size of the smart city ecosystems is now only statistically significant for the 'Intensity of partnerships with universities' and shows opposite signs for the different regions. Lastly, strategy remains the most important contingency factor across the measures of collaboration considered. However, while its coefficient in the Brussels and Wallonia municipalities is statistically significant for 'Intensity of general collaboration', 'Intensity of partnerships with firms', and 'Intensity of partnerships with citizens', in Flanders it is only significant for 'Intensity of partnerships with universities'.

6. Discussion and Implications

The results of this study contribute to the literature on smart cities and digital government by, through a contingency approach lens, demonstrating how the contextual and environmental factors of the smart city ecosystem matter for how intensively local governments collaborate with stakeholders. This agrees with the previous literature suggesting one-size-fits-all approaches to managing smart cities and engaging in their ecosystems are not appropriate (Esposito et al., 2021; Hajer, 2016). In practical terms, there emerge certain organizational configurations, whereby similar smart city ecosystems will have similar collaboration outcomes. Characteristics of the ecosystem shape the intensity of collaboration amongst stakeholders.

In addition to contributions to the literature and theory, certain policy implications arise. First, they suggest that having a 'smart strategy' is critical for municipalities aiming to improve their collaboration with the other smart city stakeholders, as we found that a smart city strategy correlates with more intensive collaboration between the local government and other smart city stakeholders. This is consistent with the literature using case studies (Angelidou, 2014; Brorström et al., 2018; Mora, Deakin, & Reid, 2019) and widely supported in the smart city literature, as strategy has been identified as a key component for the successful development of smart cities (Ben Letaifa, 2015; Mora & Bolici, 2017). Smart city strategies have also been found to strengthen urban innovation ecosystems, facilitate collaboration, and foster new partnerships (Komninos et al., 2019). Finally, the development of strategies helps overcome silos in government to improve collaboration across stakeholders (Nesti, 2018).

Moreover, municipalities should be aware that the size of the smart city ecosystem can hinder collaboration with the other stakeholders. For large smart city ecosystems, we suggest that a smart city manager or a dedicated smart city department will be helpful in increasing collaboration. This aligns with the literature acknowledging the role of smart city managers as 'horizontal managers' who are skilled in communicating with stakeholders and are able to break down sectorial silos to organize initiatives across many domains (Michelucci et al., 2016) and garner consensus amongst a variety of stakeholders (Engelbert et al., 2021). The larger the set of stakeholders in the smart city collaborative ecosystem, the more resources may need to be dedicated to ensuring the local government stays connected to it. A manager of this sort may still be beneficial in smaller ecosystems, but less essential. Therefore, precious municipal resources may be more useful in other areas.

Our findings also indicate that the smart characteristics, in particular Environment and Governance, only matter to improve collaboration with citizens. On the one hand, this questions efforts by municipalities towards other smart characteristics (if the aim is indeed to facilitate collaboration). On the other hand, this suggests that smart cities, at least in Belgium, largely care about public participation and perhaps less about technology, as emerging smart city literature is beginning to claim (Manjon et al., 2021; Meijer & Bolívar, 2016; Sharifi, 2019). With regards to Smart Governance, its relevance for collaboration is strongly supported in the literature. Namely, Smart Governance intensifies collaboration amongst stakeholders (Viale Pereira et al., 2017), and in particular citizen participation (Nicolas et al., 2021; Silva et al., 2018). Our findings concerning Smart Environment are less pronounced in the existing literature, which tends to provide the general suggestion that this feature provides foundational support for collaboration in smart cities (Albino et al., 2015; Appio et al., 2019; Snow et al., 2016).

Despite not altering the main results, the results modeling regional effects considering a Flemish dummy show that institutional dynamics matter for collaboration in the smart city. For instance, for the environmental factors, results show that the importance of the Smart Environment and Smart Governance for 'Intensity of partnerships with citizens' previously found (see Table 2), arises from the Wallonia/Brussels and Flemish municipalities, respectively. More generally, in Wallonia, Smart Environment is the most important environmental contingency factor, while in Flanders Smart Mobility, Smart People, and Smart Governance emerge as the most relevant. These differences suggest that projects relating to the natural environment may spur more intensive collaboration in Wallonia, while projects relating to transport and mobility, social factors, and citizen participation may encourage greater collaboration in Flanders.

On a final note, we ran several robustness tests against our main results. First, we weighted our regressions using the inverse of the population in 2017 to address possible concerns about the representativeness of our results (see Manjon et al., 2021 for an analogous procedure on similar data). These weighting regressions yielded similar estimates to the ones reported in Table 2 with generally smaller standard errors, which supports the use of this procedure (Solon et al., 2015) and indicates that our results are largely representative of smart cities in which local governments are engaged in collaboration relations with the rest of stakeholders.

Second, to address the potential endogenous nature of the strategy variable, that is – strategy may affect collaboration, but collaboration may also influence strategy – we used an instrumental variable approach (Wooldridge, 2010). In particular, the instruments used are a third-degree polynomial of the share of seats of the winning party in the 2018 elections and the density of population in 2015. Notice that, in principle, these (lagged) variables are exogenous to the (current) collaboration measures. Also, robust F-joint tests from the first stage regressions turned out to be statistically significant, thus supporting the relevance of these instruments. Lastly, results from a robust score test (see Wooldridge, 2010) rejected the null hypothesis of endogeneity. Also, instrumental variables estimates were largely consistent with those reported in Table 2. Results of the robustness tests are available upon request.

7. Conclusion

The collaborative ecosystem has been framed as a major component of smart cities, supporting smarter solutions that lead to sustainability, economic development, and an overall improved quality of urban life. As a result, understanding the factors that support collaboration across stakeholders is essential for smart city performance. In response, we considered the digital government literature to elaborate the role of the local government in engaging other stakeholders in smart city collaborative ecosystems. We then evaluated how different contextual and environmental contingency factors influence the intensity with which the local government collaborates with different stakeholders in its smart city ecosystem.

The contingency factors studied were size, strategy, and the environment. The smart city collaborative ecosystem was conceptualized through the quadruple-helix framework, which incorporates local government, firms, universities or research institutions, and civil society. As the local government is a key actor in the smart city, and arguably the most influential stakeholder, we assume that how intensively it collaborates with other stakeholders influences the collaboration in the overall ecosystem, and thus the performance of the smart city.

The results of this paper suggest that adopting a smart strategy is an important factor in collaboration between local government and its smart city ecosystem. The results also indicate that for certain types of partnerships, the size of the ecosystem matters. Our findings suggest that while local government collaborates more with a larger group of stakeholders up to a certain point, too many stakeholders in the ecosystem may lead a local government to collaborate less. Finally, environmental factors seemed to matter, but their relevance to different stakeholders may depend on the institutional setting. Taken together, through the contingency lens this indicates that municipalities can foster collaboration with their stakeholders across different types of situations. That is, there are some factors that seem to matter for collaboration, like strategy, despite the circumstances. However, for other factors that cannot be readily changed – like ecosystem size – there are measures local governments can put in place to increase collaboration efforts.

Some limits to the research should be highlighted. First, one of the main findings is that having a defined smart city strategy is positively correlated to how much a local government collaborates with their ecosystem. This assumes that the implemented strategy is appropriate for the local context and desired objectives. This may not be true for all municipalities. Also, it may also not be the case that all smart city projects are either led by or have a significant involvement with the local government, such as a smart city initiative run by a private firm. As our data was limited to the perspective of the local government, we could not evaluate this type of smart city. In these uncommon cases, the model and subsequent empirical results presented here may not be fully applicable. The perspective of the firm, notably viewed through a contingency approach, is suggested for future research. Next, our sample size was only 40 municipalities. While our results should hold in analogous settings for municipalities engaged in collaboration with multiple stakeholders, it is difficult to fully generalize the results of our study. Then, our study assumed that collaboration leads to smart solutions based on existing smart city theory. Future research is required to better understand the empirical relationship of collaboration between stakeholders and the advancement of the smart city. Finally, our study did not significantly focus on the role of leadership. This line of inquiry could offer insight into how leaders, both from local governments, but also perhaps other sectors, may encourage collaboration in the smart city. We thus highlight this as important for future research. In particular, now that we have identified some key factors driving collaboration, future research could investigate if the leadership is not from the municipality, whether or not our results hold. Other avenues to explore related to leadership concern active versus passive collaboration. We assumed that all the stakeholders are actively engaged in collaboration. However, our results may not hold if or when local governments engage with individuals or groups that passively collaborate (through, for instance, associations).

Despite these limitations, the results reveal interesting policy implications. Notably, developing a smart city strategy supports local government collaboration with the stakeholders in its ecosystem. The results also suggest that local governments who endeavor to create smart cities and operate in large collaborative ecosystems should have a smart city manager or department to ensure collaboration across numerous stakeholders. Finally, as the empirical findings suggest that the development of an ecosystem and their related smart outcomes do not just depend on municipalities, the importance of the institutional setting is highlighted, and should be considered during the development of smart city initiatives.

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Appendix

Table A: Table outline variables used from Giffinger et al. (2007) framework

	Factor	Indicator	Year	Level
Smart Environment	Attractivity of natural conditions	Share of woodland areas[1]	2015	Local
	Attractivity of natural conditions	Share of parks and gardens[1]	2015	Local
	Attractivity of natural conditions	Average hours of sunshine per day	1981-2010	Local
Smart Mobility	Local accessibility	Inter-city train stop at municipal station[2]	2018	Local
	Sustainable, innovative, and safe transport systems	Number of traffic accidents	2018	Local
	Availability of ICT-infrastructure	Share of population with access to 200MB Internet speed over landline	2019	Local[3]
Smart People	Level of qualification	Share of population with university degree	2011	Local
	Social and ethnic plurality	Share of foreigners in population	2018	Local
	Participation in public life	Voting turnout in local elections	2012	Local
Smart Governance	Political activity of inhabitants	Number of electoral lists (political parties) in municipal elections[4]	2012	Local
	Participation in decision-making	Share of female city representatives	2012	Local
	Public and social services	Share of children in daycare	2018	Local

Source: Adapted from Giffinger et al. (2007).

[1] These variables represent ‘Green space share’

[2] This variable is a proxy for the variables used to represent Local accessibility

[3] In Giffinger et al. (2007), this variable was at the national level, but we provide localized data.

[4] Number of electoral lists is a proxy to represent political activity of inhabitants.