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Understanding cross-sectoral innovations for urban water management through the lens of organizational ambidexterity

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ABSTRACT

Urban water systems worldwide need integrated, cross-sectoral innovations to anticipate developments like climate change and population growth. Development and implementation of such innovations is challenging due to the operational and sectoral mindset of organizations in which these innovations take place. This study uses the concept of ambidexterity to get a better understanding of how organizations responsible for urban water management deal with the tension between operation and the need for innovation. We focused on Amsterdam and Rotterdam, two Dutch cities that are global frontrunners in urban water management. Combining a desk study with 25 semi-structured interviews, we found four mechanisms to manage innovation and operation tensions: network, hierarchical, process and human-resource mechnanisms. Different from the literature on ambidexterity, our empirical findings show that the connection between operation and innovation is dominated by networks rather than by executives. Hierarchical mechanisms could be used to complement this, catalyzing innovation or formalizing it.

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1. Introduction

Urban areas are highly dependent on their urban water systems, providing essential services such as access to clean drinking water, public health protection and flood control. Global developments like climate change, population growth and resource limitations increasingly threaten the provision of these services: changing weather patterns, increasing anthropogenic activities, and depleting natural resources lead to environmental and public health issues and increase the risk of urban flooding (e.g. Lee et al. 2017; Miller and Hutchins 2017). The traditional approach to urban water management has aimed to address these issues using a sectoral approach – thus through (additional) urban water infrastructure. This has resulted in large-scale water systems that are based on linear models with a 'take-make-dispose' strategy, i.e. centralized water supply systems, sewer networks and large-scale wastewater treatment facilities (Wong and Brown 2009). It is becoming increasingly clear, however, that urban water systems need, rather than sectoral solutions, cross-sectoral solutions to adapt them to these global developments: they need solutions that extend to other urban systems like roads, green infrastructures (e.g. parks) and energy infrastructures (Hoek et al. 2017; Nieuwenhuis et al. 2021; Wan Rosely and Voulvoulis 2022). There are numerous examples of the benefits of such cross-sectoral solutions. Storm water solutions could contribute to values such as ecology, aesthetics and recreation (e.g. Gogate, Kalbar, and Raval 2017; Skrydstrup et al. 2020). Thermal energy could be recovered from wastewater, drinking water, ground water and surface water (van der Hoek et al. 2018). Energy, nutrients and water could be recovered from wastewater (Mo and Zhang 2013). Clearly, integrated solutions have the potential to increase the resilience and sustainability of urban water systems; i.e. to prepare them for future changes, and increase the efficiency in their use of energy, water and resources, while avoiding the production of waste.

We refer to such integrated innovations as urban water systems integration (UWSI). This is defined as 'the physical, social, and institutional interlinking of (parts of) the urban water system with other urban systems' (Nieuwenhuis et al. 2021). Urban Water Systems Integration involves integration that is based on, for instance, space, resources, infrastructures, data and planning. In Nieuwenhuis et al. (2021) we introduced a typology of urban water systems integration that distinguishes between geographical, physical, informational, and project-based forms. In practice, these forms of UWSI often occur simultaneously. For example, the implementation of climate adaptation measures typically requires spatial alignment with other urban infrastructures (*geographical UWSI*), and often takes place together with construction or rehabilitation works of other urban infrastructures (*project-based UWSI*).

Not only scientists, but also policy makers and politicians recognize the need for UWSI innovations to adapt urban water systems to global developments. Supranational governments such as the European Union have introduced water legislation to steer toward integrated planning, management, and operation of water systems. Examples include the Water Framework Directive (2000/60/EC), the Water Reuse Regulation (2020/741) and, recently, a proposed revision of the Urban Wastewater

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Treatment directive (1991/271/EEC). Such supranational laws put pressure on central governments and local organizations that are responsible for urban water management to develop and implement UWSI innovations in a timely manner to prepare for the future. The question is, however, how these organizations can put the challenge of an integrated approach to urban water management into practice; i.e. how these organizations can organize the development and implementation of UWSI innovations. On the one hand, the sectors involved in UWSI often have a strong operational orientation that challenges the development and implementation of innovation. In sectors such as water, transportation and energy, processes of construction and maintenance require an operational mindset, with precise, often linear, and long-term planning. The tolerance for failure in these sectors is typically low, as failures could lead to large social costs. It is clear that such an operational mindset is not conducive to innovation. On the other hand, innovation is needed, not only within sectors, but also across sectors. This will influence the operational processes of these sectors, as well as the boundaries between them: an innovation in one sector can have a major impact on the other sectors (Nieuwenhuis et al. 2021; Vollaers et al. 2021). Innovation thus requires a completely different mindset of organizations: innovation processes are non-linear, need flexibility, assume a high tolerance for failure, and may overhaul the operational practices of an organization. This means that there are two worlds: the world of operation and that of innovation. When organizing innovation, these two worlds require a balancing act between preventing that the operational mindset dominates so strongly that innovations get no room to develop, and preventing that the attention to innovations leads to distraction and serious disruption of the operation.

This article aims to provide insight into how organizations responsible for urban water management could perform this balancing act – after all, worldwide cities are challenged to develop and implement UWSI innovations to prepare urban water systems for the future, while also making sure that systems are properly maintained and operated. In this article, we use the theory on organizational ambidexterity to get a better understanding of this balancing act (Duncan 1976; O'Reilly and Tushman 2004). Ambidextrous organizations are organizations that balance exploration and exploitation activities – i.e. operation and innovation activities, respectively, which are the terms we use in this article. One way to achieve this balance is through creating organizationally distinct units, one for operation and one for innovation, which are tightly integrated at senior management level (O'Reilly and Tushman 2004). This article seeks to contribute to the theory on ambidexterity by exploring how the units of operation and innovation are connected, and the role of top management therein. The research question is: 'how do urban water management organizations manage the tension between innovation (i.e. initiatives to UWSI) and operation (i.e. day-to-day activities undertaken by the line organization)?'

To answer this question, we focused on Amsterdam and Rotterdam (the Netherlands) and looked at the key organizations in charge of urban water management in each city: Waternet and the Municipality of Rotterdam, respectively. We expect the cases to be a rich source of practical information on how UWSI innovations are organized, and that they could provide valuable lessons for other cities worldwide: the two cities are characterized in the literature as 'global frontrunners' in implementing an integrated approach (see e.g. den Exter, Lenhart, and Kern 2015; Koop et al. 2017; Mees et al. 2013). In addition, both organizations have started various cross-sectoral and cross-organizational initiatives such as programs and collaborations that co-exist alongside their regular organizational activities to adapt urban water governance to more integrated approaches; i.e. initiatives to UWSI. The analysis consisted of two steps. First, we identified the different initiatives to UWSI and empirically explored how these were used to develop UWSI. Second, we investigated how the initiatives to integration interacted with operational processes. In each city, we analyzed a diverse set of initiatives. Combining a desk study with semi-structured interviews, we looked at the types of the initiatives and the mechanisms that played a role in managing the interface between initiatives and the line organization.

The structure of this paper is as follows: Section 2 introduces the concept of ambidexterity in relation to this study. In Section 3, we outline our research approach and introduce the cases. Section 4 presents the results, which are subsequently discussed in Section 5. We conclude with the implications of our research and ideas for further research in Section 6.

2. Organizing UWSI innovations in parallel to line organizations: viewing through the lens of ambidexterity

In this article we use the concept of organizational ambidexterity to understand how innovations are organized in hierarchical organizations that are defined by strict procedures for operation. Ambidextrous organizations have the ability to both explore new opportunities, and at the same time exploit existing capabilities (Gibson and Birkinshaw 2004). The research on ambidexterity originates from organizational science (Duncan 1976; March 1991; Tushman and O'Reilly 1996) and has shown that both components, i.e. exploitation and exploration, or operation and innovation, are key to success of organizations: they allow adaption to a changing environment, while being aligned with the management of today's demands (Gibson and Birkinshaw 2004; O'Reilly and Tushman 2004). Finding the right balance between operation and innovation activities, however, could be challenging, due to the potential tension between both activities (March 1991; O'Reilly and Tushman 2004).

To deal with this tension, Tushman and O'Reilly 1996; 2004) suggested that organizations should segregate their innovation units from their operational units, giving the autonomy to the innovating units to develop their own processes, structures and cultures, while operational units could focus on ongoing operational processes. Leaders of the innovation units should be able to operate independently and have the willingness to challenge the status quo (O'Reilly and Tushman 2004). At the same time, however, both autonomous units should also be tightly integrated at the senior management level, with executives managing the tensions between innovation and operation, being fully committed to operating ambidextrously. They are responsible for maintaining an overall consistency, for example, through letting innovation managers report to

a single executive that manages the trade-offs and conflicts between both activities, as well as inviting innovation managers to executive team meetings (O'Reilly and Tushman 2004).

From the perspective of systems integration, the approach to ambidexterity has two potential strengths. First, it indicates how to deal with the tension between the line organization that is characterized by their fixed processes and procedures on the one hand, and the need for innovation which fundamentally challenges these processes, on the other hand. Second, it provides space for a variety of cross-sectoral innovations – from initiatives to innovation that have a more planned character, as well as those that follow a more emergent approach, resulting from bottom-up initiatives.

Since the publication of these first insights on ambidexterity (Duncan 1976; March 1991; Tushman and O'Reilly 1996), much research has been published that leads to a richer, and sometimes more nuanced, picture of the management of the tension between innovation and operation. We summarize these in four observations.

- *Contextual versus structural ambidexterity*. O'Reilly and Tushman translated ambidexterity mainly into the structure of an organization: they aim to solve the tension between exploration and exploitation through creating two autonomous subunits. This mode of ambidexterity is also referred to as *structural ambidexterity* (O'Reilly and Tushman 2004). An alternative is what Gibson and Birkinshaw (2004) called *contextual ambidexterity*. The idea is that rather than the structure of an organization promoting ambidexterity, the entire organizational context should be oriented towards it; i.e. that the systems and processes of an organization encourage ambidextrous behavior of individuals. Such a context means that each individual employee is aware of the tension between innovation and operation and can make its own choices in this respect. As ambidexterity is in the case of this contextual approach not achieved through physically separating operation and innovation units with individuals assigned to either, the separation between operators and innovators becomes a bit more blurred than in the structural approach.
- *Senior leadership versus leadership at all levels*. Within both the structural and contextual approach to ambidexterity, leadership plays a key role, yet at different hierarchical levels. The approach of O'Reilly and Tushman is underpinned by a top-down way of thinking: innovation and operation activities are organized separately, with senior management taking care of the connection between them (O'Reilly and Tushman 2004). From this perspective, supporting senior executives play a decisive role in creating an ambidextrous organization (Jansen et al. 2008). Later studies point to the importance of leadership at other organizational levels. Taylor and Helfat (2009), for example, found that the role of middle management was key to eventually implement innovation. Nemanich and Vera (2009) looked at transformational leadership of team managers.
- *Leadership versus networks*. Rather than leadership, there is a research stream that looks at the role of social relationships and networks to connect innovation and operation activities. Especially when many innovations are generated, with many potential applications, it is almost inconceivable that the bridge that only goes through leadership teams will lead to sufficient integration (see Brockner et al. 2015; Stadler, Rajwani, and Karaba 2014). The underlying idea is that network activities expose employees to different perspectives, providing them the opportunity to learn from each other, and that this contributes to ambidexterity (Brockner et al. 2015).
- *Internal networks versus external networks*. So far, the focus has been on a single organization and the ambidexterity of that organization. However, systems integration needs the involvement of multiple organizations. Until now, only few studies have been conducted that looked at this inter-organizational level, yet it is suggested that relationships across organizations is required for ambidexterity (see Brockner et al. 2015; Stadler, Rajwani, and Karaba 2014). Page (2021), for example, extended the concept of organizational ambidexterity to cross-sector collaborations, and showed how collaborations could link knowledge exploration and exploitation activities to create innovative solutions. In addition, Tiwana (2008) looked at alliance ambidexterity and found that in project alliances, strong ties were needed to integrate knowledge, while bridging ties contributed to generating new ideas. Ambidexterity is thus no longer a matter of a single organization, but also comes about in inter-organizational partnerships.

While most of these observations were conducted at private firms, the concept of ambidexterity is also highly relevant for public organizations (e.g. Boukamel and Emery 2017; Cannaerts, Segers, and Warsen 2020). Public organizations are under constant pressure to operate their systems in an efficient way and to produce more value for their citizens, while they also must be innovative to overcome emerging sustainability challenges. Several studies have successfully applied the concept of ambidexterity to public service organizations (e.g. Gieske, Duijn, and van Buuren 2020; Matheus and Janssen 2016). Overall, research has identified fairly similar antecedents of ambidexterity for public organizations and private firms (Page et al. 2021). Commonly mentioned differences are the influence of politics and the lack of competitive pressure in public organizations (Boukamel and Emery 2017; Choi and Chandler 2015). Whereas political pressure may induce a conservative response from risk-averse public managers, it could also require ambidexterity instead, such as Page et al. (2021) found in the case of political mandates. This shows that the concept of ambidexterity is potentially fruitful to get a better understanding of how organizations responsible for urban water management deal with the tension between innovation and operation.

3. Method

This study used an exploratory, multiple case-study design. We focused on two largest cities in the Netherlands: Amsterdam and Rotterdam.

Table 1. Key urban water management actors in the Netherlands, their responsibilities, and the responsible parties in Rotterdam and Amsterdam. Waternet (Amsterdam) is a water cycle organization, i.e. it is a drinking water company, and it is also the executive agency of the municipality and the water board.

Urban water management actors	Main responsibilities ('water tasks')	Responsible organization in Rotterdam	Responsible organization in Amsterdam
Municipalities	Collection and transport of wastewater, and the management of storm water and groundwater in public space (residents and businesses carry the responsibility for their own properties).	Municipality of Rotterdam	Waternet (on behalf of the municipality of Amsterdam)
District water boards	Control of polder water levels and flood defenses, management of the quantity and quality of surface water, as well as the treatment of wastewater.	Hoogheemraadschap van Schieland en de Krimpenerwaard; Waterschap Hollandse Delta; Hoogheemraadschap van Delfland	Waternet (on behalf of Waterschap Amstel, Gooi en Vecht)
Drinking water companies	Production and distribution of drinking water, including the operation and maintenance of the infrastructure required for this purpose.	Evides	Waternet

3.1. Case study description

Amsterdam and Rotterdam are of comparable size (872.757 and 651.157 inhabitants, respectively (Statistics Netherlands 2020), and face similar challenging local urban water systems conditions: i.e. high ground water levels, poor soil conditions, located in delta areas, and vulnerable for both river flooding and inundation due to rainfall runoff. Since their establishment, both cities have dealt with urban water issues. The two cases have thus much in common; however, they differ in the way they have organized their urban water management:

In the Netherlands, responsibility for urban water systems (i.e. surface water, groundwater, storm water, drinking water and wastewater) lies primarily with municipalities, district water boards[1] and drinking water companies. Table 1 provides an overview of the responsibilities of the urban water management organizations, as well as the executing organizations in Rotterdam and Amsterdam.

For Rotterdam, we only included UWSI initiatives of the municipality, which is the key organization in charge of urban water management. Rotterdam lies in the management areas of three different waterboards (Hoogheemraadschap van Schieland en de Krimpenerwaard, Hollandse Delta, and Hoogheemraadschap van Delfland). To manage and coordinate the activities of the municipality and the different water boards, the organizations initiated the Rotterdam wastewater cycle collaboration in 2013 (RoSA, or Rotterdamse Samenwerking in de Afvalwaterketen, in Dutch).

For Amsterdam, we focused on the initiatives of Waternet and those of the municipality if Waternet had a key role in them. Waternet is the executive organization of the municipality of Amsterdam and that of the water board Amstel, Gooi and Vecht (AGV). Waternet takes care of the 'water tasks' of both these organizations (see Table 1 for a description of these water tasks), but is also in charge of drinking water supply and the operation of many bridges and sluices in Amsterdam (Municipality of Amsterdam 2016). As such, it is the only water company in the Netherlands that covers the whole water cycle.

3.2. Data collection

The data collection consisted of two steps. As a first step, we identified the organizational structure of the Amsterdam and Rotterdam urban water organizations and their initiatives to integration related to the 'municipal water tasks' (see Table 1). Secondly, we analyzed a set of initiatives in more depth. We defined initiatives as ideas with an organized structure that were characterized by organized activities addressing urban water sustainability issues such as climate adaptation or circularity. The initiatives could be organized top-down, taking a planned approach, or have developed in a more emergent way. Based on their organization and approach, we inductively differentiated between four types of initiatives: programs, movements, collaborations and line-based initiatives. The characteristics of each of the types are provided in the results section (Section 4.1).

For the first step of data collection, we conducted six exploratory telephone interviews with urban water policy practitioners working at a strategic position at one of the municipalities or at Waternet in August and September 2020. Due to COVID-19 restrictions, the interviews for this study were not conducted face to face. All interviews were conducted in Dutch. We asked the interviewees about the organizational structure and ongoing initiatives to UWSI. This resulted in an initial list of 7 initiatives in Rotterdam and 9 in Amsterdam. We further expanded this list by a desk study. We collected general policy and strategy documents about urban water management and documents about initiatives that focused on an integrated approach to urban water management. This resulted in a final list of 18 and 16 initiatives for Rotterdam and Amsterdam, respectively. Based on policy documents, legislation, internal and industry reports, and scientific literature we collected key-information on the initiatives, such as their goals, ambitions, and drivers. We subsequently mapped the initiatives, categorizing them by the following urban water management themes: asset management, climate adaptation and resource recovery.[2] We used this subdivision as it allowed to effectively map the approach to urban water management for both cities. In addition, it very well represented the themes in the urban water world, and was in line with the integrated approaches to urban water management that can be found in the literature (Nieuwenhuis et al. 2021). We validated the list of initiatives in our next research step. We asked the interviewees whether they had any suggestions for initiatives that we might have overlooked. This did not result in any new initiatives.

For the second step of data collection, we selected 8 initiatives for each city and conducted semi-structured interviews to

Table 2. Overview of the selected Rotterdam UWSI initiatives.

Initiative	Type of initiative	Urban water management theme	Aim
Rotterdam Reyeroord+	Program	Asset management, climate adaptation	Changing current asset management practices: involving inhabitants and using system renovation as the start of a transition.
Rotterdam Multifunctional roofs	Program	Climate adaptation	Creating multifunctional roofs and contributing to sustainability.
Rotterdam Strat. asset management	Program (line-based initiative)	Asset management	Implementing uniform asset management practices and the joint replacement of urban infrastructures.
Rotterdam Next SB-SO	Line-based initiative	Asset management	Changing current approaches of the departments of City management and City renewal.
Water Sensitive Rotterdam (Club of 36)	Movement	Climate adaptation	Implementing climate adaptation measures on a neighbourhood level through linking urban professionals, residents and civil servants with eachother.
Rotterdam Weerwoord	Program	Climate adaptation	Making Rotterdam climate-proof through a citywide and neighbourhood-specific approach.
Rosa Consortium	Collaboration	Resource recovery	Making the Rotterdam urban water cycle climate-proof, circular and effective.
Rotterdam Circularity	Program	Resource recovery	Closing material cycles through increasing circular-thinking and facilitating a circular economy.

analyze them in more depth. We decided to focus on interviews rather than observations, as the initiatives typically spanned periods of years. Observations were therefore considered not feasible. Aiming to provide a rich base of empirical knowledge, we selected initiatives that varied both in type (programs, collaborations, movements and line-based initiatives, see Section 4.1 for more information on these types) and in theme (asset management, climate adaptation and resource recovery). See Tables 2 and 3 for an overview of the selected initiatives.

In total, 25 video-conferencing interviews were conducted with 27 persons, in the period from February to September 2021 (see Supplementary Material I for an overview of the respondents). All interviewees had provided informed consent for recording and using the interview data, as well as for the use of anonymized quotations. Ethical approval for the study was obtained from TU Delft's Human Research Ethics Committee. All interviewees were knowledgeable about the initiatives: they were practitioners involved as manager or advisor, or they worked at a more strategic level at the organization and knew more about initiatives in general. One interviewee was an independent researcher who was involved in a study that looked at two initiatives that were included in this study (see Willems, van Popering-Verkerk, and van Eck 2022). In the interviews, we explored the concepts and themes that were relevant for the organization of innovation. Questions focused on two main issues: the development of the integration initiatives (i.e. how the initiatives developed over time, which challenges were faced and how practitioners dealt with these challenges) and the organization of these initiatives (i.e. how they were initiated, what role executives had in the innovations, how the initiatives were financed and what strategies the practitioners involved in the initiatives used to establish the innovations). All interviews were recorded and transcribed.

3.3. Data analysis

To analyze our data, we used the software atlas.ti9 (version 9.1.2.). We defined our coding scheme combining a deductive and inductive approach. See Supplementary Material II for a description of our coding scheme and process. We combined the data of the two cities to get a rich understanding of how Waternet and the Municipality of Rotterdam organized UWSI innovations. We first looked at a more descriptive level; i.e. the type and theme of the initiatives, and their approach. We subsequently looked at a more analytical level, looking into how the organizations dealt with the interface between the initiatives (innovation) and the line organization (day-to-day operation). This resulted into four types of mechanisms to manage this interface: network mechanisms, hierarchical mechanisms, process mechanisms and human-resource

Table 3. Overview of the selected Amsterdam UWSI initiatives.

Initiative	Type of initiative	Urban water management theme	Aim
Amsterdam Rainproof	Movement	Climate adaptation	Preparing Amsterdam for heavier rainfalls together with citizens, entrepreneurs, and knowledge workers.
Amsterdam Climate adaptation	Program	Climate adaptation	Preparing Amsterdam for a changing climate (heat, drought, (urban) flooding).
Waternet Climate adaptation	Program	Climate adaptation	Making the Waternet area climate proof and resilient.
Koppelkansen	Program collaboration)	Asset management, Climate adaptation	Addressing multiple sustainability challenges in public space through smart, integrated solutions, both above and below ground.
Amsterdam Future-proof assets	Line-based initiative	Asset management	Preparing assets in Amsterdam for the future through concrete projects together with knowledge institutes and industry.
Waternet Circular economy	Program	Resource recovery	Reducing the environmental impact trough reorganizing the Waternet urban water cycle.
Waternet Energy transition	Program	Resource recovery (aquathermal energy)	Contributing to the heat transition through aquathermal energy projects and making Waternet carbon neutral/energy positive.
Waternet New sanitation	Program	Resource recovery	Developing knowledge and gaining experience with (local) resource recovery through concrete projects.

mechanisms. A detailed description of these mechanisms is provided in the results section (Section 4.2). To interpret our results, literature on ambidexterity was used.

4. Results

In this section, we first discuss the different types of initiatives. Then, we look at how the connection between the initiatives and the line organization was organized.

4.1. Different types of initiatives: their organizations and approach to integration

Based on our data, we identified four types of initiatives to UWSI: programs, movements, collaborations and line-based initiatives.

4.1.1. Programs

Eleven of the initiatives were programs. Overall, the programs had a formal character: they were planned and top-down initiated vehicles to innovation, with a predefined goal and scope. Programs ran typically for a set period (e.g. 4 years, connected to the council's tenure), with budget available for doing pilots and innovations. Several respondents mentioned that the formal status of a program helped them to develop innovation. Two respondents said that by calling something a program, executives indicated to the line organizations that the issues the program addressed had a certain priority.

While the formal character of programs and having a dedicated team to work on the issue could speed up innovation, it was also mentioned as an obstacle to getting new practices embedded and to reaching people in the line organization.

4.1.2. Movements

We identified two movements: Water Sensitive Rotterdam and Amsterdam Rainproof. A common thread of these movements is their bottom-up approach. Executives were only involved at a distance, supporting the movements by giving space to develop their own identity and approach. Both movements presented themselves as non-associated with the government: they built their own identity, characterized by, for example, their own logo, website, and communication. They heavily relied on enthusiastic, and thus intrinsically motivated people, both from inside and outside the organization.

4.1.3. Collaborations

A third type of initiative is the collaboration, of which we included two in our dataset. The essence of a collaboration is its network-like character, with strong ties to other organizations. An example is the RoSA consortium in Rotterdam, which connects the municipality with the drinking water company and the three waterboards that are active in Rotterdam. Collaborations also had some top-down characteristics. For example, the establishment of the RoSA consortium followed a national agreement (the National Water Agreement (Ministry of Infrastructure and the Environment 2011)). In addition, higher management and administrators of the various organizations played a prominent role in the collaborations, such as with defining the projects.

With respect to the mobilization of resources, a collaboration has the advantage that costs could be shared among the participating parties. According to two respondents, this facilitated the development of innovations. Additionally, having multiple parties involved made it more interesting for international (research) investments, such as from the European Union (respondent 10).

4.1.4. Line-based initiatives

We identified three initiatives to integration that were based in the line organization. According to the theory on structural ambidexterity, innovation should take place in distinct units that are not part of the line organization. However, as several practitioners involved in the line-based initiatives described a similar tension between innovation and operation, we decided to include these initiatives in our dataset, referring to them as 'line-based initiatives'.

All line-based initiatives originated within the line organization. Their main characteristic was that they focused on innovation of regular activities, yet going beyond the optimization of day-to-day tasks. In the case of Next SB-SO, for example, civil servants aimed to reorganize and integrate the approaches of the department of City management and that of City renewal. Practitioners involved in the line-based initiatives typically divided their time between regular tasks and innovation. The initiatives often developed gradually and did not have a clear starting point. They started with little or no involvement from higher levels in the organization. Instead, lower-level managers, such as department heads, or civil servants who saw the relevance of changing current practices, were closely involved in the establishment of these initiatives. At a later stage, support from higher management was sought. Line-based initiatives had thus both some bottom-up and some top-down aspects.

4.2. Mechanisms to manage the interface between initiatives and the line organization

Looking into our data, we found different mechanisms to protect innovations on the one hand, and integrate them with the line organization on the other. We inductively categorized the mechanisms into four groups: network mechanisms, hierarchical mechanisms, process mechanisms and human-resource mechanisms.

4.2.1. Network mechanisms

We found that networks played an important role throughout the entire innovation process, both to develop UWSI innovations as well as to implement them. As sustainability challenges do not comply to disciplinary and organizational boundaries, initiatives typically relied on a network approach to be able to work across these boundaries. Additionally, networks were used to spread the philosophy of integration and associated knowledge and skills. Networks had thus a double use in the innovation process: they contributed to the development of UWSI initiatives, as well as to

their implementation. As a consequence of this, we noticed that both processes merged into each other.

We identified network structures on different scales and with different purposes (see Table 4). For each of them, we provide a brief description, including an empirical example from the cases.

Intraorganizational networks. Within organizations, intraorganizational networks were used to facilitate working across departmental boundaries and spread innovative thinking. Respondent 23 described how she approached civil servants who were enthusiastic about circularity and initiated the Blue Rebel network. The Blue Rebels had regular meetings for brainstorming and talking about possible interventions to promote circular practices. Respondent 13 explained that such a network of intrinsically motivated people could have a knock-on effect on adopting innovative practices: 'In every department you have people, colleagues, who are happy to help … And, because they are in the same department, they can often convince their own colleagues more easily about something'.

Networks of initiatives. In addition to ties between departments, we found connections between initiatives. Multiple respondents mentioned that they, on purpose, looked for these connections, to save costs, but primarily to strengthen the position of individual initiatives. By pairing up, they could create a 'critical mass' such that innovative practices were adopted more easily. Civil servants who were involved in diverse initiatives and networks across the organization played a key role in the connections between initiatives. These 'bridging actors' could work at different levels; i.e. at the operational or tactical level, e.g. involved in diverse projects, or at a more strategic level.

Another way to establish networks of initiatives was via initiative managers: for Rotterdam, several respondents mentioned that most of the sustainability initiatives were led by young, highly motivated people who knew where to find each other, and that this contributed to alignment between initiatives. Additionally, we noticed that in each program plan, relationships with other programs were mentioned, highlighting the overlap between challenges and goals. At Waternet, two respondents indicated that the organizational positioning of the three programs (climate adaptation, circularity and energy transition) was mainly beneficial for the collaboration between them. Recently, the programs were restructured, now falling all directly under the responsibility of the executive board, rather than each having their own position in the line organization. Facing the same struggles, respondent 23 explained that this shared position helped to join forces on several issues:

> All three of us actually have to fight a bit of the same battle against the existing organization, just on different themes. . . . So we are now preparing a management proposal together … as we are actually running into the same kind of problems.

External networks. Network activities outside the organization were primarily undertaken to establish either short-term or long-term relationships with external parties that were essential to integration. Pairing up with these parties could help to get innovations adopted more easily by the internal organization. Multiple respondents indicated that urban water organizations rely on other parties to achieve the goals of UWSI initiatives. Respondent 20 described this on the basis of climate adaption: 'Climate adaptation is a problem you really can't solve on your own; not just as a water authority, but actually not even as government … more than half of the city is private property'. This dependency of others was mentioned an important reason for building external relationships. Rainproof even decided to hire someone who was specifically in charge of managing and maintaining external relationships, i.e. a community manager – a role that was completely new to Waternet at the time.

While addressing sustainability challenges required on the one hand many different collaborations and coalitions, several respondents also underlined the need for long-term partnerships, such as between water boards and municipalities, like the RoSA consortium: these pave the way for cooperation on other topics.

Local, regional, national and international knowledge platforms. Another form of external network activities that we identified was joining local, regional, national or international knowledge platforms. In addition to knowledge-sharing, these platforms could be helpful in jointly putting pressure on parties operating at a larger scale. For example, they facilitate approaching higher tier governments (to change prohibitive regulations) or trade associations that operate at a regional or national scale.

4.2.2. Hierarchical mechanisms

While network activities were the dominant mechanism for managing the interface between the initiatives and the line organization, our data showed that hierarchical mechanisms

Table 4. Overview of the different type of network activities and their objectives such as identified in the cases.

Type and scale of network activities	Identified objectives of network activities
Intraorganizational networks	• working across departmental boundaries • creating a knock-on effect
Networks of initiatives	• saving costs • strengthening the position of initiatives • pairing up to build a critical mass
External networks	• gaining support from parties that are vital for the innovation (dependency) • getting innovations more easily adopted within the organization
Knowledge platforms	• sharing of knowledge • putting pressure on parties operating at a larger scale, e.g. trade associations

played an important role as well. Rather than being in conflict with each other, we found that networks and hierarchy could complement each other.

Hierarchy as a vehicle for integration. Our data showed that committed executives were beneficial to UWSI innovations: they could play a key role in the establishment of initiatives, and thereby protect and fuel the innovation process. For example, a (temporary) director at Waternet positioned the Waternet innovation programs directly below the board of directors. Before, the initiatives were part of the line organization. Respondent 23 explained that this director's decision strengthened the position of the programs with respect to department heads: 'At the position we now have in the organization, we are at the same level of authority with those department heads. Thus, it was a strategic move; we are now colleagues'.

Another finding related to the role of hierarchy, was that the support of executives could help to get line organizations moving. Respondent 14 attributed this to hierarchy and the chain of command: 'There are certain departments and colleagues, and sometimes organizations as well, very susceptible when something is organized much more top-down. That, if the management says: "it [the innovation] is good", they will take part in it'. In addition, we found that the support of a certain executive could help to get the support of other executives: since UWSI initiatives involve cross-sectoral innovations that need the involvement of different executives, one could 'use' the executives that are already enthusiastic about the initiative to get the other executives on board as well.

Institutionalizing innovations. Besides fueling the innovation process, we found that hierarchical mechanisms played a role in institutionalizing innovative practices through incorporating them in guidelines and official documents. Initiative practitioners could play a part in this as well, actively searching for opportunities to formalize innovative practices.

This was, for example, the case in Rotterdam for the four-years policy plans for urban water management (municipal sewerage plan). Since these plans need to be approved by the municipal councils and provide the basis for daily operations and practices, multiple respondents explained that establishing innovative management principles in these plans could help mainstreaming innovative practices. Respondent 7 elaborated on how the ideas of the Weerwoord program about climate adaptation now have been established in the newest sewerage plan of Rotterdam, which is entitled *From pipe to outdoor space*: 'In principle, we were already doing that [from pipe to outdoor space], but it is now much more formalized and has really become a guiding principle'. Another example of institutionalizing UWSI innovations that was observed in the case studies related to design guidelines: in both cities, steps were taken to include climate adaptation measures in municipal design guidelines for public space.

4.2.3. Process mechanisms

A third set of mechanisms revolves around the interactions between practitioners who focus on innovation and those who focus on day-to-day operation of systems, hereinafter referred to as initiative practitioners and line-organization practitioners, respectively. Rather than innovations first being fully developed within the initiatives and then being connected to the line organization, we saw that developing and implementing innovation was more of a process of interaction, with line-organization practitioners (gradually) becoming co-producers of the innovation. This also relates to our findings about networks: in Section 4.2.1 we showed that UWSI innovations are typically developed in close collaboration with other practitioners and organizations.

We identified different ways in which people across the line organization were involved, differentiating between informing, inspiring, motivating and encouraging them to action:

Informing people in the line organization. In all initiatives, we could identify some form of *informing* line-organization practitioners about the initiatives, such as sharing information through platforms like LinkedIn or intranet. In Rotterdam, programs officially belonged to a department, which was, according to several respondents, beneficial for information-sharing. In Amsterdam, two respondents mentioned that practitioners in the line organization were trained to learn about new practices, such as through the course System Innovation, which was related to the Koppelkansen program.

Inspiring people in the line organization. Informing often went hand in hand with *inspiring*. For movements in particular, inspiration was an important part of the initiative. Rather than just providing information about what climate adaptation is and how it could be done, movements focused on making people enthusiastic about climate adaption, such as through presentations and one-on-one conversations throughout the organization. Additionally, movements organized social events, such as the 'Water Sensitive Cafes' in Rotterdam and coffee breaks. These social events were organized to bring people from different organizations together, to get to know each other, share ideas and have fun.

In the same vein, respondent 1 (Reyeroord+ program) organized guided tours through the Reyeroord neighborhood for colleagues to talk about the initiative and make people enthusiastic about the 'Reyeoord approach'. The Blue Rebel network (see Section 4.2.1), which was part of the circularity program of Waternet, was also a form of reaching the line organization through inspiration. That same program also introduced 'roving reporters' ('razende reporters' in Dutch) who made vlogs about successful circular cases and shared those with the rest of the organization.

Motivating and encouraging people in the line organization to action. *Motivating* and *encouraging to action* focused on convincing people in the line organization of the need for change and persuading them to contribute to the solution. Several respondents emphasized that, within initiatives, one should make the translation from (sustainability) ambitions to everyday practices. For example, respondent 21 (Circularity program) mentioned that one must break down the complexity into smaller bits:

> So when you see the long-term horizon, with the complexity that comes with it, that you break it [the complexity] down [translating

> it] to the here and now, so that the small steps that are taken now, give people the energy right away, and that it fits into their processes.

Two other respondents highlighted the importance of 'problem ownership', making line-organization practitioners part of the innovation challenge through involving them directly in activities of initiatives, such as in pilots and in the development of artifacts like models and maps that support innovative practices. Involving people in such activities could give them the confidence to incorporate innovative practices in their daily work, such as elaborated on by respondent 21:

> What we see is that also people in the line [organization] get a kind of daring and realization: 'Okay, so I can do something, I may do something, I can convince [other] people now, and I know that there is also a large group of people supporting me, including the management and board, to go and do that.'

4.2.4. Human-resource mechanisms

The last category of mechanisms to organize the connection between initiatives and the line organization relates to human resources. The results showed that individuals and their skills could play an important role in managing the tension between innovation and operation.

The human factor: initiative managers contributing to integration. The skills of initiative managers, i.e. individuals that led the initiatives, played an important role in managing the interface between innovation and operation, such as in networks (see Section 4.2.1) and in facilitating the process of interaction (see Section 4.2.3). Multiple respondents related these actions to a certain skill set; i.e. that initiative managers had certain skills that were beneficial for the innovation process. These included networking and convincing others, as well as creating an open and positive atmosphere, stimulating creativity, allowing for errors, and with a lot of emphasis on what is possible rather than what is not possible.

We also found actions, taken by initiative managers, drawing on hierarchy: initiative managers actively approached executives to get their support, knowing their support was beneficial to innovation (see Section 4.2.2). For example, they invited executives to successful cases, indicated and translated the added value of and initiative for the (various) directors/aldermen involved, and translated abstract, long-term goals to goals with a shorter time horizon that were more attractive for directors in charge. For Rotterdam, several respondents attributed the necessary skills to the type of people leading the initiatives: they explained that most of the program managers were young, highly motivated people with strong interpersonal skills, who had often first done a traineeship at the municipality.

Creating new roles and hiring external people. Multiple respondents highlighted that developing UWSI innovations required different capacities than traditional urban water management. Our data showed that this knowledge gap was typically dealt with by educating people, creating new roles and/or hiring external people for initiatives. For example, for the Waternet Circularity program, initiative practitioners followed a course on transition management to gain knowledge about accelerating transitions. Amsterdam Rainproof and Waternet's Climate Adaptation Program both employed a community manager. These were responsible for managing (external) relationships (see Section 4.2.1), and thus contributed to a culture that was more externally oriented, fostering integration.

Another reason for hiring external people that was mentioned by two respondents, was that these external people could more easily bring winds of change. Respondent 16 explained that Rainproof on purpose recruited a program manager from outside the organization to prevent that Amsterdam Rainproof would become 'just another Waternet story'. On the other hand, many respondents emphasized that initiative managers who came from inside the organization and who had an established reputation were beneficial to an initiative, getting support from senior management more easily.

5. Discussion

In this section, we use the concept of ambidexterity to reflect on the results of our study. With the early studies on ambidexterity emphasizing the connection between innovation and operation activities at senior management level (Duncan 1976; March 1991; Tushman and O'Reilly 1996), and later research highlighting that these connections take place at various hierarchical levels of the organization (e.g. Nemanich and Vera 2009; Taylor and Helfat 2009), we found an even more nuanced picture. In our study, the interface between innovation and operation was dominated by networks, and complemented by hierarchy. In Section 5.1 we interpret our findings about networks, and in Section 5.2 we discuss the role that hierarchy could play in managing the interface between innovation and operation activities.

5.1. Networks dominating the connection between initiatives and the line organization

We have made four observations related to networks in managing the tension between innovation and operation:

First, our results show that innovation and operation activities did not take place completely isolated from each other, such as specified in the studies on structural ambidexterity (O'Reilly and Tushman 2004; Tushman and O'Reilly 1996). According to those prior studies, innovations need to be developed in separated organizational units, and then transferred to the organizational units that are responsible for the operational process. We found, however, that, although most initiatives were accommodated in separated organizational units (i.e. programs, collaborations and movements), there was a continuous interaction between the initiatives and the line organization. For example, practitioners in the line organization were continuously informed about innovation initiatives, they were part of informal networks, and they were also directly involved in pilots and projects. Second, the continuous interaction with the line organization means that innovation is not like a project that is carried out in isolation and which is then rolled out, but that innovation is a co-creation with the line organization. This suggests that initiative practitioners should not define the innovation too early in the process, but rather give the line organization the space to become co-producers of

the innovation. These first two observations relate to the literature on learning alliances, which focuses on the engagement of multiple stakeholders to develop and scale up innovations (Darteh, Moriarty, and Huston 2019; Lundy et al. 2005). In learning alliances, there is often a shared desire to address an underlying problem, and the alliances should preferably be represented by multiple actors in the horizontal dimension (multiple stakeholders working at city level), as well as the vertical dimension (e.g. working at community, city and national level) to develop creative solutions for complex problems such as related to urban water governance (Verhagen, Butterworth, and Morris 2008). These characteristics of learning alliances were also observed in networks were UWSI innovations came about.

Third, we observed a prominent role for the connections *between* innovations – thus the network of initiatives (see Section 4.2.1). This means that there is not a single innovation unit (see Section 2), but there are many. This observation also has implications for the interface between operation and innovation: the network of initiatives is used to get the ball rolling; i.e. to create a critical mass such that the innovation cannot be avoided anymore (Caniels and Romijn 2008). Actors with a bridging position, i.e. *bridging actors* (Spekkink and Boons 2016), play a key role in creating these networks. Fourth, and also related to the other three observations, the role for networks, interactions and co-creation means that the boundaries between initiatives and the line organization are less clearcut. Different than the literature on ambidexterity suggests, we did not find a clear distinction between the world of innovation and that of operation.

Based on these observations and the many connections between innovation and operation that we found, the question is what is left of the concept of ambidexterity. After all, with a dominant role for networks and with innovations also emerging in the line organization (i.e. line-based innovation), the idea that there are autonomous subunits for innovation and operation which are connected at the top does not hold for UWSI innovations.

We argue, however, that the (conceptual) distinction between operation and innovation remains relevant, as the concept could be helpful to understand the *essence* of the innovation challenge: it makes individuals alert to the tension between the need for UWSI on the one hand, and the focus on safety and operability on the other. Being alert to that tension allows for anticipating it. For example, it could help initiative practitioners think about how to organize the interface between innovation and operation such as through undertaking network activities or actively involving executives. The same applies to top executives: by being alert to tension between operation and innovation, executives could act upon it. For example, they could give initiatives a strategic position in the organization or facilitate a network approach. This is supported by the finding of Lewis et al. 2018 who found a relationship between leadership and networking and their effect on innovation capacity.

We therefore argue that the concept of ambidexterity could be helpful in understanding and dealing with the innovation challenge (i.e. the tension between innovation and operation), yet organizations should not stick too much to it. After all, the results of this paper show that organizational separation between innovation and operation goes hand in hand with interconnectedness through networks – and we argue that exactly this combination of separation and connection is the key to success.

5.2. Bringing about UWSI: smart combinations of hierarchy and networks

In this section. we revert to the role of senior executives – an element that is central to the original theory: top management connects the world of innovation and operation and resolves the tension between the two worlds. As mentioned earlier, we observed a smaller role for senior executives and identified all kinds of other connections between innovation and operation (Section 4.2.1 and 4.2.3). At the same time, however, many respondents stressed the pivotal role of executives in the innovation process (Section 4.2.2).

Bringing about UWSI is a complex and hard-to-predict process: there are many different initiatives to UWSI that occur in parallel, of which some of them have a more planned character and others a more emergent one. Furthermore, these initiatives are connected to each other as well as to the line organization, in which networks are important, but in which we also identified a role for senior management. Organizations are challenged to connect hierarchy and networks, linking top-down planning with the emergent process that characterizes networks. Based on our results and previous work about using hierarchical interventions in networks (de Bruijn 2005), we see two ways to do this:

- To catalyze the innovation process: rather than a top-down decision that strictly defines what has to be done and how it should be done, a top-down decision should leave room for emergence, giving space to practitioners to anticipate emerging developments and opportunities. This could be done through, for example, defining an initiative, such as a program or collaboration, and select motivated practitioners, without defining how these practitioners should operate. By starting the initiative, executives indicate to the line organization that the innovation has priority, strengthening its position with respect to operational activities. The added value of the executive lies in timely identifying innovation opportunities and defining initiatives. If the initiative would not have been started from top down, there might not have been a process, or it may had taken much longer before a line-based initiative would have emerged. Executives could thus play an important role in speeding up innovation.
- Or to complete the innovation process: executives could formalize innovations that were developed in an emergent way. For example, they could embed innovative practices into guidelines or procedures, or they could start a program in parallel to a movement, allowing to reach practitioners that are more sensitive to hierarchy. By doing so, executives could take a determining role in strengthening or completing the innovation process.

6. Conclusion

Aiming to get a better understanding of how organizations responsible for urban water management can deal with tension between the need for innovation on the one hand, and the focus on operation on the other hand, this paper used a case study approach to analyze 16 UWSI initiatives in Amsterdam and Rotterdam. Semi-structured interviews ($n = 25$) were combined with desk study research. We looked at the types of initiatives as well as the mechanisms to organize the interface between initiatives and the line organization.

This resulted into the identification of four types of initiatives: programs, collaborations, movements and line-based initiatives. Each initiative has its own characteristics, and the specific challenges and context determine the type of initiative that is considered most appropriate. In addition, we found four mechanisms that shaped the connection between innovation and the line organization: network mechanisms that focused on network activities between organizations, as well as within organizations and between initiatives; hierarchical mechanisms that drew on hierarchy to foster the development or implementation of innovation; process mechanisms that focused on the process of interaction between the line organization and initiatives; and human-resource mechanisms that related to human aspects.

The main finding that followed from our empirical results was that the connection between innovation and operation was not primarily achieved through top executives such as mentioned in the literature on structural ambidexterity, but mainly through networks. Nonetheless, we found that executives could play an important role in the connection between the line organization and initiatives: their support could strengthen the organizational position of initiatives. In addition, they could guide and structure the bottom-up processes that occur in the organization by taking a systems perspective.

This article gives valuable insights for both practice and theory. We provide valuable lessons for other cities worldwide that are struggling to develop and implement UWSI in their hierarchical organizations to become more sustainable. We give insights into different initiative types and their characteristics, as well as the mechanisms that enable managing the tension originating from the innovation challenge. In addition, regarding the theory on ambidexterity, this study gives relevant insights on the pivotal role of networks. Our empirical findings are supported by more recent studies on ambidexterity that argue that the tension between innovation and operation should be managed at different hierarchical levels – thus not just at the top (see Brockner et al. 2015; Stadler, Rajwani, and Karaba 2014). We show that this happens by all kinds of actors throughout the organization and during the entire innovation process; i.e. through networks. The organization of innovation in urban water organizations is thus much more nuanced than the original literature on ambidexterity suggests, and we show that networks deserve further attention in this field of research.

For future research, we recommend taking a closer look at the role of networks and agency in bringing about UWSI innovations. Our results show that individuals such as initiative managers could have an important contribution to managing the tension between innovation and operations, such as through their role in networks or by engaging executives. Insights from the literature of institutional entrepreneurship may be valuable here, such as by looking at the direct strategies and activities that individuals use to bring about change, and/or at the skills and abilities that are required to carry out these activities (e.g. Klein Woolthuis et al. 2013). In addition, the role of networks in developing and implementing innovations should be further investigated. We found a large role for networks, but these findings could be specific to the Dutch context. A comparative case study, looking at different geopolitical contexts, that examines possible inhibitors or barriers to networks supporting innovation initiatives, could provide valuable insights into the role of networks in innovations.

Another suggestion for further research relates to the influence of organizational structures on the effectiveness of UWSI initiatives. Our results show that, despite the large organizational differences regarding urban water management in Amsterdam and Rotterdam, both organizations have started comparable initiatives. In addition, we found similar mechanisms that were at play. Given the explorative character of this study, we did not look at the role of organizational structure and their effectiveness. Future research should address this, for example through a case study with multiple organizations and/or different types of initiatives.

Notes

1. Dutch water boards are decentralized public authorities in charge of water management with boundaries that are primarily defined by hydro-geographical properties such as river basins and drainage areas.
2. For Amsterdam, we also included an initiative on the recovery of aquathermal energy in the category of resource recovery. In Rotterdam, there was not such an initiative; only a few small, occasional aquathermal projects had been implemented.

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No potential conflict of interest was reported by the authors.

Data availability statement

The participants of this study did not give written consent for their data to be shared publicly, so due to the sensitive nature of the research supporting data is not available.

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