MANAGEMENT SCIENCE
Articles in Advance, pp. 1–22
ISSN 0025-1909 (print) | ISSN 1526-5501 (online)

http://dx.doi.org/10.1287/mnsc.2015.2164

Do CIO IT Budgets Explain Bigger or Smaller Governments? Theory and Evidence from U.S. State Governments

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Given the recent concern on "big governments" and rising budget deficits in the United States and European nations, there has been a fundamental economic debate on the proper boundary and role of governments in a society. Inspired by this debate, we study the relationship between information technology (IT) and government size. Drawing on a broad range of the literature from multiple disciplines such as information systems, industrial organization, and political sciences, we present several theoretical mechanisms that explain the impact of IT on government expenditures. Using a variety of data on IT spending and state government expenditures, we find that greater IT investments made by a state chief information officer (CIO) are associated with lower state government spending. It is estimated that on average, a $1 increase in state CIO budgets is associated with a reduction of as much as $3.49 in state overall expenditures. This study contributes to the literature by identifying a key technological factor that affects government spending and showing that IT investments can be a means to restrain government growth.

Keywords: IT investments; government growth; U.S. state government; CIO budgets
History: Received May 8, 2012; accepted November 19, 2014, by Anandhi Bharadwaj, information systems. Published online in *Articles in Advance*.

1. Introduction

In recent years, the "big government" has been at the center of heated political debates in the United States and European nations. In countries with democratic political systems, the public and their political representatives have continued to voice their concerns on rising government spending and mounting budget deficits. The challenge in the public sector, however, is that governments face as uncertain and turbulent an environment as for-profit organizations do, as is evident in natural disasters, terrorism, and economic downturns (Moore 1995, Moore and Khagram 2004, Swilling 2011), and the public demand governments to be more responsive to such emerging challenges (Smith 2004, Alford and Hughes 2008, Alford and O'Flynn 2009). This has led to a fundamental economic debate among the public, the media, and academia as to what is the proper boundary and role of a government in the contemporary economy. For instance, after the financial crisis in the late 2000s and the BP oil spill in the Gulf of Mexico in 2010, whether and why the U.S. government should be involved in crises caused by private-sector industries became a subject of heated debates (*Wall Street Journal* 2009, *Examiner* 2010). To the best of our knowledge, however, information systems (IS) researchers have been largely silent on this important issue. In general, the IS literature has paid less attention to the public sector than to for-profit organizations (Pang et al. 2014b).

Numerous economists and political scientists have studied the growth of governments since the nineteenth century (Larkey et al. 1981). Witnessing a continuing expansion of the public sector for many decades and concomitant controversy over the size of government, a large body of research has studied why governments continue to grow. The literature on this issue is so broad that Lybeck (1988) classified the literature on government growth into 12 theories, and Tarschys (1975) suggested nine broad categories and 25 explanations for government growth, although both authors admit that their coverage is by no means exhaustive.

Of relevance to IS research is that this literature identifies technological development as one of the key

Figure 1 **The Size of U.S. State and Local Government Expenditures as a Share of U.S. Gross Domestic Product (GDP)**

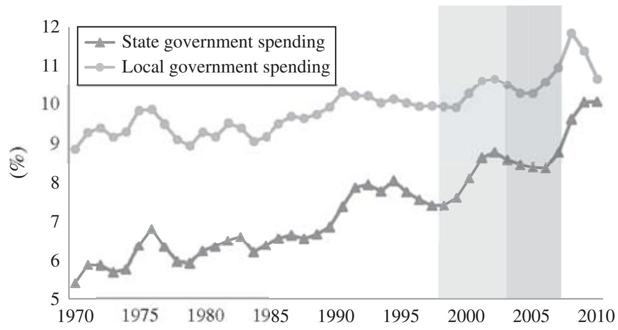

Table 1 **State Government Expenditure Components (FY 2007–2008, 50 States Total)**

Components	Amount ($ million)	Share (%)
Salaries and wages	215,876	13.21
Nonsalary current expenses	594,622	36.37
Capital outlays	110,302	6.75
Intergovernmental expenditures	457,377	27.98
Assistance and subsidies	31,363	1.92
Interest on debt	42,802	2.62
Others	182,459	11.16

Source. U.S. Census Bureau, State Government Finances.

factors behind government growth (Tarschys 1975, North 1985). Specifically, the industrial revolution fueled by technological advances, income growth, and accompanying societal changes such as urbanization have led the public sector to increase its size and influence on the economy. Technology development has caused economic activities to become more complex and sophisticated, requiring more government regulation and intervention (North 1985), as illustrated in recently established U.S. federal agencies—the Consumer Financial Protection Bureau in 2011, the Federal Motor Carrier Safety Administration in 2000, and the Office of Cybersecurity and Communications in 2006.[1]

Motivated by this literature, we are interested in how information technology (IT) investments made by governments affect the size of government spending. Specifically, utilizing a data set from U.S. state governments, we examine the relationship between IT budgets of a state chief information officer (CIO) and state government size. We are interested in state government size because state governments provide a range of essential services to state residents such as transportation infrastructures or higher education. In addition—unlike federal agencies, each of which performs different functions such as national defense, regulation, or public welfare—state governments offer similar public services with each other.

As our primary measure of government size, we use the ratio of state government expenditures to state gross domestic product (GDP). This measure quantifies to what extent a state economy relies on a state government and is widely used in the public economics literature on government size (Rubinson 1977; Lowery and Berry 1983; Landau 1983, 1985; Lewis-Beck and Rice 1985; Borcherding 1985; Saunders 1993; Devarajan et al. 1996). A larger share of government spending to GDP indicates that more goods and services are produced by a government, not by the private-sector market. Rubinson (1977) states that the share of government expenditures to GDP measures the ability of a government "to control the activities of the population within its boundaries" (p. 7). Lewis-Beck and Rice (1985, p. 4) state: "The salient issue is whether government has gotten larger relative to the rest of society." In essence, this measure is related to a philosophical and ideological discussion that we mentioned earlier on the proper boundary of the public sector in the overall economy. We suggest that IT should be part of this public discourse.

Figure 1 shows the trend in the size of state governments from 1970 to 2011. In this period, U.S. state governments have experienced as much as a twofold increase in expenditures from 5% to 10% of the U.S. GDP. This share has climbed quite rapidly from 8.77% to 10.06% from 2008 to 2011, during which states endured financial and housing crises. However, it is interesting to see that state governments expanded their size between 1998 and 2003 during the "dot-com" boom and shrank between 2003 and 2007 after the dot-com bust. This is the case with local government expenditures as well. We investigate how this trend is influenced by internal IT investments in U.S. state governments.

Table 1 shows the breakdown of total state government expenditures in all 50 U.S. states in fiscal year 2007–2008. It shows that approximately half of the state spending is appropriated to current operational expenses, which consist of salaries, wages, and nonsalary current expenses. Capital expenditures in such assets as buildings, equipment, and infrastructures account for 6.75% of state spending. State governments spend about 30% of their expenditures on intergovernmental transfer to local governments and school districts. Assistance and subsidies to individual citizens account for as much as 2% of state government expenditures. In §2, we explain how IT spending made by state CIOs affects these state government expenditures.

Drawing upon a variety of theories from multiple disciplines including IS, public administration,

[1] http://www.consumerfinance.gov/the-bureau/, accessed December 29, 2012; http://www.fmcsa.dot.gov/mission, accessed December 29, 2012; http://www.dhs.gov/office-cybersecurity-and-communications, accessed December 29, 2012.

and political sciences, we theorize the impact of CIO IT budgets on state government size. From public records and our phone interviews with senior IT officials in a large Midwest state, we find that state CIOs are responsible for managing statewide digital infrastructures, integrated enterprise systems, consolidated information resources, IT strategy, and policy management. Our IT budget measure captures the amount of all expenditures made by a state CIO to perform the above duties. We explain below that the size of CIO budgets indicates a strategic importance of IT within a state government and the organizational power and authority that the CIO has vis-à-vis other executives. We offer two opposing hypotheses on the effect of IT budgets managed by state central CIOs on state spending. On one hand, we argue that IT investments make state administration more efficient, productive, and transparent, leading to a reduction in state expenditures. On the other hand, we predict that state governments can utilize digital technologies in initiating a new range of public services that would not have been offered without IT, so that they fulfill unmet needs of the public and, in effect, expand the boundaries of state governments toward the private sector or other levels of governments.

Next, adopting the state government growth model proposed by Garand (1988, 1989) as our empirical framework, we examine the effect of CIO IT budgets on state government spending. We utilize data from a variety of sources. We obtained a data set on IT budget and IT organizations in U.S. state governments for 2001–2005 from the *Compendium of Digital Governments in the States*, published by the National Association of State Chief Information Officers (NASCIO). We collected state government spending data from the U.S. Census Bureau. We built a five-year unbalanced panel consisting of 190 observations in 44 states.

Our empirical analysis with the dynamic panel-data model (Blundell and Bond 1998) supports the hypothesis that a larger amount of IT investments made by a state CIO is associated with lower state government spending. We find that a \$1 increase in IT spending by a state CIO is associated with a \$3.49 reduction in total state spending. We find that this pattern is consistent with the use of different measures for government size and alternative empirical approaches. We have also examined the impact of IT on individual expenditure accounts (e.g., wages or subsidies) and specific government service areas (e.g., education or highway) and obtained interesting and more nuanced findings. For instance, we find that IT investments by state CIOs are positively associated with spending in higher education, police, and parks and recreation. Most significantly, CIO IT budgets have a negative impact on spending in general administrative functions such as financial, human resources, and facility management.

This work contributes to the IS literature by expanding the boundary of IS research on IT and organizational size to the public sector organizations, to which the IS research has not paid as much attention as it has to the business setting. We take an interdisciplinary approach to theorize the relationship between IT and government size based on the literature from political science (the theory of bureaucracy and public choices), public administration (public value theory) and industrial organization (the transaction cost economics and the agency model). Thus, we contribute to the IS literature by introducing a new boundary-spanning approach in theory development. Also, whereas a large body of the IT management literature studies the responsibility, authority, and structural power of a CIO within an organization and its performance consequences (e.g., Feeny et al. 1992, Armstrong and Sambamurthy 1999, Preston et al. 2008, Preston and Karahanna 2009, Banker et al. 2011), to the best of our knowledge, this study is the first to investigate the size implication of CIO IT budgets.

The remainder of this paper is organized as follows. Section 2 offers our theoretical discussion and develops the hypothesis. Section 3 describes the data sources, measures, and methodology. Section 4 presents the results of our empirical analyses. Section 5 discusses implications and contributions. The paper concludes with limitations and future research directions in §6.

2. Theoretical Development

2.1. Related Work

The relationship between IT investments and organization size in the for-profit context has been among the key research interests in IS literature. For example, an industry-level analysis by Brynjolfsson et al. (1994) shows that the level of industry IT stock is related to a smaller size of firms as measured by the number of employees, sales, and value-added per establishment. Also, in an industry-level study, Wood et al. (2008) find that the relationship varies across the industry sectors; IT investments are associated with smaller firm size in manufacturing industries and with larger firm size in retail and service industries. Extending these studies, Im et al. (2013) find that the effect of IT on firm size is mediated by internal coordination costs. At an organizational level, Hitt (1999) finds that increased use of IT is associated with an increase in vertical integration and a decrease in diversification. In a study from the transportation industry, Baker and Hubbard (2004) find that adoption of onboard computers (OBC) in trucks is associated with an increase in truck ownership by shippers and a decrease in ownership by independent drivers (contractors). Similarly, Rawley and

Simcoe (2013) find that the adoption of computerized dispatching technology for a taxi fleet is associated with an increase in fleet ownership of taxicab firms. Forman and McElheran (2012) show that supplier-focused IT is associated with decreased within-firm transfers downstream.

The aforementioned studies primarily draw on IT productivity, transaction cost economics, and principal-agent models. These theories may not be entirely sufficient in explaining the impact of IT on government size for several reasons. First, as Table 1 shows, state government expenditures consist of not only current expenditures and capital outlays, which can be considered cost parts of the expenditures but also consist of intergovernment transfers or subsidies to local governments, school districts, and individual citizens. It is not straightforward to explain how IT affects this broad range of government spending only with theories rooted in the private-sector business context. Second, the public-sector organizations have different incentives and objectives from the for-profit firms. Unlike business organizations, governments do not have profit motives, nor do they experience competitive pressures. Rather, the literature suggests that governments are interested in maximizing their size (Miller and Moe 1983, Banks 1989, Horn 1995). Third, government size is determined by a more diverse set of factors than firm size, such as the demand of citizens for government services and political interactions among government officials, elected representatives, and citizens. Hence, to address these challenges and to explain this multifaceted aspect of government expenditures, we draw on theories from the political sciences and public economics disciplines.

This work is related to a nascent research stream of IT value in the government sector (e.g., Lee and Perry 2002, Garicano and Heaton 2010). For example, using the production function model, Lehr and Lichtenberg (1998) estimate IT productivity in U.S. federal government agencies. Using a stochastic frontier estimation approach, Pang et al. (2014b) find a positive relationship between IT spending and cost efficiency in U.S. state governments. The present study differs from Pang et al. (2014b) and others in that whereas Pang et al. (2014b) measure cost efficiency of states with current expenses and capital depreciation, which correspond to the first three items in Table 1, this study investigates the impact of IT budget on the whole state expenditures. Furthermore, Pang et al. (2014b) are interested in how efficient a state government is given its size and scope, whereas this paper is concerned with how big a state government is relative to the state's overall economy. This difference is in parallel with two research streams in IS—the effect of IT on firm performance (Brynjolfsson 1993, Dewan and Min 1997, Melville et al. 2004) and on firm size (Brynjolfsson et al. 1994, Hitt 1999, Baker and Hubbard 2004, Im et al. 2013), and each stream is complementary to the other but distinct with respect to theoretical grounds and empirical approaches. Note that the relationship between organization size and efficiency is nontrivial and has been a central research topic in economics dating back to Coase (1937) and later, Alchian and Demsetz (1972).

2.2. IT Investments of State CIO

The primary focus of this paper is IT investments made by a state CIO. A state government is a multidivisional organization consisting of autonomous executive agencies. Both a central IT group headed by a state CIO and state agencies may have separate IT budget accounts. However, public records, anecdotal evidence, and our interviews with state officials demonstrate that state CIOs manage a range of statewide IT resources and assume a broad responsibility of statewide IT management as follows.

First, state CIOs in many states are in charge of operating technology infrastructures throughout the states. According to a survey by NASCIO, on average, a state CIO takes a statewide operational responsibility in 5.6 out of the nine following items—application development, desktop management, email services, infrastructure development, data center, portal development, security, server support, and telecommunication (NASCIO 2005a). For example, the Georgia Technology Authority (GTA), which the state CIO heads, "currently manages the delivery of IT infrastructure services to 85 Executive Branch agencies and managed network services to 1,400 state and local government entities."[2] GTA also oversees statewide information security. Michigan Executive Order No. 2001-3 mandates that the Department of Information Technology shall "lead state efforts to re-engineer the state's information technology infrastructure with the goal of achieving the use of common technology athe executive branch."

Second, a number of state CIOs are responsible for statewide enterprise systems, integration of disparate application systems across state agencies, and enterprise data architectures that manage a variety of data assets generated by state agencies. For instance, the Pennsylvania Office of Information Technology "provides direct oversight for large, enterprise-wide initiatives, such as IT consolidation, commonwealth shared services."[3] The New Mexico Department of Information Technology "provides the State with the information technology fabric that enables agencies

[2] http://gta.georgia.gov/about-gta, accessed June 26, 2014.

[3] http://www.portal.state.pa.us/portal/server.pt/community/information_technology/402/about_it/548378, accessed June 26, 2014.

to innovate and excel in their specific domains with the goal of consolidating services duplicated within agencies to promote cost savings and efficiencies" and operates "the State's consolidated financial and human capital management system."[4] The Virginia CIO supervises implementation of enterprise information architectures that include statewide data governance and standards for seamless data sharing across state agencies.[5]

Third, state CIOs are in charge of statewide IT management and supervision in a range of areas. According to a NASCIO survey, 46 state CIOs are responsible for or involved in devising statewide strategic IT plans and standards, and 42 CIOs are in charge of setting and enforcing statewide IT policies in such areas as IT human resources or IT procurement (NASCIO 2005a). These duties are stipulated in a large body of state laws and statutes. For example, the Rhode Island Executive Order 04–06 states, "The CIO shall be responsible for oversight, coordination and development of all IT resources within the executive branch." According to the Iowa Code Chapter 8A, the duties of the Director of Information Technology include "prescribing and adopting information technology standards and rules." The CIO of North Carolina is empowered by North Carolina General Statutes Chapter 147 to "suspend the approval of any information technology project that does not continue to meet the applicable quality assurance standards."

Although we find some general consistency in the roles and responsibilities of CIOs at the state level from the above evidence, to better understand the nature of CIO duties and budgets, we contacted the CIO and the Chief of IT Policy and Planning of a large Midwest state and conducted two separate phone interviews with each of them. Both interviews verified that the responsibilities of the state CIO are to formulate statewide IT strategies and policies, to manage statewide major IT projects such as interagency IT integration initiatives, and to manage IT capital investments. The CIO oversees and enforces implementation of IT strategies and policies across the state agencies by controlling IT capital budgets that are allocated to the state agencies' IT projects, which include investments in software. Succinctly, we learned that the state CIO is the steward of overall IT governance and strategy. Among other responsibilities, the state CIO may initiate and oversee projects that integrate and streamline enterprise IT applications, business processes, and data consolidation across agencies.

[4] http://www.doit.state.nm.us/about.html, accessed June 26, 2014.

[5] http://www.vita.virginia.gov/oversight/DM/default.aspx?id=10338, accessed July 9, 2014.

Theoretically, the size of budgets endowed to a state CIO represents his or her power within the state government. Buckley (1967) defines power as "control or influence over the actions of others to promote one's goals without their consent, against their will or without their knowledge or understanding" (p. 186). A large body of the management literature shows that the amount of resources given to an organizational function represents the power of the function vis-à-vis other groups within the organization (Pfeffer and Salancik 1974a, b; Pfeffer and Moore 1980; Hackman 1985; Mannix 1993). Astley and Sachdeva (1984) state that one of the sources of intraorganizational power is "the capacity for obtaining resources from the environment and controlling the supply of these resources to others through processes of exchange" (p. 105). Thus, a state CIO who secures a larger amount of IT budgets is able to play a more powerful role in promoting strategic priority of IT and enforcing statewide IT management guidelines and policies. Feeny and Willcocks (1998) propose that for effective exploitation of IT resources, a CIO plays a leadership role to build the overall business perception of IT's role and contribution, to establish strong business/IT relationship at the executive level, and to leverage that relationship to achieve a shared vision for IT.

2.3. CIO IT Budgets Make a Government Smaller

IT resources that a state CIO manages—integrated enterprise systems, digital infrastructures, and information repositories—can help lower overall government spending by improving productivity of administration processes, decreasing monitoring costs of administration, and reducing transaction costs with external private-sector partners.

First, statewide IT infrastructures and integrated IS that state CIOs operate help state agencies digitize and modernize their business processes in a coordinated manner with an enterprise perspective. This is in line with prior research on IT and firm size, in which one of the primary mechanisms in the impact of IT on organization size is substitution with other production inputs (Brynjolfsson et al. 1994, Dewan and Min 1997, Im et al. 2013). By automating and digitizing business processes, firms can reduce the use of labor, non-IT capital, and other production factors, leading to smaller firm size. A similar effect takes place in the government sector. North Carolina's eCITATION project (NASCIO 2006) is a notable example of this. This information system connects patrol cars of the North Carolina State Highway Patrol to the North Carolina Criminal Justice Information Network, so that the entire process of issuing, transmitting, and processing citations is executed electronically. This eliminates paper citations, redundant data entries, and time and resources consumed in filling and processing paper tickets, reducing a sizable amount of labor and storage costs. This cost saving occurred because this project integrated application systems in several law enforcement agencies. This integration of multiple systems is facilitated by the state CIO's leadership role in championing enterprise IT strategies and standards. In this regard, we predict that state CIOs' IT investments in statewide digital infrastructures and enterprise systems will be associated with lower state spending.

Second, state CIOs manage integrated enterprise systems and consolidated data assets that help reduce government expenditures by alleviating information asymmetry between legislatures and government agencies and reducing internal monitoring costs. The theory of bureaucracy from the political sciences literature interprets the relationship between legislatures and government agencies with a principal-agent model (Moe 1984, McCubbins et al. 1987, Banks 1989). The legislatures, who play a role of principal on behalf of citizens, delegate policy implementation and public service delivery to government agencies (agents), who possess a greater expertise and domain knowledge than the principals. However, this relationship involves conflicts of interests and information asymmetry. First, the principals (legislatures) and the agents (government officials) have different incentives. The theory of bureaucracy posits that the primary interest of the agents is to maximize the size of expenditures they manage, as it represents their power, authority, and prestige (Niskanen 1968, Miller and Moe 1983). It is not congruent with the principals, whose interest is to offer the maximum value to their constituencies (Banks 1989). Second, the principals do not have complete information or adequate expertise to monitor the agents' activities and evaluate their performance. Therefore, in the presence of such information asymmetry and divergent interests, the government agencies may spend larger amounts in expenditures than in the absence (Banks 1989).

We expect that digital infrastructures and integrated IS across state agencies will generate a broad range of information on administration, which makes it easier for legislatures to monitor the agencies' day-today activities and decision making and to assess their performance. Thus, statewide performance information collected from integrated enterprise systems can reduce the information asymmetry between the principals and the agents, such that the principals (i.e., legislatures) prevent agents (i.e., government agencies) from making unnecessary, wasteful expenditures. Based on the model of Banks (1989), we prove that a smaller auditing cost that the legislatures incur is associated with a reduction in the amount of agency expenditures. (See Appendix A for the proof.)

Furthermore, Banks and Weingast (1992) suggest that the information asymmetry in governments can be further addressed by information input from citizens. In recent years, following the "open government" movement, many governments are beginning to make more information on government administration available to the citizens (Rodríguez Bolívar et al. 2007, Lee and Kwak 2012). For instance, the National Taxpayers Union was able to discover a substantial amount of illegitimate expenditures in the State of Missouri agencies via the Missouri Accountability Portal[6] (Government Technology 2008). This website publishes comprehensive financial records of state agencies on a daily basis, which help citizens monitor state officials' activities and detect their unnecessary use of tax revenues. The City of New York also operates a similar website called NYCStat,[7] which posts a variety of information related to city-wide services, including city agency performance records and customer satisfaction reports (Public CIO 2009). Banks and Weingast (1992) state that the citizens can aid their representatives by gathering and providing information input that the legislatures can use to control the bureaucratic agents, further restraining the size of government expenditures. Standardized digital infrastructures, integrated enterprise systems, and information governance spearheaded by a CIO enable a state to consolidate the state agencies' information on performance and spending, as in the Missouri Accountability Portal described above, which legislatures and citizens can use to oversee state agencies.

Third, interorganizational systems on top of the integrated systems and standardized technology infrastructure can decrease the costs of transaction and coordination between state governments and private-sector firms that supply what used to be governmental services. For the last several decades, privatetization of government services has been promoted by elected representatives, based on the rationale that business organizations with profit motives can supply public services more efficiently than governments do (Dunleavy and Hood 1994, Lane 2000, O'Flynn 2007).

Drawing on transaction cost economics, the IS research on firm size posits that IT reduces external transaction and coordination costs with suppliers, leading to smaller firm size (Gurbaxani and Whang 1991, Brynjolfsson et al. 1994, Hitt 1999, Wood et al. 2008, Forman and McElheran 2012). It shows that the use of interorganizational IS facilitates coordination and communication with external partners. Information sharing with supply chain partners lessens information asymmetry between the focal firm and its partners and makes performance monitoring more

[6] http://mapyourtaxes.mo.gov/, accessed May 12, 2010.

[7] http://www.nyc.gov/html/ops/nycstat/, accessed May 12, 2010.

effective, further reducing transaction costs. This favors sourcing from external suppliers over vertical integration.

A similar argument can be made in the government context. By reducing external transaction costs, flexible digital infrastructures and integrated application systems will facilitate the privatization of public services, shrinking government size. For example, states such as Nevada and Utah set up websites that allow third-party vehicle inspection stations (for-profit firms) that conduct safety and emission tests to access the states' vehicle registration systems (NASCIO 2009). The inspection stations now process vehicle registration renewals on behalf of the states, so that customers do not need to visit an office of Department of Motor Vehicles. In essence, the states have privatized part of the vehicle renewal process by opening up the system to the external private-sector providers. The enterprise IT architectures and standards that the state CIO enforces across the state make it seamless for the executive branches to coordinate and collaborate with external third-party organizations and businesses, facilitating privatization of government activities.

In sum, we argue that IT investments by state CIOs in statewide technology infrastructures, enterprise systems, and IT standards and governance are associated with a reduction in government size by (i) reducing the use of other input factors such as labor, (ii) enabling legislatures and citizens to better control and restrain the agencies' interests to expand spending, and (iii) facilitating privatization of government production. Based on the foregoing discussion, we propose the following hypothesis.

Hypothesis 1A (H1A). *The size of CIO IT budgets in a state is associated with lower state government spending.*

2.4. CIO IT Budgets Make a Government Bigger

State IT investments made by a state CIO can lead to growth in state expenditures in the following two ways. First, state digital infrastructures and enterprise systems supported by state CIOs can enable entrepreneurial initiatives of state governments by helping create a new set of public services that would not have been possible to offer without IT. The public administration literature points out that it is the governments' responsibility to cope with economic and societal challenges, such as housing and financial crises, pandemic diseases, or environment protection, which continue to rise and evolve (Moore 1995, Swilling 2011). Furthermore, the literature emphasizes that for the governments to better handle these matters, the public sector managers need to take a strategic, entrepreneurial approach, as business managers do (Moore 1995, Stoker 2006, Alford and Hughes 2008). This is because their expertise, ingenuity, and creativity in public management (Williams and Shearer 2011) put them in a great position to fulfill the public's needs. Proactive public managers take advantage of flexible digital infrastructures and integrated enterprise systems for their entrepreneurial endeavors (Pang et al. 2014a).

A range of anecdotal evidence suggests that integrated enterprise and interorganizational systems are pivotal in implementing state governments' entrepreneurial endeavors. For instance, California and Utah initiated intelligent traffic management programs to mitigate worsening traffic congestions in their metropolitan areas (NASCIO 2005b, 2008). Both state governments recognized that building expensive transportation infrastructures can no longer solve the congestion problems. Instead, they adopted state-of-the-art traffic management systems that consist of sensor technologies in roads and bridges, data warehouses and data mining, and integration with local government IT systems. To contain emerging threats from pandemic diseases and bioterrorism and to quickly respond to statewide emergency situations, the State of Illinois expanded its efforts to monitor a statewide disease spread. It developed a public health surveillance system with intelligence gathering from local medical facilities, federal agencies, and real-time analysis and reporting features (NASCIO 2009). These examples illustrate that public managers, whose primary responsibility is not profit maximization or cost reduction, but fulfillment of the mandates from the public with any means necessary, can strategically utilize flexible enterprise architectures and standardized digital infrastructures, which enable their initiatives to expand the reach of governments. It is evident in the Federal Health Insurance Marketplace (Healthcare.gov), which is a central piece of the Affordable Care Act that expands the role of the U.S. federal government in healthcare.

Second, digitally enabled monitoring and coordination allows state governments to assume greater control over functions that external organizations would otherwise handle. Previous research in IT and firm boundaries predicts that advanced communication and integration technologies make it less expensive for an organization to control assets and employees and to coordinate internal functions, leading to an increase in asset ownership. Baker and Hubbard (2004) and Rawley and Simcoe (2013) empirically confirm this effect. Dunleavy et al. (2005, p. 467) predict that in what they call the "digital-era governance," government functions that had been privatized for the last several decades will be reintegrated into the public sector organizations. They reason that if a digitized, modernized government is able to offer public services at least as efficiently as business firms do,

Table 2 Summary of Explanations

Negative impacts of CIO IT budgets	• Digital infrastructures and integrated systems make government production more productive and efficient, reducing the use of other inputs. • Digitized processes and integrated enterprise systems make performance monitoring and audit by principals (legislatures and citizens) less costly. • Reduced transaction and external coordination costs from interorganizational systems promote privatization of government services.
Positive impacts of CIO IT Budgets	• Integrated enterprise systems and information resources support state governments' strategic initiatives with a new set of public services that the governments would not be able to provide without IT. • IT-enabled monitoring and coordination allows state governments to assume greater control over functions that external organizations would otherwise handle.

it will take over production of the services that had been relegated to the private sector.

We point out that with integrated enterprise systems and centralized information repositories managed by a CIO, a state government can expand its boundary toward public services that have been offered by governments in other levels—the federal or local governments. For example, several state governments are involved in facilitating a job search of the local unemployed and business development of local entrepreneurs, both of which have been considered by many to be a role of the private sector. To support these efforts, U.S. states such as Michigan and Washington are using online channels, internal information resources for local businesses and regulations, and statewide integrated systems for private-sector economic development (NASCIO 2005b, 2007). State governments are also expanding their functions by playing a coordinating role across local jurisdictions in public services that individual municipalities have traditionally administered, such as emergency responses, police, or land management and conservation.[8] This is possible since coordinated public services offered by state governments, which integrate some local government functions, are more efficient and less redundant than those provided by individual localities. Through extensive use of interorganizational IS and digital technologies, some state governments are even spreading their reach into such federal functions as homeland security and information security (Emergency Management 2013).

In IT-driven strategic initiatives that aim to expand state government boundaries, the role of a state CIO is crucial. In order for a state government to create IT-driven public services, the state CIO with deep knowledge and expertise in IT needs to play a pivotal role in leading state agencies to utilize cutting-edge technologies and systems. Like their private-sector counterparts, public-sector CIOs are being increasingly required to act as Chief Innovation Officers (Government Technology 2013). The new, expanded state functions that were introduced above require a large scale of information resources and integrated enterprise systems across state agencies. To achieve this, many state CIOs are increasingly spearheading the efforts of statewide integration and consolidation of fragmented, silo systems.

In sum, IT investments made by state CIOs can lead to larger government spending in two ways—(i) by enabling strategic initiatives that fulfill unmet, emerging needs of the public and (ii) by expanding the reach of state governments toward federal and local jurisdictions or the private sector. Based on this discussion, we offer the following hypothesis. Table 2 summarizes our explanation in this section.

Hypothesis 1B (H1B). *The size of CIO IT budgets in a state is associated with larger state government spending.*

3. Empirical Methods

We adopt the state government growth model of Garand (1988, 1989) as a basis for our empirical analysis. Table 3 describes the variables and data sources. More detailed descriptions on some of the variables are available in Appendix B.

As we mentioned above, we measure state government size with the ratio of state government expenditures to state GDP. In measuring government size, we follow Garand (1988) by using different price deflators for government expenditures and GDP. Public economists argue that due to inherent inefficiencies in the public sector, government expenditures may increase to a greater extent than private sector spending does (Larkey et al. 1981). Garand (1988) states that "if inflation rate is higher in the public sector, ...the share of total economic output going to the governmental sector will increase even if the scope of government activity remains constant" (p. 842). To account for this variance, government expenditures and state GDP are adjusted to 2005 dollars with

[8] Kentucky Mutual Aid Program (http://kwiec.ky.gov/interoperability/mutualaid.htm, accessed November 11, 2013); Pennsylvania Justice Network (http://www.portal.state.pa.us/portal/portal/server.pt/community/pennsylvania_justice_network/4424, accessed November 11, 2013); and State of Washington Geographic Information Systems (https://fortress.wa.gov/dnr/adminsa/DataWeb/dmmatrix.html, accessed July 8, 2014).

Table 3 **Variables**

Variable	Description	Theory	Sources
	Dependent variable		
GOVperGDP	The ratio of state general expenditures to state GDP (%)		U.S. Census Bureau
GOVperPOP	State general expenditures per capita (thousand $)		
	Control variables		
INCOME	State median household income (thousand $)	Wagner's Law	U.S. Census Bureau
POPUL	State population (in millions)		
INDTAX	Personal income tax revenues divided by total state revenues (%)	Fiscal Illusion Theory	
CORPTAX	Corporate income tax revenues divided by total state revenues (%)		
COMPLEX	Herfindahl index of revenue concentration		
DEBT	Mean debt level per capita (thousand $)		
FEDGRANT	Per capita federal intergovernmental to the state (thousand $)		
GOVERNOR	1 = Republican governor, 0 = otherwise	Party Control Theory	National Conference of State Legislature
LEGIS	The proportion of Republican lawmakers in state senate and house of representatives		
EMP	The ratio of state fulltime equivalent employee to state population (%)	Bureau Voting Theory	U.S. Census Bureau
PROGBUD	1 = state adopts program budgeting; 0 = otherwise		NASBO
INCBUD	1 = state adopts incremental budgeting; 0 = otherwise		
	IT variables		
ITperPOP	Per capita IT budget of a central IT organization managed by a state CIO ($)		NASCIO Compendium
ITperGDP	Ratio of IT budget of a state CIO to state GDP (%)		

different price deflators. The size of a state government is calculated by

$$\text{GOVperGDP}_{k,t} = \frac{\text{EXPEND}_{k,t}/\text{SLDEF}_t}{\text{GDP}_{k,t}/\text{GDPDEF}_t}, \qquad (1)$$

where $\text{EXPEND}_{k,t}$ is total general expenditures of state k in year t, and GDPDEF_t and SLDEF_t are the implicit price deflators for GDP and state/local government purchases, respectively. Therefore, according to Garand (1988), this measure in Equation (1) represents government size that is independent of the inherent difference in inflation rates between the private and public sectors. The state expenditure data were acquired from State Government Finance surveys published annually by the U.S. Census Bureau. We obtained the state GDP and the price deflators from the Bureau of Economic Accounts. In addition to this measure, we also use per capita state government expenditures ($\text{GOVperPOP}_{k,t}$) as an alternative dependent variable.

For state government IT measures, we obtained IT budget information from the *NASCIO Compendium of Digital Governments in States* published in 2003 and 2005. We focus on IT spending of state central IT organizations, by which we mean a central IT office, division, or department that a state CIO directly oversees. The *NASCIO Compendium* provides the CIO IT budget figures in 193 state-years from 2001 to 2005. We found, however, that the State of Delaware reports unusually high figures of IT budgets (greater than 6σ above mean) for the fiscal years of 2003–2005. Considering these influential observations, we drop them in the estimations.[9] This results in a five-year unbalanced panel with 190 observations from 44 states. Like government expenditures, IT budget figures were normalized by population and state GDP (ITperPOP and ITperGDP, respectively). Table 4 shows the list of states and the number of appearances in our data set. Student's t-tests do not reject the hypotheses that with respect to population, GDP, and total expenditures, the states in Table 4 do not differ significantly from those that are not in the data set.

To be consistent with the prior research on state government size in public economics and political sciences, we adopted several control variables from the empirical model of Garand (1988, 1989) as follows (Table 3). First, we add a lagged government size variable (GOVperGDP_{t-1}, GOVperPOP_{t-1}) as a control variable. Garand (1988) points out that theoretically, government spending in year $t-1$ is a significant predictor for that of year t. This is because government expenditures are sticky (Davis et al. 1966, Hoole et al. 1976, Lowery et al. 1984) and do not change year-by-year drastically. A government budget in a given year is largely appropriated based on the prior year's budget and adjusted incrementally from the preceding year (Davis et al. 1966). According to the National Association of State Budget Officers (NASBO), as of 2008, 41 of the 50 states adopt this incremental budgeting procedure (NASBO 2008). Furthermore, states

[9] In estimations that do not exclude Delaware, the coefficient of ITperPOP is significant at the 10%-level.

Table 4 States in the Sample

Region	Division	States
Northeast	New England	Maine (4), New Hampshire (5), Vermont (3), Massachusetts (5), Rhode Island (5), Connecticut (3)
	Mid-Atlantic	New York (5), Pennsylvania (2), New Jersey (3)
Midwest	East North Central	Wisconsin (4), Michigan (5), Indiana (3), Ohio (5)
	West North Central	Missouri (5), North Dakota (5), South Dakota (5), Kansas (5), Minnesota (5), Iowa (5)
South	South Atlantic	Maryland (5), Virginia (3), West Virginia (2), North Carolina (5), South Carolina (3), Georgia (5), Florida (2)
	East South Central	Kentucky (5), Tennessee (5), Mississippi (5), Alabama (5)
	West South Central	Oklahoma (2), Texas (5), Arkansas (5)
West	Mountain	Idaho (5), Montana (5), Wyoming (5), Nevada (5), Utah (5), Arizona (5), New Mexico (5)
	Pacific	Washington (5), Oregon (3), California (3), Hawaii (5)

Notes. The number in parentheses next to a state is the number of years that the state appears in the sample. Geographic region and division is from the 2000 U.S. Census.

devote a substantial share of expenditures to entitlement programs such as Medicaid or infrastructure maintenance, in which the states are mandated to spend by various federal and state laws, limiting the discretion and variability of state spending. Indeed, inclusion of a lagged government size variable systematically changes the coefficients of the other variables, according to a Hausman test, and increases R^2 substantially.

Second, Wagner's Law (Lybeck 1988, Gemmell 1993) suggests that government size is a function of industrialization, economic affluence, and population growth. To account for this, Garand (1988, 1989) uses income and population as explanatory variables. Third, the fiscal illusion theory suggests that certain tax systems may hide the real costs of government production. This leads taxpayers to underestimate the true tax-prices and thus to demand production of more government services than they would if they are aware of the underlying costs. Such tax systems includes income withholding (personal income tax), indirect taxes (corporate income taxes), and complex tax systems. Also, a high level of public debt and intergovernmental revenues from the federal government may also contribute to this fiscal illusion (Grossman et al. 1999, Geys 2006). We control for five indicators of tax and fiscal systems in our estimations as shown in Table 3. This fiscal illusion theory suggests that the signs of INDTAX, CORPTAX, DEBT, and FEDGRANT are positive, whereas that of COMPLEX is negative, as a high Herfindahl index indicates a simple tax system. The detailed description for COMPLEX is available in Appendix B.

Fourth, the party control theory argues that "government growth is systematically related to control of governmental policy-making institutions by the liberal party within the state political system" (Garand 1988, p. 839). This suggests that political control by the Democratic Party is related to greater government spending. We control for two variables (GOVERNOR and LEGIS) that represent political control in a state's executive branch and legislatures, respectively. Fifth, as Becker (1983) explains, government expenditures are also determined by the influence of pressure groups. One such pressure group is government employees, who as voters may demand an increase in government spending to expand their power and to ensure their job security. Following this bureau voting theory, we include the ratio of state government employment to state population (EMP) as a control variable. Last, though not included in Garand (1988)'s model, budgeting processes may affect the size of government expenditures (Crain and O'Roark 2004, Klase and Dougherty 2008). According to NASBO, two budgeting processes are the most widely used—program budgeting and incremental budgeting (NASBO 2008). The former refers to a budgeting based on program goals and objectives, and the latter is based on incremental changes in budgets from previous fiscal years and appropriation trends. We include two dummy variables for the budgeting processes (PROGBUD and INCBUD). We obtained state budgeting information from the *Budgeting Process in States* published by NASBO.

Our complete empirical model is presented as the following equations.

$$\begin{aligned}\text{GOVperGDP}_{k,t} &= \alpha + \beta_1\text{GOVperGDP}_{k,t-1} + \beta_2\text{INCOME}_{k,t}\\ &\quad + \beta_3\text{POPUL}_{k,t} + \beta_4\text{INDTAX}_{k,t} + \beta_5\text{CORPTAX}_{k,t}\\ &\quad + \beta_6\text{COMPLEX}_{k,t} + \beta_7\text{DEBT}_{k,t} + \beta_8\text{FEDGRANT}_{k,t}\\ &\quad + \beta_9\text{GOVERNOR}_{k,t} + \beta_{10}\text{LEGIS}_{k,t} + \beta_{11}\text{EMP}_{k,t}\\ &\quad + \beta_{12}\text{PROGBUD}_{k,t} + \beta_{13}\text{INCBUD}_{k,t} + \beta_{14}\text{IT}_{k,t-2}\\ &\quad + v_k + \xi_t + \varepsilon_{k,t}, \end{aligned} \tag{2}$$

$$\begin{aligned}\text{GOVperPOP}_{k,t} &= \alpha + \beta_1\text{GOVperPOP}_{k,t-1} + \beta_2\text{INCOME}_{k,t}\\ &\quad + \beta_3\text{POPUL}_{k,t} + \beta_4\text{INDTAX}_{k,t} + \beta_5\text{CORPTAX}_{k,t}\\ &\quad + \beta_6\text{COMPLEX}_{k,t} + \beta_7\text{DEBT}_{k,t} + \beta_8\text{FEDGRANT}_{k,t}\\ &\quad + \beta_9\text{GOVERNOR}_{k,t} + \beta_{10}\text{LEGIS}_{k,t} + \beta_{11}\text{EMP}_{k,t}\\ &\quad + \beta_{12}\text{PROGBUD}_{k,t} + \beta_{13}\text{INCBUD}_{k,t} + \beta_{14}\text{IT}_{k,t-2}\\ &\quad + v_k + \xi_t + \varepsilon_{k,t}, \end{aligned} \tag{3}$$

Table 5 Summary Statistics

Variables		Unit	Avg.	Std. dev.	Min	Max
GOVperGDP	*Expenditure/GDP*	% of GDP	11.45	2.61	6.75	18.72
GOVperPOP	*Expenditure per capita*	$1,000 per capita	4.42	0.89	2.64	7.15
INCOME	*Income*	$1,000 per household	46.56	7.11	32.61	65.71
POPUL	*Population*	Million	5.78	6.26	0.50	35.99
INDTAX	*Personal Tax*	% of revenues	2.52	1.67	0	10.08
CORPTAX	*Corporate Tax*	% of revenues	14.79	8.84	0	32.18
COMPLEX	*Tax Complexity*		0.42	0.11	0.23	0.73
DEBT	*Debt*	$1,000 per capita	7.19	3.75	1.59	19.22
FEDGRANT	*Federal Grant*	$1,000 per capita	1.44	0.50	0.69	4.04
GOVERNOR	*Governor*		0.54	0.50	0	1
LEGIS	*Legislature*	Ratio of Republicans	0.50	0.16	0.12	0.81
EMP	*State employee per capita*	% of population	1.75	0.60	1.04	4.63
PROGBUD	*Program Budgeting*		0.83	0.38	0	1
INCBUD	*Incremental Budgeting*		0.68	0.47	0	1
ITperPOP	*CIO IT Budget per capita*	$ per capita	21.31	19.03	0.04	92.85
ITperGDP	*CIO IT Budget/GDP*	% of GDP	0.06	0.05	0.00	0.26

Notes. $N = 190$; fiscal year 2003–2007 with a two-year lag of IT measures (ITperPOP and ITperGDP) (2001–2005). All dollar amounts are in 2005 dollars.

where IT = ITperPOP or ITperGDP and k and t represents a state and a year, respectively. Consistent with the prior literature, we chose a two-year lag of IT measures ($\text{ITperPOP}_{k,t-2}$ and $\text{ITperGDP}_{k,t-2}$), as the impact of IT investments is unlikely to materialize immediately due to organizational learning and adjustment effects (Brynjolfsson 1993). However, we estimated the models with different lag lengths, and the main results do not change considerably. Tables 5 and 6 provide the summary statistics and the correlations between the variables, respectively.

There are several challenges in empirically estimating Equations (2) and (3). As government spending is likely to be affected by state-specific unobserved heterogeneity (v_k) that may be correlated with explanatory variables, state time-invariant fixed-effects need to be accounted for. However, the fixed-effects estimation does not completely control for the correlation between v_k and the lagged dependent variable ($\text{GOVperGDP}_{k,t-1}$ and $\text{GOVperPOP}_{k,t-1}$) (Roodman 2009b). Thus, we estimate Equations (2) and (3) with a dynamic panel data model with the System Generalized Method of Moment (GMM) estimation (Arellano and Bover 1995, Blundell and Bond 1998). We chose the System GMM model over the Difference GMM model (Arellano and Bond 1991) because the former does not drop the first-year of observations.[10] Appendix C offers a brief description of the dynamic panel data estimation. We include year dummies (ξ_t) in Equations (2) and (3) to account for nationwide trends in political and economic environments and to ensure that there is no autocorrelation between idiosyncratic disturbances ($\varepsilon_{k,t}$) (Roodman 2009b). In addition, to address potential over-identification issues, we follow Roodman (2009a) by including only the first four lags of government size as instruments for the lagged dependent variable.

[10] In §4, as a robustness check, we also present the result of the Difference GMM estimation.

4. Results

Table 7 presents the estimation results of Equations (2) and (3) with the System GMM model. Columns 1 and 4 show the estimation without IT variables for the 12-year observations from 2000 to 2011. The positive coefficient of INCOME (median household income) in column 4 confirms Musgrave's hypothesis (Gemmell 1993) that demands for government outputs increase in income level.[11] Relevant to fiscal illusion theory, the coefficient of tax complexity (COMPLEX) is negative and statistically significant in all estimations but column 4. Because a smaller Herfindahl index indicates a more complex tax system,[12] it appears that states with more diversified revenue sources demonstrate higher expenditure figures. The positive coefficients of FEDGRANT and DEBT show that a large amount of federal grants and debts is associated with a higher amount of government expenditures, as predicted by the fiscal illusion theory. Table 7 also shows that states with more Republican state legislators (LEGIS) are likely to exhibit lower expenditures. These results are

[11] According to median voter theory (Holcombe 1989, Stiglitz 2000), which is based on a horizontal differentiation model, a voter with the median income is a decisive voter, whose preference becomes the representative demand of the entire populace for government outputs. We believe the reason why the coefficient of INCOME in columns 1–2 is negative is because the dependent variable in columns 1–2 is normalized by state GDP, which is highly correlated with income level.

[12] If the entire state tax revenues come from one source, COMPLEX is 1. If state tax revenues are from seven tax categories with an equal amount, COMPLEX is $7 \times (1/7)^2 = 0.1429$, the lowest possible value.

Table 6 Correlation Table

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
GOVperGDP	(1)	1															
GOVperPOP	(2)	0.6895	1														
INCOME	(3)	−0.3626	0.1269	1													
POPUL	(4)	−0.3666	−0.1874	0.0663	1												
INDTAX	(5)	−0.0802	−0.0310	0.2405	0.0752	1											
CORPTAX	(6)	−0.0242	0.0874	0.2456	0.1217	0.2233	1										
COMPLEX	(7)	−0.4388	−0.3859	−0.0349	0.1498	−0.4520	−0.4464	1									
DEBT	(8)	0.3233	0.4669	0.3035	−0.2039	0.2919	0.2257	−0.2900	1								
FEDGRANT	(9)	0.5498	0.6247	−0.2902	−0.1948	−0.2481	−0.2620	−0.2394	0.1429	1							
GOVERNOR	(10)	0.0110	0.0068	0.1322	0.0129	−0.2063	0.0073	0.1560	0.1135	−0.0669	1						
LEGIS	(11)	−0.2309	−0.3214	−0.1361	−0.0085	−0.0595	−0.2924	0.0609	−0.4551	0.0244	−0.1062	1					
EMP	(12)	0.5439	0.5707	0.0463	−0.4656	−0.2238	−0.0887	−0.1491	0.2456	0.3731	0.1253	−0.2472	1				
PROGBUD	(13)	−0.0042	0.0447	−0.0533	0.0876	−0.0906	0.1247	0.0309	−0.0797	0.0653	0.1227	−0.0739	0.0160	1			
INCBUD	(14)	0.2649	0.2292	−0.1306	−0.1251	0.1020	−0.2432	−0.1274	0.1270	0.3196	−0.0789	0.0812	0.2761	−0.0334	1		
ITperPOP	(15)	0.0012	0.0631	−0.1264	−0.2734	−0.1369	−0.1793	−0.0312	0.0044	0.3169	0.0962	0.2636	0.1864	−0.0335	0.1865	1	
ITperGDP	(16)	0.0798	0.0250	−0.2194	−0.2913	−0.1426	−0.1841	−0.0601	0.0082	0.2998	0.1213	0.2462	0.1986	−0.0241	0.1863	0.9819	1

Note. $N = 190$.

generally consistent with past findings on government size, thus supporting the reliability of our data set and estimation approach.

Next, when we add ITperPOP and ITperGDP (state CIOs' IT budgets) into the model, its coefficient is negative and significant, supporting H1A. This indicates that IT investments managed by state CIOs are negatively associated with state government expenditures. This is the case whether the dependent variable is normalized by either state GDP (columns 2–3) or population (columns 5–6). The coefficient of ITperGDP (the percentage of CIO budget to state GDP) in column 3 suggests that a \$1 increase in the IT budget of a state CIO is associated with a \$3.49 reduction in total state government expenditures.[13] This negative impact of IT on government size persists when we vary the lag-length of IT measure from zero to four years (Table 8).

Following the approach of Levine et al. (2000), we have conducted several specification tests for the dynamic panel data estimation. Hansen J tests in Table 7 show that the null hypotheses of overidentifying restrictions cannot be rejected, supporting the assumption that the instrumental variables are exogenous (Hansen 1982). In addition, Arellano and Bond (1991) tests do not indicate the presence of second-order correlations in differenced error terms ($\Delta\varepsilon_{k,t}$) in all estimations in Table 7 but column 4.

To further investigate the relationship between CIO IT spending and state expenditures, we measure the impact of IT on individual expenditure accounts as shown in Table 9. All of the dependent variables are normalized by state GDP. Whereas internal IT spending has a significant impact on state expenditures (Table 7), it does not on tax revenues (Table 9, column 1). Whereas more efficient and transparent government administration may need a lower amount of tax revenues, anecdotal evidence suggests that automated business processes and use of business intelligence in tax administration increase collection of tax revenues that would otherwise have been unpaid (Government Technology 2010a, b). Although the size of IT budgets does not have a significant impact on the amount of wages (column 3), it does negatively influence both the size of current expenses (column 2) and the combined amount of capital outlays and current expenses (column 5), providing some evidence that IT spending by a state CIO reduces the costs of state administration. Table 9, column 6, also shows that IT budgets are negatively related to intergovernmental grants to local governments. It appears that enterprise systems and architectures for information sharing built by state governments improve the productivity of local governments as well. Although the

[13] Note that in Table 7, column 3, both the dependent variable and the IT measure are normalized by state GDP.

Table 7 The Baseline Estimation Results

Dep. var.	Expenditures/GDP ($GOVperGDP_t$)			Expenditures/Population ($GOVperPOP_t$)		
Method	Two-step system GMM estimation					
	(1)	(2)	(3)	(4)	(5)	(6)
ITperPOP		−0.0103***			−0.0017**	
		(0.0018)			(0.0007)	
ITperGDP			−3.4861***			−0.6411**
			(0.6421)			(0.2979)
Lagged Dep. Var.	0.8132***	0.7234***	0.7218***	0.7637***	0.6455***	0.6424***
	(0.0383)	(0.0526)	(0.0517)	(0.0251)	(0.0479)	(0.0489)
INCOME	−0.0303***	−0.0281***	−0.0317***	0.0102***	0.0168***	0.0162***
	(0.0071)	(0.0090)	(0.0092)	(0.0014)	(0.0020)	(0.0020)
POPUL	0.0017	−0.0137*	−0.0141*	0.0069***	0.0033	0.0033
	(0.0023)	(0.0074)	(0.0073)	(0.0011)	(0.0033)	(0.0034)
INDTAX	−0.0107	0.0194	0.0183	0.0176**	−0.0023	−0.0020
	(0.0162)	(0.0463)	(0.0461)	(0.0079)	(0.0174)	(0.0174)
CORPTAX	−0.0077*	−0.0063	−0.0072	0.0005	0.0009	0.0009
	(0.0043)	(0.0077)	(0.0078)	(0.0011)	(0.0023)	(0.0023)
COMPLEX	−1.8383***	−2.1567**	−2.3228**	−0.1182	−0.4936**	−0.5112**
	(0.5117)	(0.9745)	(0.9773)	(0.1089)	(0.2134)	(0.2126)
DEBT	0.0318***	0.0341*	0.0360**	0.0102***	0.0080	0.0083
	(0.0098)	(0.0176)	(0.0174)	(0.0026)	(0.0063)	(0.0065)
FEDGRANT	0.4482***	0.8165***	0.7760***	0.4427***	0.5227***	0.5224***
	(0.0767)	(0.1089)	(0.1151)	(0.0430)	(0.0490)	(0.0473)
GOVERNOR	0.0105	0.1145	0.1125	−0.0133	−0.0119	−0.0116
	(0.0317)	(0.0779)	(0.0772)	(0.0106)	(0.0247)	(0.0249)
LEGIS	−0.5256**	−0.6646**	−0.7302***	−0.0021	−0.3914***	−0.3978***
	(0.2228)	(0.2671)	(0.2607)	(0.0598)	(0.1197)	(0.1209)
EMP	0.1137	0.1671*	0.1737*	0.1856***	0.1030	0.1068**
	(0.0755)	(0.0979)	(0.0973)	(0.0272)	(0.0441)	(0.0451)
PROGBUD	−0.0939	−0.0296	−0.0169	0.0010	0.0527	0.0539
	(0.0742)	(0.0864)	(0.0878)	(0.0290)	(0.0435)	(0.0441)
INCBUD	−0.0190	−0.0337	−0.0390	−0.0074	0.0075	0.0058
	(0.0488)	(0.0813)	(0.0802)	(0.0156)	(0.0353)	(0.0362)
Controls	Year	Year	Year	Year	Year	Year
N	600[a]	190	190	600[a]	190	190
No. of states	50	44	44	50	44	44
Wald stat.	150,128***	27,440***	26,794***	268,554***	59,610***	51,421***
No. of instr. variables	73	39	39	73	39	39
Hansen test[b]	0.999	0.281	0.280	0.993	0.256	0.244
Serial corr. test[c]	0.134	0.200	0.193	0.010	0.190	0.189

Notes. Standard errors are in parentheses; year dummies are omitted. Only the first four lags of the dependent variable are used for instruments. Fiscal year 2003–2007 with a two-year lag of IT (2001–2005).

[a]2000–2011.

[b]*p*-value. The null hypothesis is that the instruments used are exogenous.

[c]*p*-value. Arellano-Bond test for AR(2). The null hypothesis is that the errors in the first-difference regression exhibit no second-order serial correlation.

$^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

coefficient of ITperPOP in column 8 is negative, it seems that IT investments by state CIOs do not affect the amount of interests on debt service significantly. Using ITperGDP instead of ITperPOP in Table 9 does not change these results drastically.

Additionally, we analyze the impact of IT on expenditures in individual state service areas (Table 10). As in Table 9, all of the dependent variables are normalized by state GDP. Interestingly, the coefficients of state IT spending for expenditures in education (column 1), police (column 7), and parks and recreation (column 11) are positive and significant, in contrast to the finding from Table 7. We further broke down education spending on primary (K-12) and higher education. Table 10 demonstrates that the coefficients of ITperPOP in columns 2 and 3 (primary and higher education) are negative and positive, respectively. The effect of IT on healthcare (column 5) and housing and community development (column 10) is estimated to be negative and significant, whereas that

Table 8 Estimation Results with Different Lag Lengths

Dep. var.	Expenditures/GDP ($GOVperGDP_t$)				
Method	Two-step system GMM estimation				
Lag length	No lag	1 year	2 years	3 years	4 years
ITperPOP	−0.0038***	−0.0090***	−0.0103***	−0.0086***	−0.0097***
	(0.0012)	(0.0021)	(0.0018)	(0.0020)	(0.0029)
Lagged Dep. Var.	0.8105***	0.6312***	0.7234***	0.5880***	0.5712***
	(0.0355)	(0.0597)	(0.0526)	(0.0341)	(0.0464)
INCOME	−0.0278***	−0.0557***	−0.0281***	−0.0472***	−0.0607***
	(0.0077)	(0.0110)	(0.0090)	(0.0090)	(0.0106)
POPUL	−0.0009	−0.0086	−0.0137*	−0.0108	−0.0066
	(0.0045)	(0.0082)	(0.0074)	(0.0075)	(0.0090)
INDTAX	−0.0540*	−0.0706	0.0194	−0.0283	−0.0225
	(0.0288)	(0.0489)	(0.0463)	(0.0412)	(0.0350)
CORPTAX	−0.0067	−0.0155*	−0.0063	−0.0062	0.0025
	(0.0047)	(0.0086)	(0.0077)	(0.0072)	(0.0069)
COMPLEX	−2.7222***	−3.9461***	−2.1567**	−3.4671***	−2.6250***
	(0.6674)	(1.0721)	(0.9745)	(0.8203)	(0.6241)
DEBT	0.0490***	0.0629***	0.0341*	0.0452***	0.0413**
	(0.0130)	(0.0207)	(0.0176)	(0.0150)	(0.0164)
FEDGRANT	0.1938***	0.3565***	0.8165***	0.7125***	0.9208***
	(0.0717)	(0.1106)	(0.1089)	(0.1352)	(0.1581)
GOVERNOR	0.0603	0.0559	0.1145	0.0988	0.0700
	(0.0748)	(0.0817)	(0.0779)	(0.0779)	(0.0913)
LEGIS	−0.3736**	−0.6857**	−0.7302***	−1.0068***	−1.0516***
	(0.1818)	(0.3138)	(0.2607)	(0.3110)	(0.3516)
EMP	0.1089	0.4443***	0.1671*	0.3773***	0.4420***
	(0.0849)	(0.1185)	(0.0979)	(0.0804)	(0.0816)
PROGBUD	0.1297	0.0439	−0.0296	−0.0934	0.0103
	(0.0883)	(0.1326)	(0.0864)	(0.1378)	(0.1246)
INCBUD	0.0885	−0.0688	−0.0337	0.0523	−0.0051
	(0.0629)	(0.1102)	(0.0813)	(0.0899)	(0.1081)
Controls	Year	Year	Year	Year	Year
Wald stat.	61,183***	27,638***	27,440***	35,947***	50,687***
Hansen test[a]	0.325	0.104	0.281	0.734	0.802
Serial corr. test[b]	0.169	0.691	0.200	0.209	0.070

Notes. $N = 190$; no. of states $= 44$; no. of instrumental variables $= 39$. Standard errors are in parentheses; year dummies are omitted. Only the first four lags of the dependent variable are used for instruments.

[a] *p*-value. The null hypothesis is that the instruments used are exogenous.

[b] *p*-value. Arellano-Bond test for AR(2). The null hypothesis is that the errors in the first-difference regression exhibit no second-order serial correlation.

$^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

on police (column 7) and parks and recreation (column 11) is positive. As we discussed in §2.4, anecdotal evidence illustrates that IT investments of CIOs help states expand their strategic role in emergency management, homeland security, and land conservation. Also interesting to note is the negative coefficient of ITperPOP on expenditures in the area of general administration (Table 10, column 12), which the U.S. Census Bureau defines as government units for financial administration, tax collection, judicial and legislative branches, human resource management, and facility management.[14] It appears that IT makes government administration more efficient by reducing expenditures on back-end supporting administrative functions. Once again, using ITperGDP in lieu of ITperPOP in Table 10 does not change these results substantially.

We have conducted a series of robustness checks as shown in Table 11. First, we adopt several alternative measures for government size such as the number of state employee per capita (column 1) and government expenditures per employee (column 2). The IT budgets of state CIOs are negatively associated with state expenditures per employee (column 2), whereas the size of state employment is not affected by CIO IT spending. In our baseline estimation, we use the government size measure in Equation (1), in which different price indexes are used in the numerator and the denominator, in accordance with Garand (1988). Alternatively, we estimated the model (Equation (2)) with $GOVperGDP_{k,t} = EXPEND_{k,t}/GDP_{k,t}$, which does not use the different price indexes, and obtained a very similar estimation result (column 3). As state governments financially support local governments via intergovernmental grants, we measure the impact of IT on the total combined expenditures of state and local governments divided by state GDP (column 3).[15] We find that the coefficient of ITperPOP is negative and statistically significant. Also, to show that our result is robust to alternative estimation approaches, we use the Difference GMM (Arellano and Bond 1991) (Table 11, column 5) in lieu of the System GMM in estimating Equation (2). The coefficient of ITperPOP is still negative and significant. We also estimated the model in Equation (2) without normalizing variables with GDP or population and did not obtain a substantially different result.

So far, we have examined the impact of CIO IT budgets on state expenditures. However, in some states, state CIOs control a small portion of total IT expenditures, the rest of which are made by other executive branch agencies. As stated above, our NASCIO data set reports the executive branches' IT budget information only in 29 states, compared to the state CIO budgets in 44 states. To further affirm our finding that state IT investments affect state government size, we examine the impact of total statewide IT spending on state government size. As shown in Table 11, column 6, although the number of observations (95) is smaller than in Table 7, the impact of the entire state IT budget on state government expenditures is still negative and significant.

[14] http://www.census.gov/govs/classification/, accessed March 26, 2014.

[15] The dependent variable in column 3, Table 9, is calculated by (State Expenditures + Local Expenditures − Intergovernmental Transfer from State to Local)/State GDP.

Table 9 Estimation Results with Different Expenditures/Finance Accounts

Dep. var.[a]	Tax revenues	Current operation	Wages	Capital outlays	Operation + Capital	Grant to localities	Subsidies	Interests
Method	Two-step system GMM estimation							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ITperPOP	0.0004	−0.0034**	0.0001	−0.0004	−0.0050***	−0.0049***	0.0001	−0.0001
	(0.0007)	(0.0015)	(0.0002)	(0.0007)	(0.0014)	(0.0018)	(0.0003)	(0.0001)
Lagged Dep. Var.	0.9270***	0.8341***	0.9256***	0.0992	0.7109***	0.5313***	0.8984***	0.6048***
	(0.0191)	(0.0358)	(0.0530)	(0.0964)	(0.0333)	(0.0532)	(0.0529)	(0.0427)
INCOME	0.0014	−0.0075	−0.0005	−0.0170***	−0.0183***	−0.0091	0.0003	0.0002
	(0.0012)	(0.0050)	(0.0007)	(0.0031)	(0.0063)	(0.0070)	(0.0009)	(0.0004)
POPUL	−0.0030**	−0.0020	0.0006	−0.0059***	−0.0086*	−0.0020	−0.0009	0.0001
	(0.0012)	(0.0044)	(0.0005)	(0.0017)	(0.0050)	(0.0070)	(0.0006)	(0.0002)
INDTAX	0.0177*	0.0330*	−0.0013	−0.0098	0.0144	−0.0669*	−0.0075	0.0000
	(0.0100)	(0.0177)	(0.0026)	(0.0121)	(0.0213)	(0.0383)	(0.0047)	(0.0017)
CORPTAX	0.0035**	−0.0004	−0.0008*	−0.0035**	0.0002	−0.0122*	−0.0008	0.0001
	(0.0017)	(0.0030)	(0.0005)	(0.0014)	(0.0039)	(0.0064)	(0.0007)	(0.0003)
COMPLEX	0.0125	−0.1435	−0.0765	−0.2946	−0.6936**	−2.7639***	−0.1327**	−0.0322
	(0.1576)	(0.2694)	(0.0505)	(0.2180)	(0.2762)	(0.7350)	(0.0579)	(0.0296)
DEBT	−0.0050*	0.0153**	0.0023*	0.0286***	0.0299***	−0.0310**	0.0007	0.0168***
	(0.0029)	(0.0074)	(0.0013)	(0.0053)	(0.0064)	(0.0130)	(0.0019)	(0.0019)
FEDGRANT	0.1356***	0.2556**	−0.0227**	0.1428***	0.4060***	0.3050***	−0.0059	−0.0059
	(0.0203)	(0.1130)	(0.0092)	(0.0221)	(0.1048)	(0.0833)	(0.0133)	(0.0045)
GOVERNOR	0.0185***	0.0927**	−0.0139**	0.0431**	0.1290**	0.0023	−0.0094	0.0093*
	(0.0202)	(0.0408)	(0.0054)	(0.0200)	(0.0535)	(0.0584)	(0.0089)	(0.0050)
LEGIS	−0.1497*	−0.1399	−0.0255	0.5763***	−0.1961	−0.3349	−0.0198	0.0066
	(0.0837)	(0.1382)	(0.0245)	(0.1080)	(0.1727)	(0.2549)	(0.0447)	(0.0178)
EMP	0.0322**	0.2314***	0.0345	0.1367***	0.4911***	−0.3853***	−0.0104	0.0096**
	(0.0141)	(0.0765)	(0.0436)	(0.0209)	(0.0671)	(0.0693)	(0.0078)	(0.0046)
PROGBUD	0.0210	−0.0515	−0.0035	0.2258***	−0.0252	0.0486	−0.0019	−0.0120**
	(0.0316)	(0.0476)	(0.0081)	(0.0453)	(0.0641)	(0.1148)	(0.0124)	(0.0052)
INCBUD	−0.0163	−0.1046**	−0.0077	−0.0595**	−0.0804	0.1456*	−0.0060	0.0001
	(0.0236)	(0.0434)	(0.0064)	(0.0273)	(0.0520)	(0.0792)	(0.0116)	(0.0058)
Controls	Year	Year	Year	Year	Year	Year	Year	Year
Wald stat.	128,570***	64,481***	73,309***	9,948***	20,461***	7,352***	4,857***	48,031***
Hansen test[b]	0.304	0.171	0.657	0.417	0.263	0.152	0.281	0.743
Serial corr.[c]	0.827	0.507	0.045	0.389	0.468	0.088	0.137	0.669

Notes. $N = 190$; No. of states = 44; No. of instrumental variables = 39. Standard errors are in parentheses; year dummies are omitted. Only the first four lags of the dependent variable are used for instruments. Fiscal year 2003–2007 with a two-year lag of IT (2001–2005).

[a]All dependent variables are normalized by state GDP.

[b]*p*-value. The null hypothesis is that the instruments used are exogenous.

[c]*p*-value. Arellano-Bond test for AR(2). The null hypothesis is that the errors in the first-difference regression exhibit no second-order serial correlation.

*$p < 0.1$; **$p < 0.05$; ***$p < 0.01$.

The U.S. federal government provides financial aids to state government expenditures, including IT spending. For instance, as per the Patient Protection and Affordable Healthcare Act, the Centers for Medicare and Medicaid Services (a U.S. federal agency) provided \$3.7 billion by 2013 to healthcare or insurance agencies in 14 states that developed the Health Insurance Marketplace.[16] The U.S. Department of Commerce offers state public safety agencies with financial aids for implementation of the nationwide public safety network.[17] The U.S. Department of Transportation distributes State Traffic Safety Information Systems Grants to state transportation agencies.[18] As a robustness check, we estimate the impact of this federal support to state IT investments. From the Consolidated Federal Funds Report published by the U.S. Census Bureau, we collected information on

[16] http://www.cms.gov/CCIIO/Resources/Marketplace-Grants/index.html, accessed January 31, 2014. The 14 states are California, Colorado, Connecticut, Hawaii, Kentucky, Maryland, Massachusetts, Minnesota, Nevada, New York, Oregon, Rhode Island, Vermont, and Washington.

[17] http://www.ntia.doc.gov/files/ntia/publications/sligp_ffo_02062013.pdf, accessed November 6, 2013.

[18] http://apply07.grants.gov/apply/opportunities/instructions/oppFM-CVN-11-001-cfda20.237-cidFM-CVN-11-001-012558-instructions.pdf, accessed November 6, 2013.

Table 10 Estimation Results with Government Service Categories

Dep. var.[a]	Education	Primary edu.	Higher edu.	Welfare	Healthcare	Highway	Police	Correction	Natural resource	Housing	Parks and rec.	General admin
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
ITperPOP	0.0066*	−0.0007*	0.0006**	−0.0035	−0.0006**	−0.0028	0.0001***	−0.0001	0.0004	−0.0002*	0.0038**	−0.0014***
	(0.0034)	(0.0004)	(0.0003)	(0.0058)	(0.0002)	(0.0031)	(0.0000)	(0.0005)	(0.0002)	(0.0001)	(0.0001)	(0.0005)
Lagged Dep. Var.	0.4682***	0.8790***	0.8654***	0.6091***	0.9659***	0.7611***	0.7615***	0.4217***	0.7289***	0.7894***	0.9670***	0.5748***
	(0.0302)	(0.0224)	(0.0178)	(0.0496)	(0.0194)	(0.0233)	(0.0244)	(0.0268)	(0.0180)	(0.0323)	(0.0081)	(0.0245)
INCOME	−0.0543***	−0.0006	−0.0053***	−0.0661***	−0.0001	−0.0265**	−0.0001	−0.0030**	−0.0004	−0.0007**	0.0056	−0.0035***
	(0.0098)	(0.0014)	(0.0012)	(0.0179)	(0.0006)	(0.0131)	(0.0001)	(0.0003)	(0.0003)	(0.0003)	(0.0047)	(0.0013)
POPUL	0.0183	0.0007	−0.0031***	−0.0083	0.0004	−0.0198	−0.0004***	0.0002	−0.0004	−0.0009***	0.0002	−0.0013
	(0.0162)	(0.0013)	(0.0009)	(0.0099)	(0.0007)	(0.0153)	(0.0001)	(0.0030)	(0.0010)	(0.0003)	(0.0073)	(0.0029)
INDTAX	−0.1434***	−0.0081	−0.0154***	0.1423**	0.0016	−0.0446	−0.0011	−0.0211***	−0.0052	−0.0022	−0.0833***	−0.0160*
	(0.0535)	(0.0061)	(0.0058)	(0.0568)	(0.0041)	(0.0495)	(0.0008)	(0.0077)	(0.0032)	(0.0014)	(0.0290)	(0.0083)
CORPTAX	−0.0186	−0.0022**	−0.0034***	0.0252**	0.0012*	0.0307***	0.0001	−0.0009	−0.0009	0.0004	−0.0216***	−0.0001
	(0.0156)	(0.0011)	(0.0011)	(0.0114)	(0.0007)	(0.0100)	(0.0001)	(0.0014)	(0.0006)	(0.0003)	(0.0057)	(0.0018)
COMPLEX	−5.1429***	−0.4718***	−0.7481***	0.8792	0.1140**	0.9738	−0.0159	−0.4430***	−0.1218***	−0.0993***	−1.9218***	−0.1506
	(1.0127)	(0.1516)	(0.1274)	(1.0508)	(0.0450)	(0.7103)	(0.0116)	(0.1087)	(0.0365)	(0.0219)	(0.5542)	(0.1481)
DEBT	0.0206	−0.0051*	0.0030	−0.0359	−0.0019	0.1383***	0.0005*	0.0074**	0.0018*	0.0029***	0.0110	0.0186***
	(0.0165)	(0.0030)	(0.0020)	(0.0386)	(0.0016)	(0.0241)	(0.0003)	(0.0030)	(0.0010)	(0.0009)	(0.0113)	(0.0023)
FEDGRANT	−0.1774	0.0221	−0.0782***	0.8287**	0.0117	−0.3622**	0.0036*	−0.0152	0.0354***	−0.0064	0.4213***	0.0172
	(0.1648)	(0.0186)	(0.0227)	(0.3411)	(0.0112)	(0.1719)	(0.0021)	(0.0225)	(0.0093)	(0.0084)	(0.0809)	(0.0160)
GOVERNOR	0.1932**	−0.0159	0.0221	0.2613*	0.0047	−0.4336**	−0.0014	−0.0175	0.0103	−0.0120**	0.0693	0.0293
	(0.0826)	(0.0162)	(0.0156)	(0.1430)	(0.0111)	(0.1744)	(0.0021)	(0.0156)	(0.0069)	(0.0060)	(0.0554)	(0.0190)
LEGIS	2.4830***	−0.1808***	0.0513	−1.5566**	0.0385	−0.2985	−0.0208***	−0.0886	0.0710**	−0.0313***	0.3095*	−0.0438
	(0.5630)	(0.0655)	(0.0382)	(0.6073)	(0.0508)	(0.6246)	(0.0050)	(0.0795)	(0.0295)	(0.0109)	(0.1672)	(0.0852)
EMP	0.7644***	0.0091	0.0068	0.0382	0.0343***	−0.0206	−0.0066**	−0.0632***	0.0067	−0.0141***	−0.0393	0.0297*
	(0.1822)	(0.0186)	(0.0094)	(0.0940)	(0.0108)	(0.1225)	(0.0029)	(0.0118)	(0.0065)	(0.0040)	(0.0414)	(0.0166)
PROGBUD	0.2146	−0.0087	0.0064	−0.2915	−0.0202	0.1297	0.0002	0.0606**	0.0022	−0.0015	0.2105***	0.0604***
	(0.2491)	(0.0150)	(0.0181)	(0.3158)	(0.0133)	(0.2268)	(0.0023)	(0.0248)	(0.0090)	(0.0055)	(0.0571)	(0.0209)
INCBUD	0.0483	0.0156	0.0091	−0.0288	−0.0172	−0.5793***	0.0023	−0.0223	−0.0058	0.0016	−0.0224	−0.0354
	(0.2293)	(0.0180)	(0.0149)	(0.2177)	(0.0116)	(0.1493)	(0.0018)	(0.0259)	(0.0099)	(0.0052)	(0.0529)	(0.0227)
Controls	Year	Year	Year	Year	Year	Year	Year	Year	Year	Year	Year	Year
Wald	27,221***	113,063***	98,168***	2,169***	78,914***	7,957***	10,395***	5,374***	57,375***	8,426***	175,364***	9,536***
Hansen[b]	0.423	0.586	0.143	0.083	0.404	0.452	0.755	0.135	0.159	0.196	0.590	0.255
Serial[c]	0.725	0.358	0.663	0.506	0.387	0.842	0.258	0.333	0.487	0.785	0.776	0.150

Notes. $N = 190$; no. of states = 44; no. of instrumental variables = 39; Standard errors are in parentheses; year dummies are omitted. Only the first four lags of the dependent variable are used for instruments. Fiscal year 2003–2007 with a two-year lag of IT (2001–2005).

[a] All dependent variables are normalized by state GDP.

[b] Hansen J test p-value. The null hypothesis is that the instruments used are exogenous.

[c] Arellano-Bond Serial Correlation Test for AR(2) p-value. The null hypothesis is that the errors in the first-difference regression exhibit no second-order serial correlation.

$^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

intergovernmental grants from the federal government toward state IT spending,[19] which is available for all 50 states. In Table 11, column 7, we use the per capita amount of federal IT grants to a state government as an IT variable. This variable measures not only IT investments of states but also their IT capabilities, since federal agencies determine the amount of grants to the states by evaluating various factors including their strategic IT plan, IT operations and infrastructure, and the availability of matching funds from the states. As shown in Table 11, column 7, the coefficient of IT is negative and significant as well. Whereas federal IT grants support a small portion of IT expenditures in states, this estimation with 600 observations in all 50 U.S. states for 12 years (2000–2011) provides further evidence that IT investments made by state executive branches outside of the CIO office are also negatively related to state government size.

5. Discussions

Motivated by the fact that government growth is a persistent and prevalent phenomenon in many industrialized nations (Saunders 1993), we aim to investigate whether and how IT investments in the public sector affect this trend. Our empirical analysis strongly supports the hypothesis that more IT

[19] The list of federal grant programs to state IT investments is available from the authors on request.

Table 11 Robustness Checks

Dep. var.	State employees/ Population	Expenditures/ Employee	GOVperGDP with same deflator	(State + Local expenditures)/GDP	GOVperGDP (expenditures/GDP)		
IT variable	ITperPOP (CIO IT budget per capita)				ITperPOP	Entire IT budget per capita	Federal IT grants per capita
Method	System GMM				Difference GMM	System GMM	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
IT	0.0001	−0.1590***	−0.0115***	−0.0064**	−0.0070**	−0.0077**	−0.0699**
	(0.0001)	(0.0487)	(0.0016)	(0.0028)	(0.0028)	(0.0036)	(0.0355)
Lagged Dep. Var.	0.9990***	0.8654***	0.6900***	0.7155***	0.5350***	0.3868***	0.9208***
	(0.0041)	(0.0308)	(0.0449)	(0.0429)	(0.1085)	(0.1117)	(0.0261)
INCOME	0.0005	0.2239	−0.0354***	−0.0360***	−0.0653*	−0.0977	−0.0453*
	(0.0003)	(0.1509)	(0.0083)	(0.0095)	(0.0363)	(0.0625)	(0.0231)
POPUL	0.0005**	1.0575***	−0.0152**	0.0097	−0.1176	0.0721	0.0753*
	(0.0003)	(0.3070)	(0.0077)	(0.0121)	(0.3189)	(0.2563)	(0.0396)
INDTAX	−0.0055***	3.2121***	−0.0047	−0.0244	−0.1536	−0.3193	0.1623**
	(0.0014)	(0.7595)	(0.0476)	(0.0391)	(0.1414)	(0.3002)	(0.0754)
CORPTAX	−0.0009***	0.4075***	−0.0091	0.0115	−0.2015***	−0.1014	−0.0273
	(0.0002)	(0.1101)	(0.0082)	(0.0078)	(0.0616)	(0.1938)	(0.0192)
COMPLEX	−0.0772***	24.8553***	−2.8394***	−0.7813	−11.3897***	−10.0795**	−0.6078
	(0.0243)	(8.8977)	(0.9625)	(0.7455)	(3.5150)	(4.5336)	(0.6859)
DEBT	0.0012*	0.0634	0.0462***	0.0345***	0.2846***	0.3791***	−0.0269
	(0.0007)	(0.2617)	(0.0175)	(0.0123)	(0.0644)	(0.1288)	(0.0441)
FEDGRANT	0.0077*	13.6534***	0.7781***	0.6427***	1.4866***	0.3264	0.1384
	(0.0039)	(2.3404)	(0.1128)	(0.1337)	(0.4220)	(0.9475)	(0.1844)
GOVERNOR	−0.0085**	−0.0146	0.0964	0.0657	0.0746	0.1237	0.2035**
	(0.0035)	(1.6291)	(0.0797)	(0.0839)	(0.1150)	(0.4506)	(0.0917)
LEGIS	−0.0310*	14.0448**	−0.7424***	0.0452	2.4956*	0.5028	−0.8004
	(0.0161)	(6.8538)	(0.2793)	(0.3271)	(1.4453)	(3.5728)	(0.5722)
EMP			0.2335***	0.0273	−2.0283*	−2.2315	0.1506
			(0.0864)	(0.0681)	(1.1714)	(2.5220)	(0.2300)
PROGBUD	0.0013	1.1934	−0.0453	0.0229	0.3122***	2.4666	−0.3399
	(0.0036)	(1.3874)	(0.0911)	(0.0987)	(0.1188)	(6.1883)	(0.2689)
INCBUD	0.0012	−2.9491	−0.0364	0.1706	−0.0385	3.2515	0.1237
	(0.0048)	(2.4352)	(0.0850)	(0.1289)	(0.1706)	(6.6238)	(0.1652)
N	190	190	190	190	146	95	600[a]
No. of states	44	44	44	44	44	29	50
No. of instr.	38	38	39	39	34	39	74
Wald	666,302***	35,644***	37,976***	13,529***	618***	150,009***	65,496***
Hansen[b]	0.476	0.142	0.251	0.286	0.417	0.781	0.999
Serial[c]	0.525	0.249	0.205	0.642	0.819	0.125	0.192

Notes. Standard errors are in parentheses; year dummies are omitted. Only the first four lags of the dependent variable are used for instruments. Fiscal year 2003–2007 with a two-year lag of IT (2001–2005) (except column 8).

[a]Fiscal year 2000–2011 with a two-year lag of IT (1998–2009).

[b]Hansen J test p-value. The null hypothesis is that the instruments used are exogenous.

[c]Arellano-Bond Serial Correlation Test for AR(2) p-value. The null hypothesis is that the errors in the first-difference regression exhibit no second-order serial correlation.

$^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

investments by state CIOs are associated with lower state government spending. We find that on average, a \$1 increase in state CIO budgets is related to a reduction of \$3.49 in state expenditures. We also find that this result is robust to the use of alternative estimation approaches and different measures for government size such as per capita state expenditures and state expenditures per employee.

This research contributes to the IS literature by proposing a new theoretical perspective with an interdisciplinary approach that integrates theories from the IS, public economics, and political sciences literatures. To the best of our knowledge, only a handful of studies have examined the impact of IT investments on government finance (e.g., Pang et al. 2014b), although a substantial amount of tax revenues are being spent in IT every year. In addition, few prior studies have examined the relationship between IT and government size. Thus, our study contributes to the IS literature by offering quantitative empirical evidence that CIOs' IT budgets do reduce the size of government. Our research is also the first to study the organizational impact of a CIO's IT investments on the size of a multidivisional organization. This study shows that the strategic and coordinating role of the central CIO in organization-wide IT management, supported by sufficient budgets bestowed to the CIO, is a key factor for effective utilization of IT resources.

This study offers meaningful implications for policy makers and IT managers in public-sector organizations. We inform policy makers that for IT to be a key factor for government transformation, governments need to support the duties of a central CIO in overseeing and orchestrating organization-wide IT operations by appropriating sufficient resources to his or her functions. Also, policy makers can exploit IT to make government administration more transparent by promoting open government data initiatives involved with collecting real-time and fine-grained information on decision makings and publicizing it to the public. As shown by the present study, enhanced transparency by enabled IT will help governments reduce overall expenditures and close gaps in budgetary deficits.

6. Conclusion

In conclusion, we attempt to move the frontier of IS research to the public sector setting by studying the relationship between IT investments and state government size. To the best of our knowledge, the public sector is a domain that has not been extensively studied in IS research, despite a substantial amount of investments in IT made by public organizations. We expect that our study sparks new interests in further research in the government setting among IS scholars and helps bring new audiences to the IS discipline.

The present study is not without limitations. First, the theoretical development in §2 may not fully explain every aspect of government expenditures. Future research can further review the literature on government size and build a more integrative economic model that theorizes the effect of IT investments on government spending. Second, on the empirical side, although we use appropriate econometric techniques to estimate a causal relationship between IT budget and government size, there may be omitted variables in our estimations.

Because this is one of the earliest studies on IT business value in the public sector, there are numerous opportunities for future research. The present study discovers that internal IT investments reduce the size of government expenditures, but it is unclear whether such a reduction effect comes from decreasing the amount of or deteriorating the quality of public services. An unanswered question therefore is whether government IT spending can generate value by improving the quality of public services. Researchers may study the relationship between IT investments and service quality such as education, public safety, or healthcare quality. We expect this study to spark further interests among IS researchers on IT value in the public sector.

This study measures a relatively short-term impact of IT on government expenditures. Future studies may investigate its long-term effect on government size. It may be the case that in the long run, an improvement in efficiency and productivity of government production driven by IT increases the demands for public services. It would therefore be interesting to investigate how the short-term and long-term influence of IT spending differ in the public sector. Also, researchers may study the incentives of IT spending in governments. One might wonder why governments would invest in IT in the apparent absence of profit-seeking motivation and competitive pressures. We find that government IT investments are associated with smaller government, an effect that is in contrast to bureaucrats' interests to maximize their expenditures (Niskanen 1968, Miller and Moe 1983). What factors motivate government officials to invest in IT? There must be interesting explanations from economic, political, and behavioral points of views that future research can explore.

Acknowledgments

The authors thank Anandhi Bharadwaj, the associate editor, and three anonymous reviewers for their valuable comments and guidance. In particular, the authors are indebted to the late Sandra Slaughter, who has provided tremendously helpful guidance and support for this paper in the review process. The authors are grateful to Nigel Melville, Francine Lafontaine, Robert J. Franceze, Jr., Sunil Wattal, Hyun Joon Kim, Youngin Yoo, and Steven Johnson for their suggestions and comments. The authors thank two interviewees at the CIO office of a large Midwestern state and seminar participants at Temple University, Korea University, University of Florida, INFORMS Conference on Information Systems and Technology 2009, International Conference on Information Systems 2010, and Workshop on Information Systems and Economics 2011. The authors are also grateful to the National Association of State Chief Information Officers for generously providing the data set. This research was supported by the Ross School of Business Doctoral Fellowship and Information Systems Executive Forum Fellowship at the University of Michigan.

Appendix A. Banks (1989) Model of the Political Control of Bureaucracy

Banks (1989) proposes a political control model of bureaucracy in the presence of information asymmetry and conflicts of interest. His work models a budget decision game between a legislature and a bureaucratic agency. The legislature has an authority to approve the budget proposed by the agency but has limited information on the actual costs of administration. The agency is interested in maximizing the budget size (b) as in bureaucracy theory (Niskanen 1968, Miller and Moe 1983), whereas the legislature's interest is to maximize the benefit to voters net of the budget ($v - b$).

In his model, the benefit of a certain public good is v and known to both the legislature and the agency. On the other hand, the cost of production c is known only to the agency, whereas the legislature is only aware of the distribution of the cost $f(c)$. The budget decision game proceeds as follows.

Discovering the true cost c, the agency submits a budget request b to the legislature. The legislature has three options. With a probability of α_1, it accepts this budget request. With a probability of α_2, it conducts an audit with a cost of k and discovers the true value of c. The budget size becomes c after the audit. With a probability of $1 - \alpha_1 - \alpha_2$, the legislature rejects the budget request.

The sequential equilibrium strategies of the legislature and the agency are given as follows.
If $k < k^*$, where k^* is the solution of

$$\int_0^v c \cdot f(c)\,dc \Big/ \int_0^v f(c)\,dc = v - k, \tag{A1}$$

the size of the budget request is

$$b^*(c) = \begin{cases} c + k & \text{if } c \in [0, c'], \\ v & \text{if } c \in (c', v]. \end{cases} \tag{A2}$$

The legislature accepts the request with a probability of

$$\alpha_1^*(b) = \begin{cases} 1 & \text{if } b < k, \\ \exp\{(k - b)/k\} & \text{if } b \in [k, k + c'], \\ 0 & \text{if } b \in (k + c', v], \\ k\exp(-c'/k)/(v - c') & \text{if } b = v. \end{cases} \tag{A3}$$

The legislature audits the request with a probability of

$$\alpha_2^*(b) = 1 - \alpha_1^*(b), \tag{A4}$$

where c' is the solution of $\int_{c'}^v c \cdot f(c)\,dc / \int_{c'}^v f(c)\,dc = v - k$.

$$\text{If } k > k^*, \quad b^*(c) = v, \quad \alpha_1^*(b) = 1, \quad \text{and} \quad \alpha_2^*(b) = 0. \tag{A5}$$

According to this equilibrium, if $k > k^*$, i.e., if the auditing is too costly, where k^* is the threshold cost of the audit, the legislature has no incentive to audit any budget request and thus accepts it. In this case, the agency requests v for the budget, which the legislature approves without audit. In the case of $k < k^*$, when c is sufficiently low ($c < c'$), the budget request is equal to $c + k$. In other words, the agency reveals its true cost. When $c > c'$, the agency requests a budget of v.

The expected budget size is given by

$$B(v, c, k) = \begin{cases} c + k\exp(-c/k) & \text{if } k < k^* \text{ and } c \in [0, c'], \\ c + \dfrac{k(v - c)\exp(-c'/k)}{v - c'} & \\ & \text{if } k < k^* \text{ and } c \in (c', v], \\ v & \text{if } k > k^*. \end{cases} \tag{A6}$$

This theoretical model predicts a negative impact of IT investments on government expenditures in three ways, as follows. First, automation and digitization by IT systems in production processes brings a decrease in the production cost c. Second, digitized administration processes can collect most information regarding costs and decision making, enabling the legislature to conduct an audit with less cost. Thus, IT investments may lead to a smaller auditing cost k. (Banks 1989) proves that the expected budget size $B(c, k, v)$ increases in c (p. 680) and k (p. 696, Corollary A2-1). Thus, a reduction in c or k will decrease the expected budget size.

Third, even though the legislature cannot observe the true cost c, it can still expect the cost reduction from IT investments. Therefore, the legislature's prior cost distribution $f(c)$ is shifted to the left. This shift in turn leads to an increase in the threshold cost of the audit k^*, so that auditing becomes more feasible. We prove here that the change in the legislature's prior distribution of the cost (f) from IT investments increases k^*, the upper boundary of k beyond which the legislature does not conduct an audit at all.

Solving Equation (A1), we obtain

$$k^* = v - \int_0^v c \cdot f(c)\,dc \Big/ \int_0^v f(c)\,dc. \tag{A7}$$

However, Banks (1989) stipulates that c is defined in $[0, v]$ (p. 674). Consequently, $\int_0^v f(c)\,dc = 1$ and

$$k^* = v - \int_0^v c \cdot f(c)\,dc. \tag{A8}$$

Suppose that F is a cumulative distribution function of c and t is the amount of IT investments. As more IT investments are made, the legislature can expect that the true cost is likely to be smaller, as represented by $\partial F/\partial t \geq 0$. By integrating by parts

$$\int_0^v c \cdot f(c)\,dc = c \cdot F(c)|_0^v - \int_0^v F(c)\,dc = v - \int_0^v F(c)\,dc \tag{A9}$$

as $F(v) = 1$ and $F(0) = 0$. Therefore,

$$k^* = v - \left(v - \int_0^v F(c)\,dc\right) = \int_0^v F(c)\,dc, \tag{A10}$$

$$\frac{\partial}{\partial t}k^* = \int_0^v \frac{\partial}{\partial t}F(c)\,dc \geq 0. \tag{A11}$$

Intuitively, $\int_0^v c \cdot f(c)\,dc$ indicates the expected value of c possessed by the legislature. IT investments decrease this expected value of c, and by Equation (A11), increases k^*.

Appendix B. Measures and Data Sources

CIO IT Budget (ITperPOP, ITperGDP)

The 2002 *NASCIO Compendium of Digital Governments in States* provides the actual IT budget figures in fiscal year 2001 and 2002 and the expected budgets in 2003. The 2004–05 *Compendium* covers the actual budgets in 2003 and 2004 and the expected budgets in 2005. We take the actual IT budgets in 2001 and 2002 from the 2002 Compendium and 2004 and 2005 budgets from the 2004–05 Compendium. For the IT budget in 2003, we first take the actual 2003 budget from the 2004–05 Compendium. If the actual 2003 budget is missing in the 2004–05 Compendium, we take the expected budgets from the 2002 Compendium. For example, New Hampshire does not report its 2003 IT budget in the

2004–05 Compendium. So we take its estimated 2003 budget from the 2002 Compendium. The correlation between the expected 2003 budget in the 2002 Compendium and the actual 2003 budget in the 2004–05 Compendium is 0.66. The ITperPOP is calculated by dividing the IT budget by population estimate. The ITperGDP is obtained by dividing IT budgets by state GDP.

Tax Complexity (COMPLEX)
We calculated a Herfindahl index of seven tax categories—personal income tax, corporate income tax, property tax, sales tax, license tax, severance tax on extraction of natural resources, and other taxes. Suppose that t_i is the ratio of tax revenues in Category i to total tax revenues. Then, the Herfindahl index is calculated by $\sum_{i=1}^{7} t_i^2$. This measure is greater as the state tax system is simpler.

Mean Debt Level (DEBT) and Federal Grant (FEDGRANT)
From the State Government Finances from the U.S. Census, we take an average of the beginning- and end-level of state debt in each year and divide it by the state population (DEBT). Also, we take intergovernmental revenues from the federal government and divide it by the state population (FEDGRANT).

Party Control of Legislatures (LEGIS)
We calculated the ratio of Republican state representatives in the state house and Republican state senators in the senate, respectively. Then we added the two and divided by two. Thus, LEGIS is between 0 and 1. For Nebraska, which has a unicameral legislature, we use the ratio of Republicans in its legislature for LEGIS.

Appendix C. A Brief Description of the Dynamic Panel Data Estimation

Consider the following model:

$$y_{it} = y_{i,t-1} + X_{it}\beta + v_i + u_{it}, \tag{C1}$$

where v_i and u_{it} are time-invariant individual-specific heterogeneity and residuals, respectively. A challenge in estimating Equation (C1) is that a fixed-effects estimation is unable to eliminate correlation between the lagged dependent variable ($y_{i,t-1}$) and v_i (Nickell 1981).

One solution to address this issue, proposed by Arellano and Bond (1991), is to take the first-difference as follows:

$$\Delta y_{it} = \Delta y_{i,t-1} + \Delta X_{it}\beta + \Delta u_{it}. \tag{C2}$$

A weakness in this Difference GMM approach, however, is that it loses the observations in the first year ($t = 1$), reducing the number of available observations for estimation. This problem is exacerbated with an unbalanced panel; if y_{it} is missing, both Δy_{it} and $\Delta y_{i,t+1}$ are unavailable for estimation (Roodman 2009b).

An alternative to the Difference GMM is to eliminate fixed effects using all future available observations. Specifically, Arellano and Bover (1995) propose that a variable w_{it} is transformed by

$$\check{w}_{it} = \sqrt{\frac{T-t}{T-t+1}}\left(w_{it} - \frac{1}{T-t}\sum_{s=t+1}^{T} w_{is}\right). \tag{C3}$$

In essence, this System GMM subtracts the average of the available future observations up to $t = T$ from w_{it} (Arellano and Bover 1995). It is multiplied by $\sqrt{(T-t)/(T-t+1)}$ to obtain the same variance.

Next, with the variables transformed by Equation (C3), we obtain

$$\check{y}_{it} = \check{y}_{i,t-1} + \check{X}_{it}\beta + \check{u}_{it}. \tag{C4}$$

The remaining issue in Equation (C4) is that $\check{y}_{i,t-1}$ can be correlated with $\check{u}_{it}$ (Bond 2002). This is taken care of by using the available lagged values of $y_{i,t-1}$ as instrumental variables. For instance, for $y_{i,t-1}$, all observations from y_{i1} to $y_{i,t-2}$ can be used for instruments. However, Roodman (2009a) cautions that employing too many lagged variables for instruments many over-identify the model. Following this recommendation, we use only four lagged observations of the dependent variable for instruments. For more technical descriptions, refer to Arellano and Bover (1995) and Blundell and Bond (1998).

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