Public Management Review

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/rpxm20

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To cite this article: Yifan Chen , Stuart Bretschneider , Justin M. Stritch , Nicole Darnall & Lily Hsueh (2021): E-procurement system adoption in local governments: the role of procurement complexity and organizational structure, Public Management Review

To link to this article: https://doi.org/10.1080/14719037.2021.1874497

Published online: 03 Feb 2021.

PUBLIC MANAGEMENT REVIEW
https://doi.org/10.1080/14719037.2021.1874497

Routledge
Taylor & Francis Group

E-procurement system adoption in local governments: the role of procurement complexity and organizational structure

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ABSTRACT

The article examines how local governments' procurement complexity and structure interact to influence e-procurement adoption. Drawing on the survey data of over 400 cities, we find that a centralized structure enhances the likelihood that local governments adopt an e-procurement system to cope with the increasing procurement complexity; while governments with a coordinated structure are less likely to adopt e-procurement as they can rely on the intra-organizational collaboration and information-sharing embedded in the structure to accommodate complex procurements. The findings shed insights on how local governments with different structures can best deal with complex managerial activities and facilitate e-procurement adoption.

KEYWORDS E-procurement adoption; organizational structure; centralization; local government; public procurement

Introduction

Over the past 30 years, public organizations have increasingly relied on information and communication technologies (Asgarkhani 2005; Buffat 2015), such as e-procurement systems, to enhance managerial efficiency and effectiveness and reduce transaction costs (Thong 1999; Damanpour and Schneider 2006; O'Neill 2009; Bertot, Jaeger, and Grimes 2010). These technologies have also improved democratic participation, civic engagement, and citizen trust since they enhance the transparency, accountability, and accessibility of public services (Asgarkhani 2005; Norris and Moon 2005; Moon 2005; Tolbert and Mossberger 2006; Dwivedi et al. 2017). For instance, the e-procurement system is an important managerial tool to integrate and automate procurement activities such as ordering, bidding, negotiating, and auditing (Bendoly and Schoenherr 2005; Moon 2005; Hardy and Williams 2008). Prior scholars suggest that the use of e-procurement technologies might provide 42% savings in purchasing transaction costs (Davila, Gupta, and Palmer 2003). Despite the merits of e-procurement systems, only recently has its adoption caught the academic attention of public management (Panayiotou, Gayialis, and Tatsiopoulos 2004; Walker and Brammer 2012).

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Extant literature of governments' e-procurement adoption is tentative and exploratory, requiring both theoretical and empirical developments (Bonsón et al. 2012; Walker and Brammer 2012). Prior studies have focused on assessing the antecedents of governments' e-procurement adoption, emphasizing the characteristics of decision-makers, the form of government and its social or political environments (e.g., Davila, Gupta, and Palmer 2003; Moon 2005; Gunasekaran and Ngai 2008; Aboelmaged 2010). In addition, scholars tend to treat the potential antecedents in an isolated fashion by focusing on a single type of factor at a time (e.g., Moon 2005; Vaidya, Sajeev, and Callender 2006; Gunasekaran and Ngai 2008). However, the reality is that the e-procurement adoption in local governments is an intricate process where determinants can be interrelated and have interactive effects. To bridge the literature gap, this study posits that procurement complexity likely affects the adoption of an e-procurement system. Public organizations tend to perceive the current system dealing with complex procurement activities as unsatisfactory. The performance gap will likely give rise to an increasing demand to automate procurement (Daft 1978; Zhu and Rutherford 2019). We also suggest that procurement complexity interacts with organizational structure to produce a more sophisticated and nuanced mechanism of the e-procurement adoption in local governments.

Drawing upon a 2017 nation-wide survey of public managers across more than 400 large cities, this paper explores (1) how procurement complexity relates to local governments' adoption of e-procurement systems; and (2) how different decision-making structures moderate this relationship. Our findings suggest a more complex mechanism of e-procurement adoption underlying the role of procurement complexity and organizational structure. The results also provide a potential explanation for the inconsistent findings on organizational structures and e-technologies adoption more generally. The results imply that digital technologies might be a potential solution to address or alleviate the tension between conflicting procurement policies because the technology enhances the government's capacity for information searching and processing. However, the extent to which e-technologies can serve as a promising solution varies across local governments with different structures.

Literature review and hypotheses

Utilizing digital technologies to purchase products or professional services and communicate with vendors has become a trend in governmental procurement (Vaidya, Sajeev, and Callender 2006; Hardy and Williams 2008). The e-procurement system refers to any web- or internet-based technologies designed to facilitate the acquisition of goods internally (Rajkumar 2001; Davila, Gupta, and Palmer 2003; Hawking et al. 2004; Moon 2005). Technologies associated with e-procurement include websites, emails, extra- and intra-nets (Vaidya, Sajeev, and Callender 2006; Walker and Brammer 2012). Evidence suggests that local governments can leverage these systems to enhance communications, identify potential suppliers, reduce transaction costs, and streamline the procurement process (e.g., Panayiotou, Gayialis, and Tatsiopoulos 2004; Moon 2005; Gunasekaran and Ngai 2008; Walker and Brammer 2012).

Professional and academic interests in governments' e-procurement adoptions increased in recent years, partly due to the significant scale of public procurement. In the U.S., states and local governments spend billions of dollars annually procuring commodities and professional or contractual services, which account for around 23%

of the national GDP (Walker and Brammer 2012). Public procurement is a complex process by which governments acquire goods, services, and supplies from outside sources to fulfil diverse goals and support essential functions (Thai and Grimm 2000; Coggburn 2004; Snider and Rendon 2012; Wang and Xiaoming 2014). Local governments utilize procurement as a policy tool to promote public values and social benefits (Edler and Georghiou 2007; Smith and Fernandez 2010; Young, Nagpal, and Adams 2016). This is typically done through a series of policies favouring local, women and minority-owned firms or environmental-friendly products (Walker and Brammer 2012; Young, Nagpal, and Adams 2016; Stritch et al. 2020). The procurement policies and requirements are designed to leverage local governments' procuring power to improve economic development, social justice, and environmental sustainability (McCrudden 2004; Nijaki and Worrel 2012; Stritch et al. 2020). However, one potential impact of these multiple objectives is to complicate the procurement process. Public purchasers likely experience difficulty in pursuing multiple policy objectives simultaneously as it places substantial limits, constraints, and information requirements on them (Boyne 2003; Vaidya, Sajeev, and Callender 2006).

Procurement complexity

We argue that procurement complexity affects the decision of e-procurement adoption in local governments. Although research rarely explores the concept of procurement complexity, the literature related to task complexity can provide some insights. The literature in the fields of management, psychology, and public administration have provided various definitions of task complexity, including multiple paths/solutions, goal multiplicity and uncertainty (Wood 2016; Campbell 1988; Bonner 1994; Andrews and Boyne 2014; Klijn and Koppenja 2015). Building on prior studies, the number of criteria that task-doers use to evaluate the task outcome can define a task as more or less complex (Earley, 1985; Lee and Rao 2009; Wood 2016). As the number of criteria increases, a task-doer's responsibility to evaluate or compare different alternatives becomes more complex, especially when these criteria are interdependent and none of them can dominate the others (Campbell 1988; Andrews and Boyne 2014).

Related to the context of public procurement, we use the number of policies as an indicator of procurement complexity. Each procurement policy comes with its own set of objectives that will be used as criteria to evaluate procurement performance (Stritch et al. 2020). These policies might collide with one another as they represent different demands and benefits, forcing purchasers to make tradeoffs within a growing set of criteria (Knutsson and Thomasson 2014; Young, Nagpal, and Adams 2016; Stritch et al. 2020). As a result, when multiple policies governing the procurement system are formally applied and pursued simultaneously, the complexity of governmental procurement decisions increases.

As the number of procurement policies grows, governmental purchasers must navigate more purchasing criteria. They have to satisfy the competing needs and demands of diverse stakeholders (e.g., vendors, political officials, internal customers, and citizens), while attending to limited procurement budgets (McCrudden 2004; Hardy and Williams 2008). The complexity of procurement decision-making might reduce efficiency because it likely results in a costly and time-consuming administrative decision process. Purchasers have to spend a larger amount of time and effort evaluating different alternatives and considering the relative tradeoffs of each

product or service in the context of relevant policies. Accountability mechanisms to ensure policy compliance require resources to justify purchasing decisions in the face of added complexity (Stritch et al. 2020). Therefore, governmental purchasers might strive to reengineer the procurement process, enlarge the information base, and strengthen the capacity of information transmission and processing, so as to accommodate multiple procurement policies (Nielsen, Møller, and Hansen 2001; Knutsson and Thomasson 2014; Young, Nagpal, and Adams 2016).

Increases in procurement complexity likely give rise to a growing dissatisfaction with the traditional procurement system. When the procurement system fails to meet expectations, local governments have greater incentives to re-engineer the procurement process and adopt an e-procurement approach (O'Neill 2009; Moon 2005). E-procurement systems help manage complex procurements by transparently, quickly, and accurately collecting the information necessary for procurement decision-making (Muffatto and Payaro 2004; Tatsis et al. 2006; Gunasekaran et al. 2009; O'Neill 2009). For example, the e-procurement system can digitize and integrate multiple vendor catalogues to generate an aggregated database, which might provide wider buying choices and more accurately filter qualified suppliers (Moon, 2005; Gunasekaran et al. 2009). Governmental purchasers can use the e-procurement system to identify whether the products with the lowest price are simultaneously environment-friendly or sold by minority-owned businesses. These systems also embed trade-off rules and mechanisms for handling multiple criteria.

Moreover, the e-procurement system advances government procurement initiatives and policy goals by standardizing, streamlining, and automating the procurement process (Davila, Gupta, and Palmer 2003; Moon 2005; Hardy and Williams 2008). The system helps to minimize human errors, simplifies procurement workflows, as well as reduces paperwork and repetitive administrative procedures with respect to the ordering and the handling of invoices and payments (Moon 2005; Gunasekaran et al. 2009; Walker and Brammer 2012). Additionally, e-procurement systems enable purchasers to track the spending, document performance information of suppliers, review and analyse purchasing patterns (Muffatto and Payaro 2004; Hardy and Williams 2008). Employees hence can better manage the process and gain knowledge on making tradeoffs among the complex and at times conflicting procurement policies.

As a result, the e-procurement system enables governmental purchasers to reduce the administrative costs, shorten the order fulfilment cycle time, and reach a more speedy, transparent, efficient, and cost-effective procurement process. The benefits make e-procurement an ideal tool to address procurement complexity. Hence, the perceived usefulness and performance expectancy of the system will be enhanced when procurement activities become increasingly complex, which builds up the likelihood of e-procurement adoption (Davis 1989; Venkatesh and Davis 2000; Venkatesh et al. 2003; Gunasekaran et al. 2009). We propose our first hypothesis:

Hypothesis 1: As the procurement activities become increasingly complex, local governments are more likely to adopt an e-procurement system.

Organizational structure

Local governments conduct procurement through different structures. For example, some leverage a hierarchical structure which concentrates all procurement tasks and

practices to a specific unit or a sub-unit of an existing functional support unit. While others, particularly larger and more comprehensive governments, likely exhibit a horizontal or nested structure as they tend to distribute procurement decisions, activities, and responsibilities to multiple units. The units can either make purchases independently or collaboratively. The paper proposes that a government's procurement structure is an important context that should be taken into account when examining the adoption of e-procurement. The extent to which procurement complexity can encourage e-procurement adoption depends on the structure in which procurement activities are embedded.

Centralized structure

Local governments traditionally conduct procurements through a more centralized structure to ensure economy, efficiency, and accountability (control) in the expenditure of public resources (McCue and Pitzer 2000; Dimitri, Dini, and Piga 2006; Andrews et al. 2007). The degree of centralization refers to the extent that the decision-making authority, power, and control are distributed among governmental units (Pugh et al. 1969; Rogers 1995; Daft, Murphy, and Willmott 2010). A centralized structure is highly hierarchical of authority and low on member participation (Hage and Aiken 1967; Glisson and Martin 1980; Andrews et al. 2007). This structure concentrates the decision-making authority to a handful of high-level executives and excludes others from participating in decision-making about the allocation of resources and the determination of governmental policies or activities (Andrews et al. 2007). In the context of public procurement, a high degree of centralization indicates that the locus of authority to make procurement decisions lies in some specialized procurement unit or thesub-unit of an existing functional support unit such as the finance department (Dimitri, Dini, and Piga 2006; Wang and Xiaoming 2014; Stritch et al. 2020). The role of other units is limited to requesting goods and services.

We suggest that local governments with centralized structures are more likely to adopt an e-procurement system when procurement complexity increases. A highly centralized structure emphasizes rule promulgation and the integrity of the procurement systems, requiring central agencies to closely monitor and control the procurement activities at all levels of the organization (Matland 1995; Glisson and Martin 1980; McCue and Pitzer 2000; Andrews et al. 2007). When procurement becomes increasingly complex, central agencies will take extra efforts to control the process and evaluate performance. They seek to process large amounts of information to maintain the control and prevent opportunistic behaviours such as corruption and violation of procurement policies (Dimitri, Dini, and Piga 2006; Wang and Li 2014; Andrews and Boyne 2014). An e-procurement system provides central agencies a real-time platform to track procurement spending, prevent maverick buying, and manage ongoing activities (Moon 2005; Gunasekaran and Ngai 2008; Walker and Brammer 2012). It eases the burden of supervision and management. Local governments with a centralized structure hence will demonstrate greater willingness in adopting the e-procurement system.

In addition, a local government with a centralized structure can effectively translate its intention or willingness into the actual e-procurement adoption. The e-procurement adoption is a dynamic process where resistance and avoidance likely emerge. For example, due to the sensitivity and the legal nature of orders and payments, local

governments might be concerned with information privacy and security when using the e-procurement system. Moreover, as the installation may require large investments and the restructuring of procurement routines (Asgarkhani 2005; Andrews and Boyne 2014), change-induced resistance may occur. The resistance to change can significantly delay or even suspend the adoption of an e-procurement system (Asgarkhani 2005; Angeles and Nath 2007; Gunasekaran et al. 2009). Prior studies suggest that the resistance will be reduced in a centralized structure as the central agency can serve as a mediator to better resolve tensions and reluctances (Dimitri, Dini, and Piga 2006). The hierarchy of authority embedded in the structure decreases the likelihood that the managerial decision will be challenged by other units (McCue and Pitzer 2000). Besides this, central agencies typically have the authority to execute the adoption despite resistance from others (Williams 1994). Local governments who have a centralized structure hence are more likely to adopt the e-procurement system in face of growing policies. We then propose our second hypothesis:

Hypothesis 2: As the procurement activities become increasingly complex, local governments with a higher degree of centralization are more likely to adopt the e-procurement system.

Decentralized – Specialized structure

Rather than consider decentralized structures as solely the opposite of centralization, we think of these as different dimensions of the governmental structure. A decentralized structure is characterized by fragmented decision-making authorities and higher member participation (Hage and Aiken 1967; Glisson and Martin 1980; Andrews et al. 2007). In decentralized structures, each government unit has a significant role in financial and administrative decision-making process. Additionally, a decentralized structure can take several forms. It may involve either a more specialized structure or a more coordinated structure (Cohen, March, and Olsen 1972; Zhu and Kindarto 2016). Given these variations, we consider two types of structure that captures decentralization: the specialized structure and the coordinated structure.

In a specialized structure, different government units conduct their own procurement activities independently. In the face of growing procurement complexity, we suggest that local governments with a specialized structure are less likely to adopt an e-procurement system. The procurement decision-making authorities, responsibilities, and accountabilities are widely and fragmentally distributed in a specialized structure (Andrews et al. 2007). The structure allows government units to have a separate procurement process (McCue and Pitzer 2000; Zhu and Kindarto 2016). Each unit has the autonomy to decide the optimal procurement choice based on its own preferences and interests and hence more in line with their specific needs. For example, an environment department likely prioritizes sustainable procurement policies while the department of economic development tends to emphasize purchasing from local businesses. As fragmented units only attend to a small portion of the entirety of the complex set of procurement activities, they are less likely to see the big picture administratively (Hage and Aiken 1967; Andrews et al. 2007). The structure disperses the information requirements across different units. Local governments will perceive fewer pressures and demands to transfer the procurement to an e-based platform. The likelihood of adopting an e-procurement system hence decreases. We propose a third hypothesis:

Hypothesis 3: As the procurement activities become increasingly complex, local governments with a higher degree of specialized structure are less likely to adopt the e-procurement system.

Decentralized – Coordinated structure

The coordinated structure allows for collaborative procurements and collective decision-making across different units. Each unit within such a structure can participate in others' procurement processes and collaborate to fulfil procurement decisions. For instance, the Kansas City Regional Purchasing Cooperative is an initiative that aggregates cooperative contracts across local agencies. It enables government units to leverage the experience from others to guide or support their own procurement decisions. The coordinated structure hence can provide a 'cushion' to 'buffer' information requirements and pressures by facilitating the information diffusion and knowledge sharing under environmental complexities and uncertainties (Dimitri, Dini, and Piga 2006; Crook and Combs 2007; Schotanus et al. 2011; Meehan, Ludbrook, and Mason 2016). The structure allows different units to exchange ideas, skills, and knowledge with each other (McCue and Pitzer 2000; Schotanus et al. 2011; Meehan, Ludbrook, and Mason 2016). For example, other units can rely on the expertise of the environment department to discern whether the products are environmentally sustainable. Each unit can also gain experience through the participation and observation of others' procurement activities (Lee, Chang, and Berry 2011).

Moreover, a coordinated structure provides local governments the flexibility and adaptability to cope with multiple conflicting procurement policies. Under this decision-making paradigm, local governments might encounter less bureaucratic obstacles embedded in the procurement process, including the burdensome paperwork and delayed procurement approval (Stritch et al. 2020). The flexibility also enables governments to cope with the complex environment by re-engineering and streamlining the procurement process without impediments from central agencies (McCue and Pitzer 2000). Local governments, therefore, have greater capacity to accommodate the requirements imposed by procurement complexity and are less likely to adopt the e-procurement system. For these reasons, we propose that local governments with a higher degree of coordinated structure are less likely to adopt the e-procurement system when procurement complexity increases.

Hypothesis 4: As the procurement activities become increasingly complex, local governments with a higher degree of coordinated structure are less likely to adopt the e-procurement system.

Data

We use data from an original survey ('Sustainable Procurement in U.S. Cities') of 1,825 finance, environment, and public works departments. The survey was sent to a representative sample of 791 U.S. cities with 25,000 residents or more. In comparing these 791 cities to data obtained from the U.S. Census Bureau on all local governments with 25,000 residents or more, there were no statistical differences when considering population, median family income, race, and geographic distributions by state. In targeting directors of finance, environment, and public works departments, the survey sought perspectives from individuals who were

either knowledgeable about the purchasing process, was affected significantly by purchasing, or had detailed information about the city's environmental management processes.

Before sending out the survey, a focus group was conducted with 14 employees, including both the department directors and purchasing officers, in the City of Phoenix to understand more about the structure of purchasing in local governments. Feedback on the draft survey was solicited from 31 stakeholders working in city government, county government, U.S Environmental Protection Agency, ICMA, SPLC, U.S. General Services Administration, environmental consulting and academia. A pre-test was conducted with 94 department directors. Among these participants, 51% were finance directors, 37% were directors for the public work department, and the remaining 12% were environment directors.

The survey was distributed online over a period of eight weeks. City directors received an initial letter informing them of the survey and then an email containing a link to a Qualtrics-based survey several days later. Non-respondents received up to four email reminders, two postcard reminders, and two phone call reminders. 585 directors have completed the survey. After adding the 31 completed during the pre-test, the final sample consisted of 616 responses out of 1,825. The response rate is 33.8%. We received responses from at least one director in 58.0% (459) of the 791 cities in our sample. The final sample consisted of 48.2% finance directors, 15.3% environmental directors, and 36.5% public works directors.

Measures

Dependent variable

The outcome variable, *E-Procurement Adoption*,[1] in this analysis is coded as a binary variable where '1' indicates that the city has adopted an e-procurement system and '0' represents no adoption. 33% of respondents in the final data indicate that their cities have adopted the e-procurement system.

Explanatory variables

This study considers the number of formally adopted procurement policies as an indicator of procurement complexity. *Procurement Complexity*, therefore, is measured with six survey items. Each item asks respondents whether their city has formal procurement preference policies in six separate domains: buying from minority, women, veteran, local or small business or purchasing environmentally sustainable products. To create the summative index of *Procurement Complexity*, the responses to each survey item are coded as dummy variables. The Cronbach's alpha is 0.74, suggesting a reasonable reliability for these summative scores. The index ranges from 0 to 6, indicating that procurement choices become increasingly complex as cities adopt more policies. Approximately 37% of respondents indicate zero policies in place with the average being two policies. And 6% of cities have five or six policies in place. We have used two general measures of influence, standardized Pearson residuals and DFBETAS, to diagnose whether such a skewedness results in overly influential cases in the data. These measures indicate that the skewedness of *Procurement Complexity* will not bias our regression results.

We measure the traditional concepts of centralization and decentralization by using three survey items each ranging from '1=strongly disagree' to '5=strongly agree'. The Cronbach's Alpha of these items is 0.25, suggesting these procurement structures are distinct. We measure *Centralized Structure* by asking respondents to indicate the extent to which they agree that in their cities 'the finance department conducts all purchasing'. The higher the score, the more centralized the structure. *Specialized Structure* is captured by asking to what extent do respondents agree that 'individual departments do all of their own purchasing'. We measure *Coordinated Structure* by asking the extent to which respondents agree that, 'separate departments coordinate to make purchases.'

Control variables

We control for three categories of exogenous variables that might affect the e-procurement adoption decision. The first category captures two real-world hybrid procurement structures found in U.S. local governments. Another category represents organizational characteristics, including size, culture, and financial capacity. The third category of variables controls for variations in the local community, such as the city's demographic compositions.

While our research focuses on centralization and decentralization, we also control for other elements of structures. Local governments in recent years are moving towards hybrid procurement structures where central agencies share the authority on purchasing decisions with other governmental units (McCue and Pitzer 2000; Dimitri, Dini, and Piga 2006). The structures delegate central agencies (e.g., the finance department or higher-level agencies) the authority to monitor or control the procurement activities while allowing other units to provide advice and feedback. In practice, there is no standard model for hybrid structures. We incorporate two hybrid structures and their interaction terms into the empirical model to explore how they interact with procurement complexity to either stimulate or suppress the e-procurement adoption decision. *Hybrid Structure I* is measured by asking respondents the extent to which they agree their 'departments coordinate with higher level offices to make purchase.' We capture *Hybrid Structure II* by asking how respondents agree that 'the finance department provides support for department purchasing'. The answers range from '1 = strongly disagree' to '5 = strongly agree'.

Departmental Size is a numeric variable instrumented by asking how many employees each respondent directly supervises in his or her department. The variable ranges from 0 to 51 with a mean of 14.09. To capture *Openness to Innovation*, we include four items ranging from '1 = strongly disagree' to '5 = strongly agree' on following statements: 'this department has a strong commitment to innovation', 'we reward employees who develop innovative solutions', 'this department is a dynamic and entrepreneurial place', and 'most employees in this department are not afraid to take risks'. The summative index has a Cronbach's alpha of 0.84. *Rule Control* is also instrumented on a 5-point Likert scale. We ask respondents to what extent do they agree that employees are 'constantly being checked on for rule violations'. The survey measures *Financial Capacity* by asking respondents how they assess their department's overall financial standing over the past five years. The responses range from '1 = very weak' to '5 = very strong'.

To hold city-level demographic variables as control, we match the survey data with the American Community Survey published by Census Bureau. The control variables include the total population in logarithm form (*Log(population)*), the unemployment

Table 1. Descriptive statistics of all variables (N = 435).

	Mean	Std. Dev.	Min	Max
Dependent Variable				
E-Proc Adoption	0.35	0.48	0.00	1.00
Independent Variables				
Procurement Complexity	1.60	1.71	0.00	6.00
Centralized Structure	1.94	1.05	1.00	5.00
Specialized Structure	3.21	1.34	1.00	5.00
Coordinated Structure	3.45	1.06	1.00	5.00
Control Variables: Hybrid Structures				
Hybrid Structure I	3.27	1.14	1.00	5.00
Hybrid Structure II	4.04	1.04	1.00	5.00
Control Variables: Org Characteristics				
Departmental Size	13.26	15.49	0.00	51.00
Openness to Innovation	3.43	0.77	1.00	5.00
Rule Control	2.40	1.03	1.00	5.00
Financial Capacity	3.95	0.95	1.00	5.00
Control Variables: Community Context				
Log(Population)	11.10	0.82	10.06	14.75
Unemployment Ratio	0.08	0.03	0.03	0.20
Race(Black) Ratio	0.11	0.13	0.00	0.77

rate (*Unemployment Ratio*), and the breakdown of population by race (*Race(Black) Ratio*).

Table 1 provides summary statistics and Table 2 shows the correlation matrix.

Methodology

As the dependent variable is dichotomous, to assess our hypotheses, we use a logistic response model. We choose this model over an ordinary linear regression because it uses the log odds ratio and an iterative maximum likelihood function. Hence, the method is more robust (e.g., does not require homoscedastic errors) and serves as a better fit for our non-normally distributed dependent variable (Gourieroux and Monfort 1981) since the linear probability model typically generates fitted values less than zero and greater than one. Moreover, we have assessed our hypotheses using a probit regression model, although we only report the results of the logistic model. We do this for two reasons: (1) the probit model produces similar but more significant results; and (2) the logistic model has a slightly smaller value of Akaike's Information Criterion (AIC) and Bayesian Information Criterion (BIC), indicating less information loss and higher model quality (Aho, Derryberry, and Peterson 2014). Additionally, we employ fixed effects to control for the omitted or unobserved variations across departments and states that might impact the regression results.

Results

Table 3 presents the results of estimating the basic model with varying levels of controls. The first column (Model 1) in Table 3 provides the simplest form of the model while the final column (Model 4) includes all control variables and accounts for state and department fixed effects. We use Model 4 as the main model to interpret the results.

Table 2. Correlation matrix of all variables (N = 435).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
(1) E-Proc Adoption	1.00													
(2) Procurement Complexity	0.17	1.00												
(3) Centralized Structure	0.08	0.19	1.00											
(4) Specialized Structure	−0.17	−0.11	−0.28	1.00										
(5) Coordinated Structure	0.07	0.10	0.06	0.02	1.00									
(6) Hybrid Structure I	−0.06	0.02	0.03	0.04	0.37	1.00								
(7) Hybrid Structure II	−0.02	0.09	0.20	−0.10	0.18	0.19	1.00							
(8) Departmental Size	0.06	−0.02	−0.01	0.00	0.04	0.02	−0.05	1.00						
(9) Openness to Innovation	0.14	0.05	0.08	−0.03	0.11	0.14	0.12	0.13	1.00					
(10) Rule Control	0.00	0.04	0.02	0.04	0.03	−0.03	−0.06	0.11	−0.09	1.00				
(11) Financial Capacity	−0.03	−0.05	0.02	−0.01	0.05	0.10	0.20	0.06	0.33	−0.12	1.00			
(12) Log(Population)	0.44	0.32	0.21	−0.30	−0.03	−0.11	0.00	−0.02	0.06	0.03	−0.09	1.00		
(13) Unemployment Ratio	0.01	0.13	0.13	−0.10	−0.06	−0.07	−0.07	0.01	−0.12	0.04	−0.30	0.13	1.00	
(14) Race(Black) Ratio	0.03	0.20	0.10	−0.10	−0.07	−0.02	0.02	0.10	−0.04	0.00	−0.06	0.12	0.41	1.00

We can see from Table 3 that the full model (Model 4) has the best Log Likelihood (−192.64) and Pseudo R-Square (0.31) comparing to other models, suggesting the best model fit. The paper also tests the sample mean to see whether there are significant differences between the observations included in the empirical model and the observations that have been dropped due to missing values. The results indicate that the mean differences of all variables are not significant at 10% level. Moreover, to check the severity of multicollinearity, we conduct the diagnostic tests relating to the variance inflation factor. All variables except for the independent variables and their interaction

Table 3. Regression results of e-procurement adoption.

	IV Only (Model 1)	Controls (Model 2)	Centra/ Decen (Model 3)	Full Model (Model 4)
	E-Adoption	E-Adoption		E-Adoption
Procurement Complexity (PC)	0.2094***	0.0278	−0.3044	−0.6199
	(0.0541)	(0.0825)	(0.3365)	(0.3927)
Centralized Structure		−0.0407	−0.4923**	−0.6526***
		(0.1483)	(0.2323)	(0.2164)
Specialized Structure		0.0267	−0.1018	−0.1761
		(0.1076)	(0.1501)	(0.1480)
Coordinated Structure		0.1665	0.3416*	0.4296**
		(0.1204)	(0.1785)	(0.1972)
PC * Centralization			0.2299***	0.2809***
			(0.0874)	(0.0883)
PC * Specialized Decentralization			0.0742	0.0913
			(0.0647)	(0.0650)
PC * Coordinated Decentralization			−0.1087*	−0.1476**
			(0.0625)	(0.0751)
Hybrid Structure I				−0.2782
				(0.1794)
Hybrid Structure II				−0.0261
				(0.1768)
PC * Hybrid Structure I				0.0894
				(0.0755)
PC * Hybrid Structure II				−0.0011
				(0.0764)
Departmental Size		0.0053	0.0062	0.0044
		(0.0087)	(0.0088)	(0.0093)
Openness to Innovation		0.2723	0.2643	0.3637*
		(0.1822)	(0.1909)	(0.1979)
Rule Control		−0.0873	−0.0720	−0.0430
		(0.1316)	(0.1364)	(0.1385)
Financial Capacity		−0.0642	−0.0574	−0.1157
		(0.1536)	(0.1572)	(0.1600)
Log(Population)		1.5641***	1.6826***	1.7324***
		(0.2195)	(0.2288)	(0.2380)
Unemployment Ratio		−4.515	−5.2419	−5.9886
		(5.918)	(6.1855)	(6.3487)
Race(Black) Ratio		−0.8412	−1.2038	−1.1051
		(1.208)	(1.1715)	(1.2091)
Constant	−1.0604***	−16.798***	−17.3288***	−16.8974***
	(0.1298)	(2.826)	(2.9238)	(3.0098)
Observations	541	438	438	435
Fixed Effects	No	Yes	Yes	Yes
Log Likelihood	−334.48	−204.11	−199.27	−192.64
Pseudo R-Square	0.02	0.28	0.29	0.31

Standard errors in parentheses;
* p < 0.10, ** p < 0.05, *** p < 0.01

terms have scores within the acceptable range (below 1.5), suggesting that predictors are not correlated.

Procurement complexity

We find no empirical support for Hypothesis 1, which expects a positive relationship between procurement complexity and e-procurement adoption. The final model in Table 3 demonstrates that the coefficient of *Procurement Complexity* is not significant at 10% level (p = 0.114). The result suggests that we cannot reject the null hypothesis that procurement complexity has no influences on the adoption of e-procurement system.

Centralized structure

Hypothesis 2 proposes the positive moderating effect of *Centralized Structure* on the relationship between *Procurement Complexity* and *E-Procurement Adoption*. A joint test on the coefficients of *Procurement Complexity, Centralized Structure* and their interaction term returns a p-value of 0.007, suggesting a significant overall effect of procurement complexity and centralization. Figure 2 gives us a more accurate view of how procurement complexity and centralization jointly affect the probability of e-system adoption when respondents 'strongly disagree (SD)', 'disagree (D)', 'neither disagree nor agree (ND/NA)', 'agree (A)' and 'strongly agree (SA)' with the statement that 'the finance department conducting all purchasing'.

In Figure 1, we plot the predicted probability of *E-Procurement Adoption* by holding all variables except for *Task Complexity* and *Centralized Structure* at the sample mean. The predicted probability is calculated based on the main effects for *Centralized Structure* (−0.653), *Task Complexity* (−0.620), as well as the interaction term (0.281). Figure 1 shows that, for local governments with the lowest degree of *Centralized Structure* (SD), there is an inverse relationship between procurement complexity and the adoption. At the next level (D), there is no significant relationship. However, the relationship turns into positive when *Centralized Structure* keeps growing. These findings offer some support for our second hypothesis that local governments with a more centralized structure likely adopt an e-procurement system as procurement complexity increases. It should be noted that approximately 80% of respondents have indicated 'SD' or 'D' so that most governments have either no or negative effect.

Specialized & coordinated structure

Hypothesis 3 and 4 posit the influence of procurement complexity on e-procurement adoption is conditioned on the degree of decentralization. In the context of specialized structure, a joint hypothesis test on the three coefficients associated with the effects of *Procurement Complexity* (−0.620), *Specialized Structure* (−0.176) and their interaction (0.091) returns a p-value of 0.409. A similar joint test associated with the three coefficients for the *Procurement Complexity* (−0.620), *Coordinated Structure* (0.430) and their interaction (−0.148) returns a p-value of 0.033. The empirical results suggest that it is the coordinated form of decentralization interacts with procurement complexity to influence the probability of e-procurement adoption. Hypothesis 4 thus is supported.

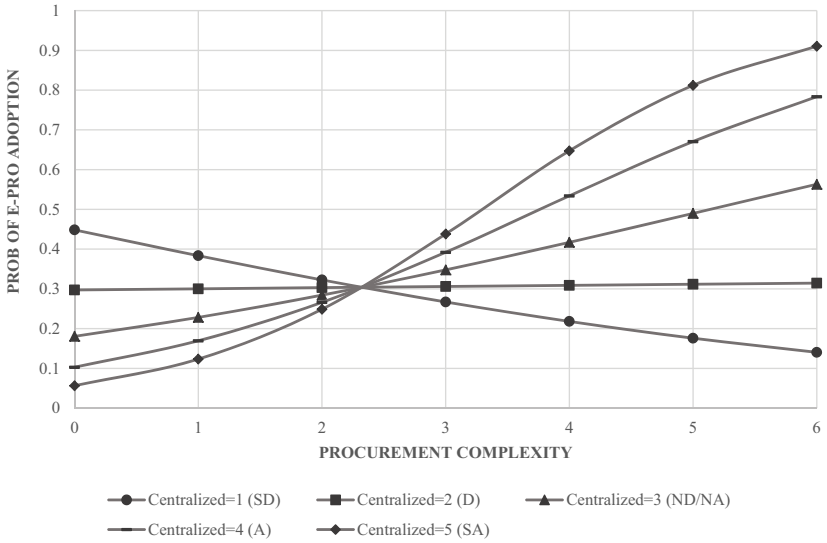

Figure 1. Interactive effect of procurement complexity and centralized structure (N = 435).

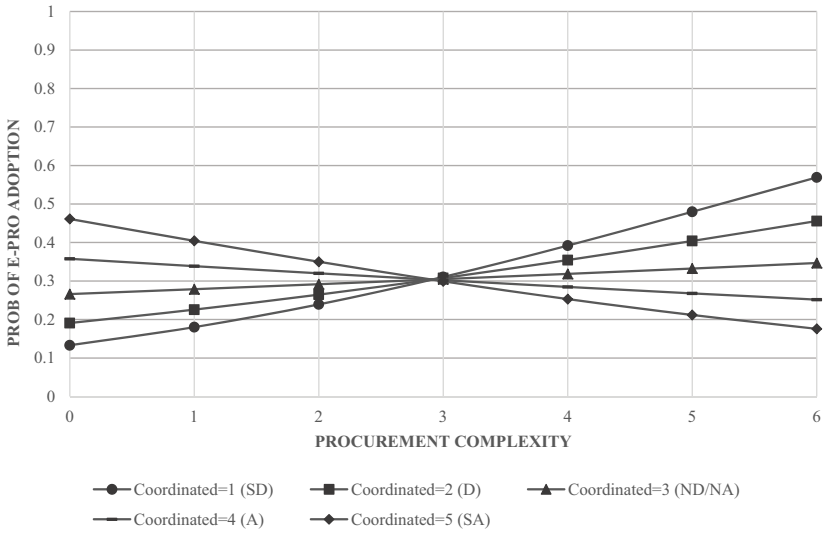

Figure 2. Interactive effect of procurement complexity and coordinated structure (N = 435).

Figure 2 provides a similar analysis as done in Figure 1 of the effects of *Coordinated Structure*. We follow a similar process to simulate all possible results of *E-Procurement Adoption*. Figure 2 demonstrates that in local governments where respondents disagree or strongly disagree that their procurement structures are coordinately decentralized, an

increase in procurement complexity enhances the probability of e-procurement adoption. While for governments with the highest degree of *Coordinated Structure* (SA), the relationship turns into negative. These findings indicate that coordinated structure interacts with procurement complexity to influence the adoption. We also note that approximately 63% of the respondents have indicated a measure of coordinated structure of four (A) or five (SA). This implies that most local governments in our sample have a negative effect, which echoes the empirical results of *Centralized Structure*.

As noted above, these models with interaction terms create a number of complexity issues. We have presented aggregated diagrams to provide substantive estimates of overall effects. We have also carried out a series of joint hypotheses tests to determine that the statistical results were not influenced by multicollinearity. A chi-square test on coefficients associated with *Centralized Structure, Procurement Complexity* and their interaction has a p-value of 0.007. Another chi-square test on the three coefficients associated with *Coordinated Structure* has a p-value of 0.033. Finally, the chi-square test with five coefficients associated with *Procurement Complexity, Centralized Structure, Coordinated Structure* and their interaction terms has a p-value of 0.009. Thus, we are confident that the results are not affected by multicollinearity and that we have results that control for the effects of sampling.

Discussion

Purchases in local governments have become increasingly complex as procurement policies are expanded to include a variety of social and environmental considerations (Knutsson and Thomasson 2014; Young, Nagpal, and Adams 2016; Stritch et al. 2020). As a result, governmental purchasers frequently face contradictory criteria, expectations, and goals imposed by different procurement policies (Dimitri, Dini, and Piga 2006; Walker and Brammer 2012; Young, Nagpal, and Adams 2016). They have to find ways to reconcile the conflicts. Drawing on a nation-wide survey of public managers in more than 400 local governments, we explore how procurement complexity and organizational structure interact to affect the adoption of e-procurement in local governments.

While we find no evidence in support of the first hypothesis, our results indicate that the ways through which local governments accommodate procurement complexity vary by organizational structures. The second hypothesis, which suggests a positive moderating effect of centralization, is supported. The results demonstrate that a centralized government is more likely to use an e-procurement system as a way to navigate complex procurement policies. E-procurement systems enable the central agencies to maintain control and enhance their information capacity (Moon 2005; Dimitri, Dini, and Piga 2006) despite of the growing complexity of public procurement.

We find mixed evidence on the effects of decentralized structures. The specialized structures have no moderating effect on e-procurement adoption, failing to support the third hypothesis. By contrast, our findings support Hypothesis 4 and demonstrate that, when procurements become increasingly complex and demanding, local governments with coordinated structures are less likely to rely on the technology support associated with e-procurement. These governments tend to address procurement complexity by leveraging intra-organizational collaboration and information-sharing behaviours across different units (Cohen, March, and Olsen 1972; Zhu and Kindarto 2016).

Finally, our results show that hybrid procurement structures have insignificant influence on local governments' e-procurement adoption.

Conclusion

Before discussing the broader theoretical and managerial implications of our findings, we recognize some limitations of the study. A major limitation is in the overall identification of the model. While we have attempted to control for most of the major factors likely affecting adoption generally and those specific to the application of e-procurement, there are some potential issues. First is the common problem of omitted variables. Some factors that might affect the decision of e-procurement adoption, such as laws and regulations, are not included in this model. Future studies can explore how these regulative aspects play a role in the adoption of e-procurement. The second issue relates to endogeneity. It is likely that many control variables affecting the adoption decision have had, at least historically, an impact on organizational structure or even procurement complexity. For example, cities with more diverse publics or public services tend to have in place complex policies designed to meet multiple objectives through the procurement process. However, to the best of our knowledge, there are no strong candidates for instrumental variables in our data.

Moreover, prior studies suggest that ICT, such as the e-procurement system, enables local governments to move from traditional hierarchies in governmental practices to a networked and fragmented model (Heintze and Bretschneider 2000; Asgarkhani 2005; Andrews and Boyne 2014). The use of e-procurement system can result in organizational and managerial changes as the technology re-engineers the ways through which local governments conduct procurement activities (Dimitri, Dini, and Piga 2006). However, given the cross-sectional nature of our data, we cannot exploit whether the adoption of e-procurement system will make differences on the procurement structure. Future studies would benefit from using longitudinal data in exploring the relationship between governmental structures and the e-procurement adoption over an extended period of time.

Thirdly, we are concerned about common source bias (CSB) problems as the study uses self-reported data. In our survey, we provide an option of 'Don't Know' when measuring both dependent and independent variables. Hence, only respondents who felt confident in their answers are included in the empirical model. Besides this, for the dependent variable, we either check the cities' official websites or directly contact their finance/purchase department if respondents within the same city have reported different answers. Our dependent variable thus will be less vulnerable to the CSB problem as it is verified by multiple sources of information and represent a less subjective measure.

Another limitation is that our conceptualization and operationalization of procurement complexity might not fully capture this concept. Other characteristics associated with governmental procurement, such as procurement risks and uncertainties, might also impact complexity. Future studies might delve into how other dimensions of procurement complexity influence the adoption of e-procurement system. Finally, this research does not examine the post-adoption phase: whether the e-procurement system is effectively being used. The adoption of e-procurement system does not necessarily result in an effective or extensive utilization. Prior studies demonstrate that the technical change in public organizations remains a developing and incomplete

agenda as the implementation process can be incremental and challenging (Moon 2005; Coursey and Norris 2006; O'Neill 2009; Baldwin, Gauld, and Goldfinch 2012). To make use of the technology, local governments should incorporate it into their strategically planned processes (Asgarkhani 2005). Otherwise, the failure of implementation can incur financial wastes and political interruptions (Baldwin, Gauld, and Goldfinch 2012). Future research would benefit from exploring how the determinants, such as procurement complexity and the organizational design, interplay to affect e-procurement utilization. Our hope is that the results of this study offer sufficient justification for studying these relationships further.

Theoretical contributions

There is a growing agreement that the technological change within public administration is an outcome of the complex interactions of a wide range of determinants (Asgarkhani 2005; Pollitt 2011). The emerging perspective requires scholars to produce a pragmatic and complex approach to unpack the mechanism of technology adoption (Pollitt 2011; Buffat 2015). The major theoretical implication of this paper hence is to produce a more nuanced mechanism of the e-system adoption in local governments by accounting for the interplay between procurement complexity and organizational structure. Besides this, prior studies offer conflicting results on how organizational structure affects the adoption of digital technology in public organizations. For example, some scholars suggest that a centralized structure facilitates the adoption process due to less resistance (Williams 1994; Moon 2005; Dimitri, Dini, and Piga 2006); while others argue that governments with a decentralized structure are more likely to fulfil the adoption (Moch and Morse 1977; Thomas and Franz 1999). Our results help to explain the inconsistent findings. The proposition of an interaction effect provides a new lens for thinking about how organizational structure can play a role in the e-procurement adoption process.

Moreover, the mechanism of technology adoption in local governments with hybrid structures has received little attention by extant studies. Hybrid structures integrate the advantages and disadvantages of centralized and decentralized structures (Daft, Murphy, and Willmott 2010). It is assumed that the strengths of centralization, such as efficiency and integrity, will be preserved in hybrid structures without placing excessive restrictions or bureaucratic controls on other governmental units (McCue and Pitzer 2000). However, the structure also has a set of limitations, such as managerial uncertainty and ambiguity, due to the various levels of hierarchy. It is challenging to locate authority, responsibility, and accountability across a complicated procurement system (McCue and Pitzer 2000; Wang and Xiaoming 2014). The challenge might give rise to confusions, frustrations, and potential opportunism (Fandt and Ferris 1990; Carson, Madhok, and Wu 2006). The complexity of hybrid structures makes it difficult to untangle the mechanism of e-procurement adoption, providing the potential to make substantial contributions to the e-procurement research agenda. This paper bridges the theoretical gap by taking an initial step to explore whether hybrid procurement structures will exert either direct or interaction effects on e-procurement system adoption. It might be interesting to follow-up this study by further investigating how hybrid structures can act a part in the process.

Managerial implications

Even though the empirical analysis in this study has specifically analysed the procurement context, the results may be generalized into other policy domains and the adoption of other e-government technologies. Generally speaking, public administrators will face two dilemmas when confronted with enterprise-wide complex tasks. First, as activities in public organizations are constrained by multiple laws, regulations, and policies, it is difficult for public administrators to rank conflicting requirements or criteria contained in different policies (Hardy and Williams 2008; Wang and Li 2014; Stritch et al. 2020). Administrators often have trouble in figuring out how to make trade-off decisions, particularly if the value generates potentially conflicting results. Second, due to limited information sources and bounded intellectual capacity, administrators may fail to conduct a comprehensive search for alternatives and end up sub-optimizing their choices (Simon 1972). An e-based system may be a potential solution to managing the tensions between conflicting criteria or multiple alternatives since the technology increases the government's capacity for information searching and processing (Asgarkhani 2005; Hardy and Williams 2008; O'Neill 2009; Bonsón et al. 2012).

In addition, the findings also shed some insights for public managers who are having difficulty transforming their desire for an e-based system into the actual adoption behaviour. The empirical results demonstrate that a centralized structure can facilitate enterprise-wide adoption when dealing with complex tasks. It is difficult to address the resistance and reach a consensus on e-government technologies adoption without the assistance from a robust central agency (Williams 1994; Dimitri, Dini, and Piga 2006). Similarly, efforts to facilitate adoption of an e-procurement system are likely to require either some type of organizational change or increase levels of inducements across units.

Note

1. There are 30 cities in our original data where two or more respondents have reported different answers to this survey item. To resolve this situation, we have either checked these cities' official websites or directly contacted their finance/purchase department to further confirm whether these cities have adopted the e-procurement system.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This research was funded, in part, with a grant from the V.K. Rasmussen Foundation.

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