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INTRODUCTION

Digital platforms refer to a sociotechnical assemblage encompassing digital technologies, associated business processes, and standards (Bharadwaj et al., 2013; de Reuver, Sørensen, & Basole, 2018). Digital government platforms can improve the efficiency of public services by providing government agencies with higher accessibility to data and data analytics tools (Brown et al., 2017). To facilitate collaborative service production, governments are converging existing IT and organizational silos with new digital technologies to generate digital platforms (Cordella & Paletti, 2019; Senyo, Effah, & Osabutey, 2021). At the same time, adopting digital platforms also changes coordination among many interacting, networked, and collaborative actors in a participatory ecosystem that enables the coproduction of public services (Janssen & Estevez, 2013; O'Reilly, 2011). Digital platforms increase data intelligence, accessibility, and reconfigurability to fundamentally reshape how public services are designed, produced, and delivered (Bharadwaj et al., 2013). Public services are becoming intelligent, integrative, and citizen-centric. On the one hand, governments on a digital platform journey need a comprehensive understanding of the associated platform coordination changes. On the other hand, introducing digital platforms implies the transformation of governments from closed and hierarchical relationships into open, flat, and ecosystem-like relationships (Cordella & Paletti, 2019). Digital platforms accompany a new way of collaboration implemented with cross-agency data and knowledge sharing, given the need for coordination for efficiency and flexibility (Gong, Yang, & Shi, 2020). Addressing these challenges requires proper coordination configuration for collaboration among government agencies.

In general, coordination refers to integrating or linking different parts of organizations together to accomplish a collective set of tasks (Van de Ven, Delbecq, & Koenig, 1976). Conventional coordination mechanisms for cross-agency collaboration are usually based on "traditional hierarchical government control through authoritative allocation of values to society" (Lange et al., 2013, p. 408). Digital platforms often trigger changes in how organizational activities are aligned and render conventional coordination mechanisms obsolete (Gkeredakis & Constantinides, 2019). However, studies in the public sector predominantly focus on the benefits or strategies of adopting digital platforms (e.g., Brown et al., 2017; Cordella & Paletti, 2019; Janssen & Estevez, 2013). Little is known about how the rise of different digital government platforms reconfigures coordination mechanisms. To address this knowledge gap, we developed a theoretical framework for scoping the features of digital platform coordination

and conducted a demonstrative case study to test the creation of coordination mechanisms for collaborative platforms.

The chapter is structured as follows. The next section briefly discusses the background of digital platforms, digital coordination, and research streams on digital government platforms. The third section conceptualizes the theories for digital government platform coordination. The fourth section describes the research method. The fifth section presents the findings of the case study. In the sixth section, we discuss the implications of our study. The final section concludes the chapter.

CONCEPTS OF DIGITAL PLATFORMS

Our discussion begins with a brief introduction to relevant digital platform concepts to provide the basis for further discussion on digital coordination and digital government platforms. Although consensus has not been reached on the definition of platforms, many scholars—both in the information systems and digital government domains—adopt the definitions of Gawer and Cusumano (2014), in which platforms are classified into three predominant types: internal platforms, supply chain platforms, and industry platforms (Brown et al., 2017; Cordella & Paletti, 2019; Kapoor et al., 2021). In this classification, internal platforms refer to a set of assets organized in a common structure from which an enterprise can efficiently develop and produce a stream of derivative products, while industry platforms are products, services, or technologies that act as a foundation upon which external innovators are organized as an innovative business ecosystem (Gawer & Cusumano, 2014). Supply chain platforms coordinate external suppliers around an assembler to replicate the benefits of internal platforms across interfaces among different organizations (Gawer, 2014). Similar to many manufacturing supply chains, a supply chain platform coordinates a set of firms that follow specific guidelines to supply intermediate products or components to the platform owner for assembling final products. Typical industry platforms are Windows and iOS. In comparison with supply chain platforms, the firms developing complementary innovations for an industry platform, such as applications for Windows or the Apple App Store, do not necessarily buy from or sell to each other (Gawer & Cusumano, 2014). Compared with other platform conceptualizations that consider a wide spectrum of platform research streams (e.g., Thomas, Autio, & Gann, 2014), this conceptualization regards the platform as the organizational structure that carries organizational resources and capabilities to enable the rapid recombination of these to create flexibility. It takes a transformational perspective of "platform organization" (Ciborra, 1996) in restructuring new *organizational forms* to respond to emerging opportunities and challenges.

This classification also implies boundary-based scoping of digital platforms. The boundary of a digital platform concerns the context within which the platform exists and evolves; in particular, the organizational and technical interfaces that the platform relies upon in innovation (Jin & Robey, 2008). The dynamics of boundaries reflect the degree of openness, which affects the participation of external actors and the incentive to innovate (Boudreau, 2010). In general, *openness* refers to the easing of restrictions on the use and development of technology. For digital platforms, openness is not only related to technologies but also to organizational arrangements such as entrance and exit rules (de Reuver et al., 2018). When a platform's rules make it easier for more participants to join, it is more likely to make desirable innovations. At the same time, the larger the number and heterogeneity of participants joining a

digital platform, the more challenging coordination and completion of specific tasks become (Kretschmer et al., 2022).

The concept of digital platforms can be viewed from both a technical and sociotechnical perspective (de Reuver et al., 2018; Kapoor et al., 2021). The technical concept of digital platforms emphasizes that the technical design of platforms matters for their ability to evolve and produce innovation (Rolland, Mathiassen, & Rai, 2018). This concept has been elaborated into a layered *modular architecture* that involves varying arrangements of devices, networks, services, and content created by digital technologies (Yoo, Henfridsson, & Lyytinen, 2010). With a modular architecture, a platform constitutes an enduring core that permits complementary modules to be easily added, combined, or modified (Baldwin & Woodard, 2009). In contrast, a sociotechnical perspective builds on the idea that work systems can be understood only when the social aspects (e.g., the organization, working processes, and roles) and technical aspects (e.g., the physical infrastructure, tools, and technologies) are considered in conjunction and treated as interdependent elements of a complex system (Hughes et al., 2017).

The creation of digital platforms involves the need to capture generativity. The concept of *generativity* refers to the capability of digital platforms to allow for the recombination of elements for assembly, extension, and redistribution of functionality (Nambisan, 2017; Warner & Wäger, 2019; Yoo et al., 2010). This generativity view assumes that digital resources and their combinations with social resources will result in new innovation possibilities and value creation (Jarvenpaa & Standaert, 2018). At the same time, such innovations and value creation can also be reflected by extending and repurposing existing digital infrastructure to produce new digital products, services, processes, and business models (Brown et al., 2017). The degree of generativity operates and affects participants' contributions, indicating the distinct nature of coordination and organizing logic in digital platforms compared with other organizational forms, such as hierarchical bureaucracy (Cennamo & Santaló, 2019).

Table 8.1 summarizes the general features of digital platforms. Our basic assumption in this study is that the different configurations of these features—in line with contextual requirements—(re)shape the coordination mechanism of a digital platform. Mechanisms in digital

Table 8.1 General features of digital platforms

Features	Description	Representative references
Openness	Technical and organizational arrangements reflect the easing of restrictions on the use and development of platform resources.	Boudreau (2010) and Ghazawneh and Henfridsson (2013)
Modularity	An architectural and technological property that allows complementary and independent modules of the platform to be easily added, combined, or modified.	Baldwin and Woodard (2009) and Tiwana, Konsynski, and Bush (2010)
Generativity	The capability of platforms to allow for the recombination of technical and social resources and the creation, extension, and redistribution of digital functionality, products, services, processes, and business models.	Yoo et al. (2010), Jarvenpaa and Standaert (2018), and Nambisan (2017)

Source: Authors' own.

platforms are characterized by contingent causality, as the implementation of a mechanism may lead to one outcome in a particular context, but another in a different context (Henfridsson & Bygstad, 2013). Such a configurational perspective is the basis for the analysis of the causal paths that explain how, in certain contexts, a coordination mechanism may lead to the successful evolution of digital platforms.

DIGITAL GOVERNMENT PLATFORM COORDINATION

Theoretical Foundation

Initiatives for digital government platforms are struggling with the application of platform theory from research on commercial digital platforms because of the differences in scope and focus (Bonina & Eaton, 2020; Brown et al., 2017). In comparison, government platforms and commercial platforms are different in value orientations toward openness and restrictions in effect (Boudreau, 2010; Gong & Li, 2023). Commercial platforms have an economic interest and often leverage openness through financial instruments, such as pricing. In contrast, government platforms emphasize accountability, authority, transparency, citizen satisfaction, and public value (Janssen & Estevez, 2013). These differences indicate the need to operationalize platform theory in the context of digital government. Existing insights on commercial digital platforms may not be directly applicable to digital government platforms (Schreieck, Wiesche, & Krcmar, 2017). In conducting digital government platform research, Brown et al. (2017) suggest informing "the consideration and evaluation of platform thinking in relation to the specific complexity of government, and to avoid the wholesale import of private sector ideas" (p. 171). In this section, we create a typology of government platforms based on the current platform theory derived from commercial platforms.

Gawer (2014) suggests that underlying the different types of platforms, the form of digital platforms may be supported by an important conceptual underpinning that offers intuition from an organizational lens to develop a framework for platforms. By bridging information systems and economic literature in her framework, distinguishing among internal, supply chain, and industry platforms, she notes that such a framework should present platforms with different organizational forms and highlight their essential features, including openness, architecture, and generativity. An underlying assumption in the platform theory of Gawer (2014) is that the types of platforms are not a discrete set of rigidly delineated configurations, but an organizational continuum with possible evolutionary pathways between these configurations. This implies opportunities to gain insights from the transformation and evolution of digital platforms from one type to another.

Theoretical frameworks that deeply ground commercial platform literature may be limited to analyzing government platforms. Scholars in digital government research also highlight the importance of understanding the roles of platform coordination in governments and of empirically examining the effects (Brown et al., 2017; Mukhopadhyay, Bouwman, & Jaiswal, 2019). This calls for a theoretical framework that distinguishes between platform types and associated organizing forms and features in the context of digital government platforms. Table 8.2 presents such a framework for understanding coordination mechanisms in digital government platforms, based on the platform typology of Gawer (2014) and the analysis of the various literature on platforms in the domains of information systems and digital government.

Table 8.2 A theoretical framework for digital government platform coordination

General platform types in Gawer (2014)	Internal platforms	Supply-chain platforms	Industry platforms
Organizational forms of digital government platforms in correspondence	Internal platforms: routine information systems with modular architecture and process-oriented design	Collaborative platforms: enable collaboration among government agencies with the joined-up mode of service creation	Open government platforms: such as OGD platforms, citizen-engagement platforms, and public transportation service platforms
Accountability and suitable types of public services	Services with high accountability over the final outcome, such as policing services	Services can be facilitated by shared accountability among public agencies, such as one-stop shop administrative services	Services with low accountability and limited administrative resources, such as public transportation services
Openness and transparency	Closed: platform development merely relies on the platform owner's resources and capabilities Low transparency: functioning and data are not visible to other agencies	Semi-open: platform development relies on resources and capabilities from the platform owner and the aligned agencies Medium transparency: providing insight into functioning and data to agencies in collaboration	Open: everyone who obeys the platform's basic rules can contribute to the platform's development High transparency: open data are highly visible to all participants
Modular architecture	The architecture enables the platform owner to have full decision rights on modules and how they interact	The architecture supports decision rights partitioning between the platform owner and external agencies	The architecture supports decision rights partitioning between the platform owner and external agencies
Generativity and control	High level of control and role-based	Medium level of control and data-driven	Low level of control and data-driven

Source: Authors' own.

Organizational Forms and Service Accountability

The first aspect in addressing digital platform coordination is the organizational form, which can be considered a manifestation of coordination configuration. The close relationship

between organizational forms and coordination may be illustrated in a fundamental definition of organization given by Barnard (1938); that is, an organization is a "system of coordinating activities of two or more persons" (p. 73). Classical organization theory emphasizes the influence of organizational forms and structures on the design and implementation of coordination mechanisms (Malone & Crowston, 1994). Gawer (2014) regards organizational form as an endogenous variable for analyzing digital platforms. When a structure does not support technology operations and use, or the structure does not take advantage of the capabilities of the technology, these misalignments will trigger the need for transformation and reform of platform organization. From a sociotechnical perspective, such organizational changes are recognized as platform evolution through the processes of development, adoption, adaptation, and use of technologies in social settings. The analogy with "ecosystems" is used to signify complex and heterogeneous systems of institutions, groups of actors, infrastructure, and data, which interact, adapt, and grow in the context of digital government platforms (Bonina & Eaton, 2020). The ecosystem metaphor, with its emphasis on evolution and self-organization among actors and processes, would be a useful heuristic for approaching the design of effective digital government platform coordination (Dawes, Vidiasova, & Parkhimovich, 2016).

To bridge the platform theory from the commercial context to the digital government context, Cordella and Paletti (2019) align the above classification with government platforms, corresponding through the three types of platforms. The authors provide an electronic medical healthcare system at a hospital as an example of an internal platform in the public sector that provides a common infrastructure to exchange medical data within departments in the same hospital. Internal platforms configure the service creation processes by recombining the subunits, resources, and competencies that are internal to the organization. In this sense, many governments' routine information systems with modular architecture and process-oriented design can be considered internal platforms. Platform coordination here is based on its process design, organizational hierarchy, and functionality with high-level and centralized control (Thomas et al., 2014). Considering the need for very high accountability and specificity, some public services, such as policing services, are also suitable for internal platforms.

Collaborative platforms replicate the shared infrastructure and benefits of internal platforms across different government agencies that need to share data and collaborate in public service delivery (Cordella & Paletti, 2019). Similar to internal platforms, the benefit of collaborative platforms is also to improve efficiency and reduce costs by systematically reusing modular components. Furthermore, the platform owner can recombine capabilities internally within the organization, thus aligning the organization's routines, and through the wider network of collaborative organizations (Thomas et al., 2014). Specific guidelines coordinate these selected organizations with a coherent and integrative strategic orientation to supply intermediate components to the platform owner. Although internal platforms also enable coordination, to avoid confusion, we distinguish internal and collaborative platforms by whether the coordination activities and business processes cross organizational boundaries. In this sense, collaborative platforms facilitate collaboration among government agencies and support the joined-up mode of service production (Gong & Li, 2023). Many one-stop-shop administrative services and integrative services created by collaboration among multiple agencies are suitable for this type of platform. This also results in government agencies, in collaboration with service production and provision, sharing accountability toward citizens (Wang, Medaglia, & Zheng, 2018).

Open government platforms are a set of organizational structures and infrastructures that enable third parties (i.e., companies or citizens) to coproduce public services, such as public transport services. A key distinction between collaborative and open government platforms is that the participants of open government platforms are not intentionally selected or contracted by the platform owner but are attracted and incentivized by the opportunities created by the platform's core offerings, and they use the platform for their purposes. Coordination here is usually implemented by the platform owner's rules for controlling the quality of complementors and the services they have developed. Examples of these rules include those contained within licensing agreement contracts (Ghazawneh & Henfridsson, 2013). Open government platforms are suitable for providing public services that do not require strict administrative and procedural accountability, such as the provision of information about the schedule and status of a public bus (Cordella & Paletti, 2019). The concept of open government platforms often refers to the emerging research on the government as a platform (GaaP) (O'Reilly, 2011). The GaaP coordinates platform participants' activities in service production and provision by providing a set of open tools, rules, and service standards (Cordella & Paletti, 2019).

Openness and Transparency

The second aspect of addressing platform coordination is the level of openness. A platform ecosystem can be closed or open, depending on the platform owner's agency in charge of a specific domain and the production of specific public services (Cordella & Paletti, 2019). A platform becomes closed when restrictions are placed on participation in its development (Eisenmann, Parker, & Van Alstyne, 2009). The internal platform is closed because platform development is based only on internal capabilities and the sources of innovation of the platform owner's organization. Many digital government platforms providing routine public services to citizens or supporting cross-agency data exchanges are still categorized as internal and closed platforms because those citizens or actors from other agencies are merely users of the platform and will not directly contribute to the development of the platform. A platform becomes semi-open when its restrictions are relaxed on the supply side of the platform (Eisenmann et al., 2009). Supply chain platforms are semi-open and allow for development and innovation between the platform owner and its pool of suppliers (Gawer, 2014). Accordingly, collaborative platforms with semi-openness allow the platform owner to assemble capabilities and resources from other government agencies in alignment with the development of platform components. This situation often occurs with national and local government agencies that share their knowledge and collaborate in service production (Chen et al., 2019; Cordella & Paletti, 2019). Collaboration does not casually happen, but the agencies in collaboration have resources and capabilities that complement each other and share accountability and public service provision. Industry platforms are open with no restrictions on participation in development and use on either side of the platform (Eisenmann et al., 2009). Similarly, open government platforms, such as OGD platforms, allow everyone (including public and private actors) who obey the platform's basic rules to create services according to their interests.

Platform owners can adopt different levels of openness between completely closed and open to configure their coordination mechanisms. A higher level of openness could make a government platform more transparent by providing insight into its functioning and government data, and at the same time, the government exerts less intervention (Janssen & Estevez, 2013). If a platform is too closed, it keeps potentially desirable participants out; if it is too

open, then there can be other value-destroying effects, such as poor quality contributions or misbehavior by some participants (Van Alstyne, Parker, & Choudary, 2016).

Modular Architecture

Platform architecture leverages the development of shared assets, designs, and standards that can be recombined to facilitate coordination within and between agencies sharing a given platform (Thomas et al., 2014). With a large degree of consensus, modular architecture is an essential feature of digital platforms of any type (Constantinides, Henfridsson, & Parker, 2018; Gawer & Cusumano, 2014). Platform architecture and modularity make a distinction between the platform core, consisting of tightly coupled components, and loosely coupled peripheral components (Constantinides et al., 2018). At the same time, design rules coordinate the interoperation among modules or between modules and the platform infrastructure (Cordella & Paletti, 2019). Kapoor et al. (2021) summarize these understandings, suggesting that platforms possess a small but stable, set of core components for establishing foundational standards, and a larger set of peripheral components that are essential to enable flexibility. Across different types of platforms, there is a fundamental trade-off couched in terms of stability and flexibility. If more modules interact with the complements, then there exists a higher interdependence among such modules, resulting in higher stability but lower flexibility (Cennamo & Santaló, 2019). As the platform core is managed by the platform owner, while the periphery is mainly contributed by complementors, it also shares the responsibility for service delivery and managing the complexity of the services involved among the various partners (Mukhopadhyay et al., 2019).

Generativity and Control

Literature on commercial digital platforms largely accounts for platforms' success based on the platforms' generative capabilities grounded in modular architectures and flexibility (e.g., Eaton et al., 2015; Ghazawneh & Henfridsson, 2013). At the same time, scholars also indicate the need to balance the paradoxical tension between generativity and control in the platform (e.g., Constantinides et al., 2018; Yoo et al., 2010). There is a need for digital platforms to remain stable to maintain a solid foundation for further enrollment, and at the same time, to be sufficiently flexible to support growth and evolution (Tilson, Lyytinen, & Sørensen, 2010). Implementing the controls necessary to achieve these dual goals of being simultaneously stable and evolving is very much aligned with the layered modular architecture of digital platforms (Constantinides et al., 2018).

Little is known about how the tension between generativity and control unfolds and affects the evolution of the digital government platform (Gong & Li, 2023). The levels of control associated with public services differ by hierarchical levels and accountability (e.g., national or local) and the importance of services (e.g., issuing a passport or providing a public bus schedule) (Cordella & Paletti, 2019). This reflects that the configuration of control in digital government platforms is highly contextualized. From a technical perspective, internal platforms for serious public services often employ a centralized and role-based control paradigm. Currently, role-based control is still the most widely used control paradigm in which functions of modules may be accessed by users fulfilling a specific role within the business process of the organization (Mundbrod & Reichert, 2019). Collaborative and open government platforms

that facilitate the creation of public services with external parties embed a medium or low level of control to allow an increase in generativity (Cordella & Paletti, 2019). The control mechanisms in these platforms are often data-centric. This is especially the case with OGD platforms, in which the platform concerns the provision of modules as datasets rather than as software functionality to external parties (Bonina & Eaton, 2020). Data-centric control emphasizes monitoring, optimization, and organizational responsiveness to facilitate value cocreation (Cennamo & Santaló, 2019). Tilson et al. (2010) suggest observing and understanding changes in control paradigms by the change in control points. Janssen et al. (2020) show that government can consider the setting of control points at an organizational or system level and a data level. Furthermore, a hybrid control strategy can be created by applying differentiated solutions at different levels. For example, combining high control in platform organization involvement with low control in the usage of technology may result in better collaboration with trusted and serious agencies, avoid overcrowding of partners, and reduce integration efforts (Mukhopadhyay et al., 2019).

RESEARCH METHOD

Research Context

This research presents a demonstrative case study that was conducted in the State Taxation Administration (STA) of the People's Republic of China. The STA is responsible for planning and developing the national platform of tax administration, which provides various tax services. This national platform is developed and maintained in a long-term project format. It is currently in the third stage, called the Golden Tax Project III (GTP III). Since October 2016, the GTP III platform has been online to serve nationwide tax administration. The GTP III platform is a huge and complex system that supports the daily work of more than 700,000 taxation staff throughout the country, serving tens of millions of enterprise taxpayers and hundreds of millions of natural person taxpayers. Through its cloud infrastructure, the GTP III platform has centralized the storage and management of data from all local tax administrative divisions since the beginning of 2019. The next step in the STA's digital transformation agenda is to enable standardized, integrative, and taxpayer-centric tax services through innovative use of the data. Given the large scale and high complexity of the platform, coordinating various local agencies under different hierarchical levels of administrative divisions and tax categories for integrative service production and delivery is a great challenge. The STA would like to explore the value of the data while using data from various local tax services under control.

Data Collection

This chapter presents the findings of our case study from November 2018 to December 2020. During this case study, we observed the development of a collaborative platform for service innovation. To understand the service production approach in the GTP III platform, 16 documents, including the system requirements, data architecture, and service form design documents, were collected. Thereafter, five interviews and two workshops with tax experts from

the GTP III department and software experts from their contracted vendor company were conducted.

FINDINGS

Challenges

The original platform was designed with "infrastructure thinking" to support the individual local agency with technical infrastructure to develop its own datasets, business processes, and digital forms for tax service delivery. The platform organization and its coordination followed the taxation administrative divisions in a hierarchical structure. The system was a shared infrastructure supporting many internal platforms in which local agencies developed tax services with their own data sources and expertise. Although the GTP III platform centralized data storage at the beginning of 2019, the platform owner and many local agencies still suffer from the data silos that the separate local agencies created under different hierarchical levels of administrative divisions and tax categories. The coordination for internal platforms cannot support cross-agency collaboration, in which high-quality data are expected to be shared among agencies to enable taxpayer-centric service design and production. The GTP III platform needs new coordination mechanisms to enable flexibility in creating integrative services and ensuring accountability in collaboration at the same time.

The GTP III platform manages a large volume of tax data from different sources. The data provided by local agencies vary in definitions and statistical scopes, leading to data silo problems. Data silos cannot be solved simply by process reengineering with authorization for cross-agency data access and sharing, because some data objects with the same nomenclature can have different semantic meanings, while others have the same semantic meaning with different nomenclatures. Furthermore, a few data objects are consistent in both nomenclatures and semantic meanings, but they are generated by applying different statistical methods. Solving this problem demands data quality and interoperability beyond the unified processes, forms, and rules for nomenclature. Finally, coordination is needed to ensure that tax data are produced consistently.

The data silos do not just exist in different levels of administrative divisions but can also appear in different tax categories. A large amount of data was accumulated by separate departments that were established to implement tax services under different tax categories. The GTP III department expects to reuse data to avoid repeating input from taxpayers. This requirement is also challenging as much of the data were provided with coarse granularity and are difficult to reuse. To enable data reusability, data objects should be divided into data items with fine granularity and a proper coordination mechanism to identify and connect them.

Centralization in data storage increases the amount of accessible data but also makes it difficult to find the required data and understand the semantic connections among data. During workshops and interviews, both tax staff and analysts admitted to the problem of data awareness: "sometimes we are not aware whether the GTP III platform has the data that we need to create a new tax service. This results in redundant input, difficulty in maintaining data relationships, and the aggravation of data silos in the long run." At the same time, the GTP III department had difficulty tracking the usage of data in each tax service because there are too many tax forms, and checking each form via current user interfaces manually would be very

time-consuming. To ensure data awareness and the maintainability of data relationships, users need an easy-to-use data index that can manage and indicate the relationships among data and between data and forms.

Developing a Collaborative Platform

To address the above challenges, a pilot platform was developed to provide new coordination tools and interfaces. The first one is an architectural solution that helps restructure the modular platform architecture. This architectural design aims to enable data modularity and to develop a stable core of data modules. Corresponding to this architectural design, tax experts from the GTP III department were involved in developing a data architecture. The most important part of this data architecture design is a formal enterprise data model that contains comprehensive data and metadata definitions, logical structures of data items (data mapping), and the data use relationships with tax categories and business units. This enterprise data model worked as a data standard for building various data models in the later stages. It defines the basic data relationships shared by the data modules and the basic rules to define how they interoperate. As the unified data standard is provided to all the agencies, it creates the foundation of platform openness.

The second one focused on data modeling and management functions. These functions address the data awareness problem by providing data modeling tools with data visualization to present data relationships. In this development, the toughest work was to clean the tax data and model the data relationships among data items by following the provided enterprise data model and improving it iteratively. A tax expert reflected on the necessity for this work, stating, "only by reviewing all data items that constitute the data objects, the data objects with the same semantics but from different sources could be checked and compared." In this way, the data standard can be compiled, and data objects from different sources with the same semantics can coalesce. Local agencies that want to use these data objects to build tax services must follow the relevant data relationships and constraints. At the same time, data items contained in these data objects can be visualized to offer data awareness. These data models also enable data access control. The use of extra data items that are not compliant with the data relationship would be constrained. Although it was time-consuming to build many data models, common data items can be linked and used in different data objects. This increased data reusability, consequently reducing redundancy and the efforts for data maintenance. Since the data models are visible to all agencies, the platform transparency is increased.

The third component is the interface for service design that provides service developers (local agencies) with a design studio to create interactable forms for taxpayers. Once the user selects a certain data object, the relevant data items are listed for further selection. If any necessary data item is missing, or a data item is no longer needed in a data object, the developer may play the role of the contributor and suggest adding, changing, or removing the data item. In addition to service production, the system also provides a visualization of the data items used in a tax form for data auditing. In this way, the platform's generativity is provided to enable the development and improvement of data models and further support the development of various tax services.

These new digital coordination tools and interfaces have facilitated flexibility and service production efficiency in the STA. In the past, each taxation department focused on its own services and tax forms for a specific tax category. Little consideration was given to reusing data

across different tax categories, and forms were provided for single tax reporting. By using the new coordination tools and interfaces, the data objects and items used in the tax forms created by other departments are visible to all service designers. This improves their awareness of whether the same data are used by other tax forms, resulting in cooperation in designing comprehensive forms for multiple tax categories. This also enables the sharing of knowledge among people and enhances the accessibility of business knowledge in tax form (re)design. A tax expert working in the GTP III department for business operations commented on this exercise that "it increased very much the efficiency in screening, comparing, and correlating between data items and forms, and consequently enhanced the efficiency in business analysis and collaboration in service production." The new coordination configuration reduces redundant functions and duplicate work, as well as facilitates collaboration among government agencies.

Transforming to a Collaborative Platform

A collaborative platform needs more openness than an internal platform. While the development of new platform components presents how technical tools and interfaces support openness, the new configuration of coordination also requires the STA to reshape the corresponding organizational form to access external resources and capabilities for the development of the GTP III platform. The large volume of data accumulated in the GTP III platform and different tax categories requires specific expertise for developing and maintaining data models. Rather than relying only on the GTP III department's own resources to develop all data models, the STA opened data modeling functionality and interfaces to tax experts from various local agencies to facilitate the data modeling. A tax expert from the GTP III department explained this new organizational form in which "it was not possible for the team to manage the modeling of such a large number of data models. Experts from local agencies joining as contributors speeded up the modeling and increased the quality of models and the tax staff's acceptance of using those data models, as they participated in the modeling." The new organizational form was not a top-down planned design by the STA, but a bottom-up emergence during the iterations of the platform and data model development. When an increasing number of local agencies participated in the development of data models, the organizational form of the GTP III platform evolved into a collaborative platform ecosystem. The role of local agencies can be either contributors or developers depending on whether they are building or improving data modules or using the data modules to develop tax services. Since the models and data logic are visible to both national and local agencies, the transparency of the platform increases along with openness.

A collaborative platform needs a modular architecture to balance the core and periphery. Given the data silo problems faced by the STA, modularity was considered not only with the software architecture but also with the data architecture of the GTP III platform. While the software architecture has been relatively stable since 2016, adding the data architecture results in the need for new software functions in the interface that allow data visualization and inference based on data relationships. The role of these semantic and data visualization technologies in this study is to implement new interface artifacts to coordinate between the core and the periphery. By implementing these instruments, the GTP III department could focus on supporting, authorizing, and monitoring the use of datasets and data models, leaving the creation of integrative services to the relevant collaborating local agencies. Flexible and

integrative tax services could emerge from self-organizing among local agencies in the collaborative platform ecosystem.

Coordination based on data relationships and accessibility is needed to balance generativity and control. Control mechanisms could be addressed on a technical level, for example, inside or between tax services, and on an organizational level, for example, the authority for an agency or cross-agency collaborations. At the technical level, the relationships among data items are managed by the given data models for certain data objects. At the organizational level, the STA can facilitate or constrain cross-agency collaboration by assigning or changing the accessibility of data objects to local agencies. In this way, the working scope of a local agency is defined by the data accessibility assigned to it. Data sharing among agencies can be achieved without many normal bilateral negotiations or the configuration of extra user roles and accounts to access data owned by the other side.

IMPLICATIONS

This case study provides three implications for government platform practitioners. Like application programming interfaces (APIs) that allow software developers to have their applications interact with the platform, unified data standards allow local agencies to understand the accessible data and connect their services and data models with the shared datasets. In this sense, data standards regulate data interoperation and enable openness. A collaborative platform requires transparent protocols, rules for the exchange of data, and conflict resolution. The first implication is, therefore, to provide data standards to address the need for platform openness and transparency. The standards regulate how data items within a data object are described, defined, and represented on the platform for sharing across agencies. These standards contribute to ensuring data quality and interoperability.

Modular architecture is an essential design feature of digital platforms that allows the platform to recombine modules for creating new products or services. The discussion of modularity in platform literature often focuses on the combinatorial nature of software modules, that is, autonomous software modules and sophisticated module interfaces (Nambisan et al., 2017). However, software modularity does not necessarily support or reflect the need for and effect of coordination in digital service provision (Gkeredakis & Constantinides, 2019). Considering that a digital government platform might deliver many services to citizens via unified digital channels, the creation and delivery of different services might rely on similar software functionality but vary in the content of services for different citizens. In comparison with many commercial platforms, a distinction of such government platforms is the provision of modules as datasets, rather than software functionality (Bonina & Eaton, 2020). The second implication, therefore, relates to structuring the core and the periphery concerning the sharing and reuse of datasets in digital government platforms. Based on the designed data modularity and the provision of an interface to interact with data modules, the platform allows agencies to both contribute to the development of data models and use the models in service production.

The paradoxical tension between generativity and control has been widely discussed in platform research (Constantinides et al., 2018; Yoo et al., 2010). While the control mechanism is often discussed in the context of very open platform ecosystems (open government platforms), little is known about the coordination configurations in semi-open platforms (collaborative platforms). Tilson et al. (2010) suggest taking the view of control points to understand

the change of control both in its levels and paradigm. Our study found that applying digital technologies to implement new platform coordination mechanisms may result in setting new control points. Proving data relationships may also facilitate data awareness by providing accessibility to the existing data models and, consequently, enabling generativity. In contrast, data accessibility constrains the use of data in service production. Digital technologies play a specific role in designing and implementing possible control points. The involvement of new digital technologies may result in changes in the control points and further influence the digital coordination configurations.

CONCLUSION

Implementing a proper coordination mechanism to improve cross-agency collaboration in public service production is a significant challenge for governments on a digital platform journey. To guide platform development, governments need to understand how the rise of different types of digital government platforms affects the scope of coordination. This practice often lacks theoretical support because platform theory, rooted in commercial platforms, has not considered the different scopes and focuses of digital government platforms. By reinterpreting platform theory in the context of digital government, we propose a theoretical framework spanning organizational forms and platform features for considering coordination configurations. This framework was tested by a case study in which the GTP III platform transformed from an internal platform to a collaborative platform. The case study demonstrates how the coordination mechanism for the collaborative platform was implemented to address the problems concerning data silos and lack of data awareness.

The findings indicate that the framework could be used to explain digital government platform transformations. This study also provides several lessons on digital coordination in government platforms. From a sociotechnical perspective, organizational forms, openness, modularity, and generativity are the general features to be addressed in coordination configurations. In the development of platform coordination mechanisms, three paradoxical tensions—openness and closeness, the core and the periphery (stability and flexibility), and generativity and control—should be considered when making design decisions. Digital government platform owners should define unified data standards, design data modularity and interfaces, and use data relationships and accessibility as control points to balance these paradoxical tensions. Finally, government platform owners should switch from "infrastructure thinking" to "platform thinking" to cultivate collaborative platform ecosystems that allow flexible and integrative public services to emerge from bottom-up collaboration among agencies.

Our study has some limitations that should be addressed in future research. We did not fully address the fuzziness and possibility of transformation among the types of platforms. In commercial platform theories, Gawer (2014) suggests possible evolutionary pathways among the three types of digital platforms. This study presents only one pathway in which the GTP III platform evolved from an internal platform to a collaborative platform. While we confirm the evolutionary view and fluidity among the types of digital government platforms, it also reflects, to some extent, the dynamics and fuzziness among the types. In the research on GaaP, Cordella and Paletti (2019) claim that a digital government platform may be a platform of platforms, where internal, supply chain, and industry platforms coexist and interact. This

fuzziness reflects the need for further development of theory and design knowledge to address the dynamics and multiplicity of modes of digital government platforms in the future.

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