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Governance of national spatial data infrastructures in Europe*

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Abstract

The effective development and implementation of spatial data infrastructures (SDIs) requires governance in order to avoid gaps, duplications, contradictions and missed opportunities in the implementation of different SDI components. Therefore, appropriate governance instruments should be established to coordinate the activities and contributions of different stakeholders. This article reviews the governance of national SDIs in Europe before, during and after the adoption of the European INSPIRE Directive, which aimed to establish an infrastructure for spatial information in the European community building on Member States' national SDIs. The analysis is based on a governance instruments approach as introduced by public administration researchers to analyse coordination and governance in the public sector (as SDIs are still mainly governed by public authorities). Evidence was found for the adoption and use of each of the six sets of governance instruments in the governance of national SDIs in Europe: collective decision-making structures, strategic management, allocation of tasks and responsibilities, creation of markets, inter-organizational culture and knowledge management, and regulation and formalization of the infrastructure. This study also demonstrates how an instruments-based approach can be a useful tool for analysing governance

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in the context of SDIs and can contribute to a structured way of understanding the mechanics of SDI governance.

Keywords: spatial data infrastructures; governance; Europe; governance instruments; INSPIRE

1. INTRODUCTION

Since the early 1990's, different European countries have tried to implement national spatial data infrastructures (SDIs). The effective implementation of SDIs requires governance, which includes the structures, policies, actors and institutions by which the infrastructure is managed pertaining to decisions made for accessing, sharing, exchanging and using the relevant available spatial information. This aims to reduce gaps, duplications, contradictions and missed opportunities in the production, management, sharing and use of the information that tend to occur in a multi-stakeholder environment. Governance can be facilitated through the use of appropriate instruments which extend to various levels of government and take into account the distribution of powers and responsibilities among different actors and institutions with an interest in the infrastructure (Verhoest and Bouckaert, 2005; Masser and Crompvoets, 2015). The governance instruments should coordinate the activities and contributions of, inter alia, data producers, users, added-value services providers, and other stakeholders.

An important change in the context in which the development of these European national SDIs took place was the adoption of the European Directive of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE) (Commission of the European Communities, 2007). The INSPIRE Directive aimed to establish a European Union spatial data infrastructure based on the creation, operation and maintenance of the national SDIs of the 28 Member States of the European Union, and several other European countries. To enter into the INSPIRE Directive, countries had to develop their national spatial data infrastructure according to the principles, rules and guidelines of INSPIRE. Therefore, the main objective of the paper is to analyse the governance of national SDIs in Europe and to identify the impact of INSPIRE on the governance of these SDIs.

In order to meet this objective, this article systematically reviews the governance of national SDIs in Europe before, during and after the adoption and implementation of the INSPIRE Directive. The review draws on data collected from a detailed documentary analysis making use of a six sets of governance instruments. The review outcomes will contribute to a better understanding of governance in the context of SDIs and better insight in governance practices and

instruments adopted in European countries as SDI governance as a central research topic has not been well investigated so far. The article is structured in the following way: Section 2 introduces the issue of governance of SDIs followed by the methodology in Section 3. Section 4 presents the analysis results on existing SDI governance practice. Section 5 provides a discussion of the main results and findings of our analysis. The article ends with a conclusion in which we summarize the main findings and provide recommendations for further research.

2. GOVERNANCE OF SPATIAL DATA INFRASTRUCTURE

Governance of public sector organizations and policies is one of the key topics in public administration research and practice (Rhodes, 1997; Kooiman, 1999; Lynn et al., 2000; Bevir et al., 2003; Andresani and Ferlie, 2006; Meuleman, 2008; Hall, 2011). The term governance, however, is defined and used in many different ways (Meuleman, 2008). In his 1997 book 'Understanding governance', Rhodes distinguished six different ways of using the concept of governance: governance as the agency of minimal state; governance as the system of corporate governance; governance as ideology of the new public management; governance as a normative concept, such as 'good governance'; governance as a socio-cybernetic system; and governance as a self-organizing activity (Rhodes, 1997). Kooiman (1999) identified additional conceptualizations of governance, these being the activities required to maintain (international) order and ruling, steering and restricting the economy, but he also recognized three common elements in all respective conceptualizations: an emphasis on rules and qualities of systems, the presence of co-operation mechanisms to enhance legitimacy, effectiveness and allocation of resources, and the attention to new organizational processes and public-private arrangements. According to Lynn et al. (2000), all definitions of governance refer in some way to "the means for achieving direction, control, and coordination of wholly or partially autonomous individuals or organizations on behalf of interests to which they jointly contribute". Increasing interdependencies between actors or organizations, at many levels and in different directions, are the main reasons why governance is needed (Kooiman, 1999). New ways of governance are needed when current problems and challenges of governments are becoming more complex and require the involvement of additional actors besides the government. Key characteristics of these new modes of governance are multi-level integration of processes, diversity and decentralization of responsibilities and accountabilities, greater collaborative deliberation, stronger participation and involvement of citizens, and increased flexibility and openness in decision making processes (Hall, 2011). The act of governing can be based on different governance modes, including hierarchical governance, market governance and networks (Meuleman, 2008; Hall, 2011). The concept of meta-governance is therefore used to refer to the process of designing and managing sound combinations of hierarchical, market and network governance to produce some degree of coordinated governance (Meuleman, 2008).

Whilst Kooiman (1999) and Meuleman (2008) primarily emphasize the functioning of governance, they do not describe the normative aspect of governance, i.e. whether governance is good or bad, effective or not effective, fair or unfair. The theme of 'good', 'effective' and 'fair' governance have especially been addressed in new public management literature and in e-government literature. In the discourse on the transition from analogue to digital processes, governance became coupled to measurable indicators, such as output, throughput, performance, value for money, degree of accountability, transparency and responsibility, and the degree of participation and openness (Bourgon, 2007; Pollitt et al., 2007; Osborne, 2010; Uzzaman and Miah, 2013).

While SDIs themselves are considered as initiatives contributing to good governance or effective governance, a key challenge in the establishment of SDIs is the governance of the infrastructure itself. Governance of SDIs is essential for the implementation of different SDI components in a coordinated and consistent manner (Craglia and Johnston, 2004). The governance of SDIs deals with the adoption of structures, procedures and instruments for managing the relationships and dependencies between all involved actors, units and organizations. The central challenge of governance is reconciling collective and individual needs and interests of different stakeholders in order to achieve common goals (Box, 2013). Masser (2006) recognized the emergence of more complex and inclusive models of governance to cope with the multi-level nature of SDI implementations of the second generation of SDIs (Box, 2013). The creation of appropriate SDI governance structures that are inclusive and are both understood and accepted by all stakeholders should be a key priority in future implementation of SDIs to facilitate success. Governance of SDIs also requires expanding the scope of stakeholders to include the private sector, research bodies and other actors outside the public sector including citizens as volunteers - VGI (Goodchild, 2007; Coleman et al., 2009), to actively promote bottom-up and participatory processes, and to find the appropriate mechanisms and instruments to enable the participation of these non-government actors (Georgiadou et al., 2005; De Kleijn et al., 2014).

According to Coetzee and Wolff-Piggott (2015) key topics in governance-related literature on SDI are the role of local authorities, SDI assessment and evaluation, legal access and licensing issues, awareness and competencies, and SDI drivers. Few studies have investigated the governance of SDIs as a whole in any systematic way. Singh (2005) applied theoretical concepts from the literature on information infrastructures for the identification and analysis of governance issues in the national SDI of India. Box (2013) reviewed contemporary theories of governance in the spheres of political science (public governance and good governance), organization theory and practice (corporate governance) and information technology (IT governance) as well as literature related to the governance of specific dimensions of SDI. Box also proposed a definition of SDI governance, analysed four case studies of SDI governance in Australia and finally

developed an SDI governance model. The analysis of cross-agency geospatial coordination by Lance et al. adheres to the public management literature that focuses on cross-agency coordination, network governance and meta-governance (Lance et al., 2009).

This article extends the discourse on what SDI governance entails, and especially how to convert this into empirical methods for investigating the governance of national SDIs in Europe. National SDIs of Member States form the foundation for the European SDI and the implementation of INSPIRE. Governance can be defined and addressed in different manners, and there are several approaches for analysing governance (Ansell and Torfing, 2016). Some authors (e.g. Bouckaert and Halligan, 2008; Ebbesson, 2010) focus on the processes of governing and the role different government, private and civil society actors play in these processes. Other researchers (e.g. Knill and Lenschow, 2005; Crompvoets and Ho, 2017) emphasize the interactions between actors, jurisdictions, administrative levels and institutional arenas for the exchange of ideas, and to coordinate actions and collaborate. Some governance analyses focus on the level of governance, and its impact and effects on solving particular societal problems, while others analyse how governance changes through time or can be different across different sectors or countries. In certain cases, several of these approaches are combined.

This paper relies on the approach introduced by Verhoest et al. (2007) for describing and analysing trajectories of specialization and coordination in the public sector. Verhoest et al. focus on the instruments–and underlying mechanisms–that are adopted through time to enhance the alignment of tasks and efforts of organizations within the public sector. Building further on existing research and literature on coordination in the public sector (Alexander, 1995; Peters, 1998; 6, 2004; Hood, 2005) they made a classification of both management and structural instruments for coordinating and governing the relationships between public bodies. Management instruments include strategic planning and evaluation, financial management, culture and knowledge management and mandated consultation or review systems. Structural instruments include reshuffling of competences and/or lines of control, establishment of coordinating functions or entities, regulated markets, systems for information exchange, negotiation bodies and advisory bodies, entities for collective decision-making, common organizations and chain management structures. Verhoest et al. used this approach to describe and analyse the different trajectories of public sector coordination in four countries. Using this approach to investigate SDI governance is useful and innovative because it connects the practical experiences gained in SDI development to conceptualization efforts in public management literature. With the aim to apply their approach to assess the governance of European national SDIs, we extend the SDI scientific discourse in the general direction of public information management.

3. METHODOLOGY

The central research questions this article aims to answer are: how have national SDIs in Europe been governed in the past 25 years, and how has the introduction of INSPIRE affected the governance of these national SDIs? To answer these questions, an exploratory and descriptive analysis is made of the development and implementation of SDIs in the different European countries. The study is based on a documentary analysis of relevant publicly available documents on the development and implementation of existing national SDIs and the implementation of INSPIRE in European countries (including non-EU countries) making use of sets of governance instruments.

3.1. Conceptual framework

In their analysis of coordination strategies and trajectories in four countries, Verhoest et al. (2007) make use of a typology of 12 coordination instruments derived from the existing literature on public sector coordination (Meuleman, 2008). Since some of the proposed instruments are related to each other, we categorize them into six sets of coordination instruments to emphasize the connections between the instruments and analyse the connected instruments jointly. The six sets of governance instruments include: 1) instruments for collective decision-making, 2) instruments for strategic management, 3) instruments for allocating tasks and responsibilities, 4) instruments for creating a market, 5) instruments for inter-organizational culture and knowledge management, and 6) instruments to regulate and formalize the infrastructure. While the instruments proposed by Verhoest et al. (2007) are included in these sets, the instruments for regulating and formalizing the infrastructure were added as a separate set, since several authors stressed the importance of rules and legislation as a separate governance mode or governance instrument (Knill and Lenschow, 2005; Armstrong and Kilpatrick, 2006; Ebbesson, 2010). Table 1 gives an overview of these six sets, including their main aims, and associated instruments. These six sets of governance instruments will be used as a conceptual framework to guide our analysis of governance practices in SDIs in Europe. Each set of governance instruments will be introduced and explained in depth in Section 4.

Table 1. Six sets of governance instruments.

Sets of governance instruments
1. Collective decision-making   Aim: To involve all stakeholders in decision-making on the infrastructure   Instruments: Creation of entities for collective decision-making; Advisory bodies

2. Strategic management Aim: To align the activities of different stakeholders by a system of interconnected plans, objectives and targets Instruments: Strategic plans; Strategic evaluations
3. Allocation of tasks and responsibilities Aim: To divide tasks and responsibilities among different stakeholders Instruments: Establishment of a coordinating entity; Reshuffling of tasks and competences
4. Creation of markets Aim: To establish and maintain markets between stakeholders Instruments: Creation of both internal markets (within government) and external markets (outside government)
5. Inter-organizational culture and knowledge management Aim: To create a shared vision, norms, values and knowledge between stakeholders Instruments: Information sharing; Awareness raising; Capacity building
6. Regulating and formalizing the infrastructure Aim: To formalize the infrastructure into a binding framework Instruments: Agreements, laws and regulations

3.2. Document analysis

Our study is designed as a synthesis of scientific literature, policy documents, reports, articles and other relevant documents on existing national SDIs in Europe. Three main types of documents were taken into account in the analysis.

The first source of information is the official country reports on the implementation and use of SDIs that have to be submitted by all EU member states every three years. According to the INSPIRE Directive, EU member states have to monitor and report on the implementation and use of their SDIs. While monitoring follows a quantitative approach and includes the establishment of the list of spatial data sets and services by member states, reporting follows a more qualitative approach, as member states need to provide information on five areas: coordination and quality assurance, contribution of stakeholders to the functioning and coordination of the

infrastructure, the use of the infrastructure for spatial information; data sharing arrangements between public authorities, and cost and benefits aspects (Commission of the European Communities, 2009; Masser and Crompvoets, 2016). The country reports contain information on many different aspects of the governance approach implemented in the different countries, and different types of governance instruments that can be used to govern the infrastructure. Reporting started in 2010, with a first set of reports on the status of the Member States' SDIs and INSPIRE implementations in 2009. A second round of reporting was organized in 2013, providing information on the status and evolution of the infrastructure between 2010 and 2012. In May 2016, the third set of country reports were submitted by the member states, covering the period 2013-2015 (INSPIRE Monitoring and Reporting, 2017). In addition to these country reports, a series of INSPIRE webinars (with associated presentation materials) have been organized since 2015 in which the status of INSPIRE implementation in individual countries was presented, focusing on the different components, strengths and main challenges (INSPIRE Maintenance and Implementation Group, 2017). Finally, the 'Summary Report on Status of the implementation of INSPIRE Directive in EU' (Cetl, 2017) was an important information source.

Official policy documents such as implementation strategies, legislation and other official documents were also included in the analysis. In many cases, references to these documents were included in the INSPIRE country reports, which allowed for easy identification and consultation of these documents. However, since most of these documents are written in the national languages of the respective countries, integrating them in the analysis was not always possible. It is interesting to note however that, especially in recent years, several countries such as the Netherlands, Finland and Denmark have made some of their SDI strategies and other policy documents available in English.

The third source of information included other studies on SDIs in Europe. Most studies of national SDIs in Europe implicitly address organizational and governance aspects of national SDIs, and thus provide a valuable source for our analysis. Masser's analysis of the first generation of SDIs, can be considered as one of the first comparative analysis of SDIs, and includes three European countries: The Netherlands, the United Kingdom and Portugal (Masser, 1999). After Masser's article in 1999, several more extensive analyses of European national SDIs, covering an even larger group of all European countries, have been executed. As part of the European GINIE (Geographic Information Network in Europe) project, a review and comparison was made in 2002 of ongoing SDI developments in 15 West-European countries, and several Central and Eastern European countries (Craglia et al., 2003). In 2002, also, the Spatial Data Infrastructures in Europe: State of play was launched, an in-depth investigation of 32 European countries (Vandenbroucke et al., 2008). In total, six editions of the study were published between 2002 and 2011. The study made use of different

data collection activities, such as desk research, interviews, workshops and surveys, and covered several governance aspects of SDIs, such as the organizational approach, coordination bodies, the involvement of different participants, legal framework, partnerships and licensing. The EUROSDR study compiled INSPIRE Experiences of European National Mapping Agencies in 2011 (de Vries et al., 2011). The Smespire study of 2013 focused on the role and involvement of non-government actors, and private companies, particularly on the development and implementation of national SDIs and INSPIRE (Vancauwenberghe et al., 2014a). In the context of the European Union Location Framework (EULF) an analysis was made of the integration of SDIs in e-government in the EU Member States (Vancauwenberghe, 2014b). Finally, the Knowledge Base of UN-GGIM also provided interesting information about national SDI developments in recent years, including good practice descriptions, national SDI profiles, and regulations (United Nations initiative on Global Geospatial Information Management, 2017). The data, results and findings of each of these studies were taken into account in our analysis.

4. ANALYSIS OF SDI GOVERNANCE PRACTICES

The analysis of the practices follows the six sets of governance instruments as introduced in Table 1. We analyze how European countries made use of collective decision-making, strategic management, allocation of tasks and responsibilities, creation of markets, inter-organizational culture and knowledge management, and regulation and formalization of the infrastructure to govern their national SDI before and after the introduction of INSPIRE.

4.1. Collective decision-making

Among the primary instruments used in the governance of the SDIs is the creation of decision-making bodies to enable joint decision-making among stakeholders on the development and implementation of the infrastructure. Since the development of the first generation of national SDIs in the 1990s, most European countries have since established strategic decision-making and/or advisory boards in which representatives of the different organizations involved in the SDI collectively set out the SDI strategy and to control the implementation of the SDI. France was among the first European countries in which such a board was established, with the creation of the national council for geographic information (CNIG) as an official advisory body on GI in 1985. By the end of the 1990s, similar SDI boards were established in several other European countries, such as the Board of RAVI in The Netherlands, the Board of the National Geospatial Data Framework (NGDF) in the United Kingdom (UK), the Inter-ministerial Committee for Geoinformation in Germany, the Technical Coordination Committee (CTC) in Italy and the Land Information Management Council (LIMC) in Cyprus. Each of these bodies consisted of representatives of various–mainly public sector–data producers and

users, especially at the national level. In the Netherlands, also representatives from the provinces, the utility companies, the notaries and the water boards participated in the board. In the UK, the NGDF Board consisted of data producers from both the public and the private sector, and a separate advisory council was created consisting mainly of data users. After a few years, however, the National Geospatial Data Framework and its governance structure were abandoned.

After 2000, the establishment of national SDI governance structures continued in several other European countries. In Switzerland, an interdepartmental coordination group was set up in 2000 to provide recommendations for strategies concerning GIS, based on users' needs. Their recommendations formed the basis for a national SDI that joins the federal administrations together with the collaboration and coordination of the cantons. In Spain, the Geomatics Commission of the Geographical High Board, a governmental body coordinating the Spanish cartographical production, by the end of 2000 took the initiative to launch the development of the Spanish SDI. In 2001, the Finnish Council for Geographic Information, the official advisory board in national GI affairs was established as a central element of the institutional framework of the national SDI. In the UK, a new governance structure was implemented in 2004, with the Geographic Information Panel and the UK Location Council. The Swedish Geodata Advisory Board (Geodatarad) was introduced in 2006 to provide advice about the Swedish SDI and European and international matters.

The adoption of the INSPIRE Directive in 2007 altered the use of joint decision-making bodies as governance mechanisms in different ways. In countries where a decision-making structure had already been in place, INSPIRE in most cases was integrated into the existing structure; in other countries, some structural changes were made. In Sweden, the Geodata Advisory Board created an additional INSPIRE working group, consisting of representatives from about 20 Swedish authorities that have a role in the provision of metadata, datasets and services in accordance with the INSPIRE directive. Some countries created a separate INSPIRE governance structure in addition to the existing SDI decision-making structure. In the Netherlands for instance, two separate governance bodies for INSPIRE were created: the steering committee and the consultative group. In the United Kingdom, the UK Location Council and UK Location Program Board were replaced by the UK INSPIRE Compliance Board in 2013. In countries without a national SDI initiative and SDI governance structure in place, INSPIRE stimulated the creation of new bodies. For example, in Slovenia an inter-sectoral INSPIRE project group was established by the Ministry of Infrastructure and Spatial Planning to coordinate and steer the implementation of the INSPIRE Directive and the measures for the sharing of data and services. In Latvia, the Ministry of Defence established a permanent working group for INSPIRE, which involves representatives of all ministries interested in the creation of the SDI. Also, in Malta,

a multidisciplinary group of representatives from different entities involved in implementing the INSPIRE directive was created, the so-called INSPIRE Group.

In this context, it is good to point out that the INSPIRE introduction coincided with several other important developments such as the introduction of an e-government in many administrations and the implementations of the EU-Directives on Access to Environmental Information (Commission of the European Communities 2003a) and Re-use of Public Sector Information (PSI) (Commission of the European Communities, 2003b). In this way, the changes in structures to accommodate for INSPIRE objectives might also be easier (than if these developments had not taken place simultaneously).

The typical decision-making structure of European national SDIs consists of a multi-level structure. In many countries, a distinction is made between decision-making and coordination at the strategic level and at the operational level. At the operational level, many countries have established working groups focusing on particular topics (such as metadata, standards, data policy, etc.) and/or working groups on particular data themes. Examples of such horizontal and vertical working groups are evident in Portugal, Luxembourg and Croatia, but can also be found in several other countries. At the strategic level, decision-making takes place within a central coordinating body in which different stakeholders meet. In some countries, such as Liechtenstein and Luxembourg, only public-sector organizations are represented in the central body. In other countries, such as Iceland, Finland and Denmark, also non-government actors are represented. Some countries have created a separate body, often with only an advisory role, in which non-government actors are represented and involved in decision-making on the SDI (e.g. the region of Flanders, Belgium). In certain countries, such as Germany and Lithuania, the political level is considered as a third separate level of SDI decision-making and coordination, in addition to the strategic and operational levels. These different types of SDI decision-making structures all allow different stakeholders group to participate in and contribute to decision-making on the future implementation of the SDI, to ensure decisions are–to a certain extent–supported by all parties.

4.2. Strategic management

A second manner of dealing with the governance of SDIs is through the strategic management of the infrastructure. Strategic management concerns the alignment of the different activities of involved actors through a system of different and interconnected levels of plans, objectives and targets. In the past 25 years, government-wide SDI strategies with general objectives and goals on the development of the infrastructures were developed in several European countries. Afterwards, the implementation of these strategies and associated actions plans was monitored and evaluated. Prior to the actual development of the SDI strategies, the need for developing such an SDI was often already pronounced in other policy

documents or reports. One of the first policy documents related to the development of a national SDI in Europe was the UK Chorley Committee recommendation in 1987 to establish a national centre for geographic information (GI). However, this recommendation was rejected by the British government. Between 1990 and 2000, policy reports proposing and sometimes preparing the development of an national SDI have been published in the Netherlands (the RAVI Masterplan and view on the National Geographic Information Infrastructure), Finland, Liechtenstein (the 1995 proposals for coordinated geo-information management adopted by the government), Germany (a 1998 report on coordination in the field of GI submitted to the federal cabinet) and France (the 1999 Lagagne Report recommending the development of a national framework of large scale reference data).

The Strategy Plan of the UK NGDF was one of the first real strategic plans on SDI in Europe. In the plan, which was published in 1998, unlocking geospatial information in the UK was described as the main goal of the NGDF. Three pillars of actions were identified that should contribute to realizing this goal: collaboration, standards and best practice, and access to data. After the UK NGDF plan of 1998, several other countries developed their own national geographic information and SDI strategy. Most of these plans strongly focused on the development of the national SDI itself and the implementation of the different components. In some countries, the development of the national SDI was considered as part of the broader e-government strategy. For example, in Norway, the national plan 'eNorge 2005', which was published in 2002 as a strategy to increase the access to public sector information, explicitly addressed geographic information. Other SDI strategies were clearly linked to the broader e-government policy. After the Federal Geodata Strategy of Switzerland in 2001, which paid attention to the role of GI in e-government, several other countries developed a national SDI strategy that recognized the significance of geographic information for realizing the objectives of e-government and defined requirements and actions for raising awareness and extending its use. Interesting examples of strategies dealing with the role of geo-information in e-government can be found in The Netherlands, UK, Denmark, Sweden, Germany and Finland. With the adoption of the INSPIRE Directive, countries started to develop separate INSPIRE strategies and action plans or to consider the implementation of INSPIRE as an element of their national SDI strategy.

Existing practices of SDI strategic management reveal top-down, more hierarchical planning processes as well as more bottom-up processes with involvement of different actors and organizations. While examples of more top-down strategies can be found in Croatia, Czech Republic, and the Former Yugoslav Republic of Macedonia, the recent Dutch 'Partners in Geo' strategy is a good example of a bottom-up and more interactive strategic planning process. 'Partners in Geo' provides a shared vision of both the private, academic and public sector on the future of the geo-information domain in the Netherlands. The document strongly

focuses on the importance of geographic data to address key societal challenges and the need for improved cooperation between government, the private sector and the academic sector. Also, the previous Dutch strategy for the development of national SDI between 2008 and 2011, which was laid down in the GIDEON policy document, was the result of a collaborative planning process. Another example is the Swedish National Geodata Strategy, which was developed by the National Mapping Agency Lantmäteriet together with other organizations and institutions, including the SDI Advisory Board. The board assigned different drafting teams to work on several elements of the strategy, such as user requirements, metadata, specifications, technical solutions and monitoring, and organization and regulation; also, the strategy itself clearly links the development of a national SDI to the realization of benefits for society. In addition, it is expected that the citizenry will become an important contributor to the further development of national SDIs, especially bottom-up planning processes that allow the needs and interests of different stakeholders to be integrated and reconciled in the national strategy, and these stakeholders agree on the key objectives of the SDI and the actions needed to realize these objectives. At the moment, the embedding of crowdsourced contributions in national SDIs are still limited across Europe.

Together with the strategic management of the SDI, countries started to monitor and assess their national GI and SDI activities, in order to prepare the development of new strategic plans or to adjust ongoing plans. Most countries started to monitor and assess their SDI as a result of the INSPIRE Monitoring and Reporting obligations, in which EU Member States have to provide information on indicators on the status of INSPIRE/SDI implication in their country, as well as to report on different aspects of the infrastructure. However, in some countries, additional effort has been directed towards estimating or measuring the performance of SDI initiatives. In the Netherlands for instance, several detailed cost-benefit analyses of INSPIRE implementation were made before and after the implementation of INSPIRE. In Finland, an intensive study on the use of spatial data in Finland was undertaken by the INSPIRE Network in 2010. The study investigated the main providers of spatial data in Finland and identified the different obstacles hindering or restricting the use of spatial data. In Sweden, efforts have gone into measuring and assessing the social benefits of INSPIRE and implementing a Balanced Score Card approach for assessing the SDI. Germany was one of the frontrunners in the development and implementation of tools for automated monitoring and assessment of its SDI. As one of the first countries in Europe to do this, it started to organize the process of identifying datasets and services, testing the quality of data and services, collecting and merging all the necessary information and reporting and publishing in an automated manner. In Portugal, a diagnostic study of the national SDI and INSPIRE was performed in 2015 based on three sources of information: the INSPIRE Monitoring Indicators, an online public consultation and a SWOT analysis among public authorities involved in INSPIRE. The online public consultation was open for 17 days and had more than 500 participants from

different sectors. Around 20 public entities participated in the SWOT analysis by providing their own SWOT analysis, which were subsequently integrated into an overall SWOT analysis of the Portuguese SDI. The results of the study were used as inputs to the development of the SNIG2020 vision on the future of the Portuguese SDI, which itself was designed through a collaborative and participatory process. The example of Portugal shows how the monitoring and evaluation of the SDI can be a collaborative process, which afterwards could serve as a starting point for (re-)defining the SDI strategy.

4.3. Allocation of tasks and responsibilities

A third commonly adopted instrument for dealing with governance challenges is the distribution and re-allocation of tasks and competences among existing and sometimes also newly established organizations. Governance can be realized through the assignment of related tasks to one single organization or through the division of tasks among different organizations. This also includes the tasks of coordinating the work and activities of different involved actors, which can be seen as a key task in the development of national SDIs (Nedović-Budić et al., 2011). The establishment of a coordinating institution is one of the most used governance instruments, also in the development of national SDIs. The main task of this institution is to coordinate the geospatial data management actors of the different organizations in an SDI context. Precise tasks include being responsible for setting up and maintaining the common components of the infrastructure, supporting data providers and data users, monitoring the infrastructure, reporting to and communication with the external parties, organizing awareness raising and capacity building activities, managing relationships with third parties and supporting the decision-making bodies.

Examples of SDI coordinating bodies currently show two main approaches for the establishment of such coordinating institutions: the assignment of the role of SDI coordinator to existing public bodies or the creation of a new organization. In many cases the existing government structure and division of tasks and responsibilities strongly determine the choice between these two alternatives. Some of the first examples of the creation of a new coordinating body are the establishment of the Portuguese National Centre for Geographic Information in 1990 and the creation of the German Federal Agency for Cartography and Geodesy (BKG) in 1997. Among the countries in which the role of SDI coordinator was assigned to an already existing organization are Italy (Ministry for Environment), Hungary (Ministry for Rural Development), Norway (Norwegian Mapping Authority under the responsibility of the Ministry of the Environment), Cyprus (Ministry of the Interior) and Malta (Malta Information Technology Agency). Interesting to note is that in some countries, the role of the coordinating body was later re-assigned to another organization. For instance, the Portuguese government in 2001 decided to merge the National Centre for Geographic Information with the Portuguese National

Geodetic, Mapping and Cadastre Agency into one single entity, the Instituto Geografic Portuges (IGP). In 2012, the role of SDI coordinator was transferred from the Portuguese Geographic Institute to a newly established institution, the Directorate-General for Spatial Planning (DGT), as a result of a reform of the Portuguese public administration. In Denmark, the Geodata Agency in 2015 moved from the Environment Ministry to the Ministry of Energy, Power and Climate, and was split in 2016 into two independent agencies, the Geodata Agency and the Agency for Data Supply and Efficiency. In Flanders (Belgium), the entity responsible for SDI coordination, the Agency for Geographic Information, in 2016 was integrated into one main agency responsible for all government data, the Flanders Information Agency.

In several countries, the adoption of the INSPIRE Directive indirectly contributed to the creation or assignment of a coordinating institution, since the Directive required the assignment of a national contact point to be responsible for the communication with the Commission. In addition, INSPIRE also had an important impact on the division of tasks among other public-sector organizations involved in the SDI and INSPIRE. Since the Directive distinguished and addressed 34 different spatial data themes, European countries started with the identification of data providers under each of these 34 themes. In some countries, such as Slovakia and the Czech Republic, one responsible authority was assigned to each INSPIRE theme. Also, the identification of priority data sets, which for instance was done in the Czech Republic, is an element of the division of tasks among data providers, since the role of certain providers becomes more important. In addition to the identification of responsible parties for the different themes, other ways of dividing tasks are also possible. While in most countries only a basic distinction is made between users and producers (and sometimes coordinators), some countries distinguish additional roles. In Malta for instance, an extra distinction is made between data producers and service producers, in addition to the coordination bodies and users. In Portugal, INSPIRE data providers are further divided into metadata managers, INSPIRE Focal Points and INSPIRE Core Focal Points. In Ireland, a distinction is made between data owners, data providers and data publishers. Although most of these roles are related to one or more data themes, the particular tasks and responsibilities assigned to the roles are different. The assignment of tasks and responsibilities ensures that different involved actors (as providers as well as users) are aware of their role in and contribution to the implementation of the SDI, and gaps, but also duplications and contradictions, are avoided.

The involvement of non-government actors as providers or users such as businesses, research institutions and other organizations in implementing the SDI and the assignment of particular tasks and responsibilities to these organizations is an element of the governance of the SDI. In Spain, several research institutions played an important role in the establishment of the national SDI. In a research

project carried out by three different universities, different SDI technologies were investigated and demonstrated in order to provide technical support to the Spanish SDI. After this research project, universities and private companies actively contributed to the development of various components of the national and regional SDIs. In the latest SDI strategy of Finland (2016), 13 different measures were proposed to improve the availability of geospatial data and the usability of services. For each measure, several tasks were identified, of which some were assigned to non-government actors, including private providers of spatial data, universities, the Federation of Finnish Technology Industries, open source code developers and software developers, and education institutions. In the Netherlands, private companies and non-governmental organizations have always been actively involved in the operational development of the SDI through the organization of pilot projects and testbeds. After the launch of pilot projects on 3D in 2010 and on linked data in 2012, in 2015 a testbed on 'Spatial data on the web' was launched in which academic and private organizations were invited to explore the possibilities for publishing spatial data as a usable and integrated component of the web. Each of these examples show that the allocation of tasks and responsibilities should not necessarily be restricted to public sector organizations, as SDI implementation will benefit from also using the specific skills and knowledge, and experiences of non-government actors, such as businesses, research and education institutions and other organizations.

4.4. Creation of markets

A fourth element of the governance of SDIs is the creation of a market where producers and users can meet and geospatial data can flow from producers to users without obstacles. It is crucial to the development of SDIs to ensure that technological components allowing spatial data to be published, found, accessed and used are properly functioning, and are effective and efficient. In Europe, but also in most other parts of the world, public sector organizations as well as relevant private sector companies in the last 25 years have been active in the establishment of geoportals, the creation and publication of metadata and the setting up of different types of web services making it possible to search for data, to view the data and the download the data and access them directly. While each of these technological components have contributed to the creation of a market for geospatial data, legal, organizational and financial components or instruments were also introduced and implemented to improve the access to and exhange of geospatial data. The development of SDIs did not only contribute to better service delivery for the public sector, but also led to improved and new services/products by the private sector (ConsultingWhere, 2013; Oxera, 2013; Vancauwenberghe et al. 2014a; PWC, 2017). With regard to the governance instruments adopted, a distinction can be made between two main types of instruments: instruments focusing on the exchange of geospatial data within the public sector ('internal

market') and instruments focusing on the exchange of geospatial data to the external market, i.e. users outside the public sector.

The original aim of most national SDI strategies was to promote and stimulate data sharing within the public sector. In line with this, the primary aim of INSPIRE was to promote and facilitate the sharing of environmental spatial information among public sector organizations, within and between member states, and especially between member states and the European Commission. The establishment of partnerships and use of partnership or framework agreements is a commonly used instrument to facilitate the sharing of geospatial data since it reduces the effort of establishing individual bilateral agreements between producers and users. In Norway, more than 600 public sector partners from different administrative levels and from different domains are taking part in the Norway Digital cooperation, a contractual but voluntary framework allowing parties to share their data and participate in the development of a national geodata policy. Under Norway Digital, each partner pays an annual fee for the use of the data that has been brought in by all the partners. Data providers contributing data receive a reimbursement but are obligated to use these funds to improve their data and services. From the beginning, the SDI of the Flemish Region of Belgium was based on a partnership between all public authorities in Flanders at regional, provincial and local levels. In 2009, several other public entities such as local police departments and educational institutions were added to the partnership. While all public authorities in Flanders are obliged to contribute their geographical data into the SDI, they also have free of charge access to the geographical data sources and services of the SDI. In Sweden, the Geodata Cooperation was introduced in 2011 as a joint agreement on public data sharing. Signing the agreement and paying a small annual fee gives public authorities in Sweden access to more than 400 geospatial data products from different data providers. The partnership agreements in Norway, Flanders and Sweden are good examples of the use of partnership agreements to facilitate the sharing of geospatial data between public authorities.

Since the use conditions for geospatial data were often vague, not harmonized and difficult to understand, the Netherlands developed and implemented a standard national license framework for INSPIRE data, the 'Geo Gedeeld' framework, aimed at harmonizing conditions for use. In 2014, it was decided by the Dutch GI Council to bring the Dutch data policy in line with international standards, and a "Creative Commons, unless" principle was introduced, which means governments had to apply one of the Creative Commons licenses when making their data available, unless they wanted to impose specific conditions the Creative Commons framework does not cover. Other than the Netherlands, several other countries and public-sector organizations have explored and prepared the implementation of a standard license framework specifically especially to facilitate and promote the access to and use of their spatial data by non-government actors. In Germany, a pilot project to develop and test a standard license model, but also a simplified cost

model for spatial data services and an e-commerce payment method, was carried out in 2011 and 2012. In the United Kingdom, the development of a UK Government Licensing Framework (UKGLF) was an important element of the UK Open data strategy. The framework provides a policy and legal overview of the arrangements for licensing the use and re-use of public sector information, and has been endorsed as the licensing framework for the use of INSPIRE data. In Finland, the Ministry of Finance published an open data license recommendation for public administrations in 2014, recommending the use of the Creative Commons Attribution 4.0 License, and a significant part of the geospatial data are currently open. In Sweden, Landmäteriet recommends the use of Creative Commons Zero or Creative Commons Attribution 4.0, in case data providers would like to claim copyright to their data. The majority of Swedish public authorities provide their INSPIRE data without fees and several of them make use of Creative Commons licenses. Both the partnership and framework agreements and the national license frameworks make it easier for stakeholders to benefit from the main outputs of the SDI, i.e. the geospatial data and services that are made available through the SDI. It would be strongly recommended to apply even more 'internationally standardized' licenses to tap the full potential of spatial data available in Europe (van Loenen et al., 2012).

4.5. Inter-organizational culture and knowledge management

A fifth set of governance instruments is related to the management of human resources as a key component of SDIs. Also, the creation of shared visions, values and knowledge between actors and organizations enhances the governance of the infrastructure. To realize this, several instruments can be adopted, including guidance and support documents, awareness raising and inter-organizational communication and training and capacity building. Several European countries have created different types of documents to support and provide guidance to public authorities and other stakeholders in the development and implementation of the SDI. Germany published a first guideline on the architecture of the SDI in 2007, which was subsequently updated several times, with a stronger focus on the standards used in the implementation of the SDI. The document is seen as a best practice in describing and explaining the architecture of an SDI and the different relevant standards. In Slovenia, an INSPIRE glossary was created with definitions of 400 terms related to INSPIRE and its implementation. In France an 'INSPIRE for Dummies' manual was developed to introduce INSPIRE and clearly explains the different components and requirements of INSPIRE to non-experts. The Netherlands has a good tradition of creating and publishing documentation on the national SDI and methods to implement it. Among this documentation are several online WIKIs, of which one clearly explains how to start and succeed with the implementation of INSPIRE.

Before and especially after the adoption of INSPIRE, most European countries started organizing various awareness raising and knowledge sharing events on SDI and INSPIRE to inform stakeholders within and outside the public sector on ongoing and future SDI/INSPIRE developments. Some examples of these are the annual SDI Days in Croatia, the national INSPIRE conferences in Germany and, more recently, the awareness raising events on the implementation of INSPIRE in Turkey. Some countries have also jointly organized events to raise awareness and exchange experiences on SDI implementation. For instance, in 2013, Belgium, the Netherlands, the United Kingdom and Germany jointly organized the 'Powered by INSPIRE' conference to raise awareness and share experiences and good practices in implementing national SDIs and INSPIRE. Particular attention was paid to cross-border projects and applications, in which cross border harmonization of data was essential. Also, the Czech Republic and Slovakia have a tradition to organize an annual joint Czech-Slovak INSPIRE Conference, where experts and stakeholders from both countries can meet and be informed about the current status of INSPIRE implementation in both countries. In the northern part of Europe, cross-border cooperation between Norway, Finland, Sweden, Denmark and Iceland was formalized in 2007 in the Nordic INSPIRE Network, a platform for sharing knowledge, experiences and best practices. Besides joint webinars and other communication activities, the network organizes meetings every six months, held alternatively in one of the Nordic countries. At the European level, the European Commission organizes the annual INSPIRE Conference in which the latest developments are presented and implementing experiences are shared.

In addition to awareness raising and communication activities, several European countries also developed and implemented training and capacity building actions on SDI and INSPIRE. In Poland, a complete training cycle on the implementation of the INSPIRE Directive, addressed to employees of public sector organizations, was delivered between 2009 and 2012. The basic training program consisted of 30 hours of training and was attended by 4700 participants. Around 240 participants attended the expert training program, which consisted of 130 hours of training on INSPIRE. In Slovenia the Surveying and Mapping Authority launched a capacity building program for INSPIRE implementation in 2014 to raise awareness of INSPIRE and ensure the development, strengthening and maintenance of the capabilities necessary for implementing INSPIRE. In several countries, designing and implementing SDI and INSPIRE training programs took place in the context of European projects. For instance, several Portuguese public administrative organizations were actively involved in European projects related to INSPIRE, such as: eENVplus on environmental services for advanced applications within INSPIRE; GIS4EU, on the provision of interoperable datasets to EU communities; or Nature-SDIplus, a best practice network for European SDI in Nature Conservation. The Italian LINKVIT-project on 'Leveraging INspire Knowledge into Vocational Innovative Training' was fully focused on the provision of training material dealing with INSPIRE and other European Directives related to GI and

environment. The EU funded cross-border project, 'INSPIRATION - Spatial Data Infrastructure in the Western Balkans' project was aimed at promoting SDIs and coordinating their implementation in the Western Balkans. Core activities of this two-year project were capacity building and knowledge transfer, but also awareness raising and communication on SDI and INSPIRE in the countries of Albania, Bosnia and Herzegovina, Croatia, the Former Yugoslav Republic of Macedonia, Montenegro, Serbia, and Kosovo.

Important actors in the organization and implementation of these events for dissemination, awareness raising and capacity building and actions in different European countries are the national GI associations and networks, such as the national Spatial Data Network of Finland, Geoforum Denmark, French Association for Geographical Information (AFIGEO), the Organization for Geographical Information in Iceland (LISA) and many others. It is the main objective of the LISA Organization of Geographic Information in Iceland to promote cooperation in the domain of spatial data and increase the use and dissemination of geographic information in the public interest. Geoforum, the Danish forum for spatial information with members from both public authorities and the private sector, organized several whole-day seminars on the INSPIRE Directive and on metadata. In France, AFIGEO released a document specifying and explaining the different rules of interoperability to be respected for SDIs to be INSPIRE-compliant. The role of these associations in developing the national SDI is not restricted to communication, awareness raising and capacity building. In several countries, these associations participate in the decision-making structure of the national SDI to represent and serve the interests of non-government actors, while in some countries they also actively contribute to the implementation of particular SDI components.

4.6. Regulating and formalizing the infrastructure

The development and adoption of a proper legal framework can be considered as a governance instrument. In this context, it is important to refer to the ambition of transforming the European Union by relevant initiatives to national legislation, see e.g. INSPIRE Directive Commission of the European Communities (2007), PSI Directive (Commission of the European Communities (2003b; 2013), Digital Agenda for Europe (2010), and EU eGovernment Action Plans. In most countries, the legal framework on SDI originally consisted of thematic laws and regulations on the national cadastre and land registration and/or on access and dissemination of public sector information. Only in Portugal, one of the first European countries with a national SDI, the national SDI development was, from the beginning, strongly driven by a legal framework. Both the National System for Geographic Information (SNIG) and the National Centre for Geographic Information (CNIG) were created under the Decree-Law No. 53/90 of 13 February 1990. In the absence of a particular legislation on SDI, several countries made use of agreements to

support and formalize their national SDI developments. Especially in federal and other countries where lower administrative levels were very active in the production and management of geospatial data, the use of agreements to govern the relationships between different organizations and administrative levels was a common practice. In Italy, an agreement between the state and the regions was concluded in 1996 for the development of a common cartographic reference system. Four years later, in 2000, an Integrative Agreement was made between the national level, regional level and local level on the necessity to concentrate all efforts towards the coordination development of geographic data. With the Norwegian Geovekst Agreement signed in 2002 several partners at different administrative levels agreed to cooperate on establishing, updating and administrating a common primary set of geographic data. In Germany, the 2006 Administrative Agreement between the federal and state governments was a major step in the development of a national SDI. The original agreement of 2006 was amended several times, to take into account INSPIRE (in 2008) and to agree on funding the maintenance of common SDI components (in 2013). Also, the Swedish SDI was strongly built on agreements and arrangements between involved parties. Under the Spatial Data Cooperation, public authorities and other organizations sign agreements to get access to a collection of spatial data.

While Portugal was a frontrunner in the development of a legislative framework for the national SDI, also in some other European countries such a legislative SDI framework–or certain parts of it–was developed before the adoption of the INSPIRE Directive in 2007. In Austria, the Coordination Office for Geographical Information and Geographical Information systems in the Federal Government was established by a Federal Order in February 1998. In Switzerland the Federal Act on Geoinformation of 5 October 2007 is the most important piece of legislation on the national SDI. The Act is fully INSPIRE compliant and even goes beyond the INSPIRE Directive, although it is not an actual transposition of the Directive, since Switzerland is not an EU Member State. In most European countries, however, there was no formal SDI in place before the implementation of INSPIRE, and the transposition of the INSPIRE Directive into national legislation was the first step in the creation of a legal framework for the national SDI. One of those countries was Slovenia, where the Infrastructure for Spatial Information Act of 2010 transposed the INSPIRE Directive in Slovenian national legislation and was the start of the development of a legal framework for the national SDI. In Latvia, the INSPIRE Directive was transposed into national law with the 2010 Law on Geospatial Information and several supplementary regulations were adopted in 2011 to regulate particular aspects of INSPIRE. These include a regulation on the mandatory content of geospatial data, a regulation on the rules for using geospatial data and a regulation for the national common geospatial information portal. In several countries in which a legal framework was already in place, the transposition of the INSPIRE Directive provided the opportunity to revise and update existing legislation. For instance, the Portuguese Decree-Law of 1990, one of the first

pieces of SDI legislation in Europe, was revised in 2009 by the new Decree-Law 180/2009 which also transposed the INSPIRE Directive into national law. More recently, several countries, such as Luxembourg and Slovenia were requested by the European Commission to amend the original INSPIRE transposition law on particular points.

While the rules and regulations of an SDI can take many different forms, from legal acts adopted by the parliament over executive orders or decisions to multi-lateral or bi-lateral agreements, the set of SDI rules and regulations is also very wide and diverse. The laws and regulations involve rules on data, standards, funding, coordination, allocation of tasks, etc. As a result, the development and adoption of a legal framework on SDI contributes to the governance of the SDI in many different ways. In most cases, the legal framework formalizes the key principles of governance and the associated governance instruments into a binding framework as well. Most legal frameworks on SDI determine and regulate the creation of governance structures, the establishment and tasks of coordinating bodies, the division of tasks between different actors and/or the creation of internal and external markets. In some countries, even separate legislation is in place to further regulate some of these governance instruments, such as the tasks and operation of the central coordinating body or the composition and tasks of the decision-making bodies.

5. DISCUSSION

The previous section analysed how SDIs in Europe have been governed using six sets of governance instruments to ensure good governance of their national SDIs. While each set consisted of multiple governance instruments, the analysis showed how the use of each of these instruments has expanded and evolved in the past 25 years, partly influenced by the adoption and implementation of the European INSPIRE Directive. Table 2 summarizes the main trends and developments in the use of these six categories of governance instruments and the impact of INSPIRE on each of the instruments.

The data in Table 2 shows how governance instruments commonly used in the public sector are also employed in the governance of SDIs. From an organizational point of view, the main challenge facing the implementation of these SDIs is the challenge of reconciling the needs and interests of different organizations and stakeholders involved in these SDIs. Since the development and implementation of SDIs can be considered as a governance problem, typical governance instruments can be used to address this problem. Different actors and stakeholders are involved in decision-making on the infrastructure through the establishment of appropriate decision-making structures. These structures in most cases consist of a central decision-making board, which sometimes is complemented with an advisory board, for instance to allow non-government actors to contribute to the

decision-making process. Decision-making on more practical or operational issues often takes place in separate working groups focusing on particular aspects or particular data themes. This all indicates that there is a change over time in governance structures from more centralized structures to more dispersed shared structures.

Strategic management of the SDI consists of two key processes, i.e. strategic planning and strategic evaluation. The main outputs of the planning process are the many different types of SDI strategies and action plans, of which some clearly focus on the actual implementation of different SDI components, while others pay attention to the use of the infrastructure and the integration of the SDI in e-government. While evaluation of national SDIs in Europe is strongly driven by the INSPIRE Monitoring and Reporting process, in some countries additional effort is directed towards measuring and monitoring the readiness of the different components, the accessibility and availability of spatial data, the use and users of the infrastructures, or the benefits achieved through the SDI.

Another way of organizing and enhancing the contribution of different actors is through the allocation of tasks and responsibilities. It is interesting to note that in several countries, non-government actors (as key data providers or users) were also involved in the development of the national SDI from the beginning. The allocation of tasks primarily focuses on data providers, who are often categorized according to the data sets and data themes they are responsible for. Also, the extent to which these data providers themselves are responsible for tasks such as the creation of metadata, the setting up of network services, the harmonization of data and the implementation of data sharing agreements, can be variable and is an aspect of task allocation. The SDI governance instruments are still mainly employed by the public sector. However, there is a notable shift happening. The private sector and citizenry are becoming more significant contributors to steering and regulating further SDI development, even though their formal roles and responsibilities are still rather limited. Therefore, it is still too early to indicate signs of a more fundamental governance shift, i.e. state-based (hierarchical) SDI governance to other forms of more shared or market-oriented governance. Moreover, crowd-based, citizens-based or self-governance phenomena, from which open infrastructures would be assumed to emerge, are still rather absent in the current national SDIs. Another element of task allocation is the assignment of an SDI coordinating body, responsible for the strategic and operational coordination of the infrastructure.

Although the creation and regulation of internal and external markets is an instrument that can be used in the governance of many policy issues, it is of particular importance in the governance of SDIs, which in essence are about organizing the market of producers and users of geospatial data. SDIs can be considered as a multi-lateral solution to the problem of acquiring geospatial data,

as an alternative to traditional more unilateral or bilateral approaches. While partnerships and framework agreements were used to optimize the sharing of data within the public sector, the development of standard licenses and license frameworks contributed to improving the access to these data for users outside the public sector, such as businesses, research institutions, non-profit organizations but also citizens.

Commonly used instruments for inter-organizational culture and knowledge management such as training and capacity building, awareness raising and information sharing events, and guidance documents are also deployed in the governance of national SDIs. Despite these efforts, it appears that organizational cultures are pretty rigid. It remains difficult to step over long-established boundaries (de Vries et al., 2015; 2016). This is clearly hindering the freedom of exchange and sharing of geospatial information.

To regulate and formalize the central principles of the SDIs and the associated governance instruments into a binding framework, European governments originally relied on collaborative agreements. With the adoption of the INSPIRE Directive, there was a need to develop a national legal framework on SDIs. While in some countries the legal framework did not go further than transposing the INSPIRE Directive, other countries used the Directive as an opportunity to also incorporate other elements of their national SDI into binding legislation.

Table 2 also clearly shows the impact of INSPIRE on each of these sets of governance instruments. It is important to note that the extent to which, and the manners in which INSPIRE influenced or determined the governance of the national SDIs, is highly variable across countries. In some countries, governance of the national SDI was rather weak or even absent prior to INSPIRE and the INSPIRE Directive was a key driver for the development and implementation of the different governance instruments. In other countries, the implementation of the different governance mechanisms started several years before the adoption of INSPIRE, and thus governance of SDI was already occurring outside the scope of INSPIRE. However, also in these countries, INSPIRE clearly affected the governance of national SDIs. The impact of INSPIRE is most pronounced in the strategic evaluation of the infrastructure, where the INSPIRE Monitoring and Reporting obligations clearly determined the monitoring and assessment activities of countries; in the regulation and formalization of the infrastructure, where all countries had to transpose the Directive into their national legislation; and in the allocation of tasks, where INSPIRE required the assignment of a national contact point and tasks were often assigned in accordance with the 34 data themes of INSPIRE. In addition, other governance instruments, such as national decision-making structures, instruments for the creation of markets and inter-organizational culture and knowledge management, undoubtedly were affected by the INSPIRE Directive.

Table 2. Use of different SDI governance instruments in Europe and the impact of INSPIRE

Governance instruments	Trends and developments	Impact of INSPIRE
1. Collective decision-making • SDI decision-making boards • SDI advisory bodies	Participation in decision-making restricted to (central) government versus involvement of all stakeholders; Governance structures become more dispersed/shared; Often separate advisory bodies and/or distinction between strategic level and operational level	Decision-making on INSPIRE implementation integrated in existing decision-making structures or creation of separate decision-making and/or advisory bodies on INSPIRE
2. Strategic Management • SDI strategies and action plans • SDI monitoring and evaluation	Policy documents on the need for an SDI followed by the development of actual SDI Strategies; Top-down versus bottom up planning processes; Efforts to monitor and assess the NSDI	INSPIRE as part of national SDI Strategy or creation of separate INSPIRE Strategy or Action Plans; Yearly monitoring and 3-yearly reporting on progress of INSPIRE implementation
3. Allocation of tasks and responsibilities • Creation of SDI coordination bodies • Definition of roles and responsibilities • Involvement of non-government actors	Assignment of the role of SDI coordinator to existing public bodies the creation of a new organization; Definition of different roles in SDI implementation with specific responsibilities Private sector and citizens initiatives are increasing (see VGI, crowdsourcing, social media, etc.)	Assignment of national contact point for INSPIRE; 34 INSPIRE themes used for identification of responsible data providers and assignment of roles and responsibilities
4. Creation of markets • Partnerships and framework agreements • License frameworks	Focus first on data sharing within government and use of partnership agreements; Standard license frameworks for facilitating sharing of data to users outside the public sector	Main focus of INSPIRE Directive also on data sharing within the public sector; Licensing templates provided by INSPIRE; Standard license framework for INSPIRE data
5. Inter-organizational culture and knowledge management • Guidance and support documents • Awareness raising • Training and capacity building	Different types of guidance documents on SDI implementation; Awareness raising and capacity building events, with strong input from national GI associations; Pretty rigid cultures making it very difficult to step over long established boundaries	Guidance documents with particular focus on INSPIRE implementation; National and multi-national INSPIRE events; National and multi-national training on INSPIRE
6. Regulating and formalizing the infrastructure • Agreements • SDI laws and regulations	Originally strong use of agreements to regulate the infrastructure; Development of SDI legal frameworks prior to INSPIRE or to transpose INSPIRE Directive	Transposition of INSPIRE Directive into national legislation; INSPIRE as driver for updating and/or extending national SDI legislation

6. CONCLUSIONS

The aim of this paper was to analyse how national SDIs in Europe have been governed in the past 25 years, and how the introduction of INSPIRE affected the governance of these national SDIs. The analysis was mainly exploratory and descriptive, using a 'governance instruments' based approach as introduced by Verhoest et al. (2007). The analysis mainly focused on the presence of each of the governance instruments in different countries and on the different ways in which these instruments have been implemented. These governance instruments, mainly applied in the public sector, were also evidently applied in the governance of national SDIs in Europe. It is also noteworthy to stress that the –governance of SDI is an ongoing process as organizations are continually 'learning by doing'.

Our analysis also showed that the INSPIRE Directive brought changes to existing governance instruments of certain countries. Therefore, it can be argued that INSPIRE had an important impact on the governance of national SDIs in Europe. Summarizing our analysis, we can distinguish three main periods of implementation. In the first period (until 2000), a small group of countries started with implementing and adopting some governance instruments, especially the creation of coordinating bodies, decision making structures and strategic plans. In the second period, the example of these front running countries was followed by a growing group of countries, who could benefit from the experiences of the other countries. The adoption and implementation of the European INSPIRE Directive can be considered as the start of a third period, in which remaining countries started–and to a certain extent were obliged to start–the SDI governance instruments.

The analysis presented in this paper contributes to a better understanding of SDI governance changes by providing empirical evidence on the use of different governance instruments in the development and implementation of national SDIs in Europe. The analysis offers valuable insights into the importance of governance in SDI development and implementation. It proves that the different governance instruments all aimed to extend and strengthen the involvement of various stakeholders in the development and implementation of the national SDI. These instruments allow for different stakeholders to contribute to decision-making on the SDI, have their own tasks and responsibilities in implementing the SDI, facilitate the necessary knowledge, skills and competencies to perform their tasks and, finally, also have access to the data and services provided by the SDI. The most important trend identified in our analysis is a continuous move towards increasing the effective involvement of an increasing number of stakeholders. As for all other SDI components (both technological and organizational), the implementation of appropriate governance instruments should not be seen as an end in itself. Rather, effective governance of the infrastructure should lead to or contribute to an

increased availability of geographic data and services, a better use of these data and services and the realization of different types of benefits.

The analysis relied on a documentary analysis of existing scientific and policy documents. By combining different sources of information, we aimed to increase the reliability and validity of our results. The INSPIRE country reports were used as a first source of information, mainly to detect relevant governance practices and instruments. These reports are an interesting source of information, since they cover three different periods, are available for all countries implementing INSPIRE and address several governance issues. However, since the information presented in the country reports can be incomplete or even incorrect in some cases, other sources of information were used to validate and complement the information from the INSPIRE country reports. These other sources of information include other studies and scientific reports on national SDIs in Europe and national policy documents, such as strategies, action plans, policy reports etc. The use of official national documents in combination with information from other sources increases the validity and reliability of our results, allowing us to provide a complete and correct answer to our central research question.

The results and findings presented in this paper can be a starting point for further research to investigate the precise impact of different governance instruments, and the ways in which they are adopted, on the performance of the SDI. It could be interesting to identify a set of national SDI typologies (e.g. strong, medium, light governance implementations) and identify the ingredients of such. Further research could also investigate the differences between the different generations of SDI governance, and the impact of the historical governance traditions and geographical context. Investigating these causal relationships and effects will require other research methods, such as comparative case studies through in-depth interviews and/or executing a limited number of case studies as (country) examples showing how INSPIRE influenced the governance structure or examining how an evolved governance structure caused a notable change in the management of geographic information. Moreover, additional research is needed to value the impact weights of SDI developments and e-governance initiatives (such as Digital Agenda for Europe) and INSPIRE and compare against each other.

Before INSPIRE, the governance of national SDIs was about managing relationships and dependencies within countries, between different data producers, between producers and users and between different administrative levels. In some countries, SDI governance was, from the beginning, also about managing relationships between government and non-government actors, such as businesses, research institutions and non-profit bodies. INSPIRE added a new level of relationships and dependencies, i.e. the European level, that meant existing governance instruments had to be adapted or revised completely, or new

governance instruments had to be created. In recent years, especially the need for governance of the relationships with non-government actors, including citizens, has increased with the move towards open data, open government and crowdsourcing. Since other governance challenges still remain in place, the effective governance of SDIs becomes more important than ever before.

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