Tackling the Capability Gap in Utility Firms: Applying Management Research to Infrastructure Sectors

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Abstract

Infrastructure services such as electricity, water supply, sanitation and transportation are crucially important in our economies. Despite this importance, utility firms have found little attention in management research. This is surprising because the lack of adequate organizational structures, skills and specialized managerial know-how is an emergent issue and main challenge for many utilities worldwide. We propose a capability-based framework to explain performance deficiencies in utilities. The framework elaborates why capability gaps emerge and persist, and how this, in turn, affects performance. The insights from this framework go beyond the conventional explanations of the transaction cost and agency approaches, which suggest that appropriate incentives and regulatory structures increase the performance of public utilities immediately or after a short adaptation process. In contrast, capability gaps – understood as an inadequate availability of competences, expertise and experience – tend to have long-lasting effects because capabilities take time to develop. Especially if capabilities are highly tacit, correcting for a gap and rebuilding capabilities take time due to the involved learning processes. Consequently, performance deficiencies affect utility firms more severely than expected by traditional approaches. Deriving from the proposed framework, we discuss possible strategies that utility firms can implement to respond to capability gaps.

Keywords: capability gap, public utilities, infrastructure sector, capability building, tacit knowledge

JEL subject codes: J24, L32, L94, L95, M50

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The Sustainability Science Program at Harvard's Center for International Development harnesses the University's strengths to promote the design of institutions, policies, and practices that support sustainable development. The Program addresses the challenge of sustainable development by: advancing scientific understanding of human-environment systems; improving linkages between research and policy communities; and building capacity for linking knowledge with action to promote sustainability. The Program supports major initiatives in policy-relevant research, faculty research, training of students and fellows, teaching, and outreach. See http://www.hks.harvard.edu/centers/cid/programs/sustsci.

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1 Introduction

Infrastructure services such as electricity, water supply, sanitation and transportation are crucially important in our economies. Social welfare and economic prosperity are based on the quality of the services in these sectors. In addition to being central input factors for virtually all industries, the production output of infrastructure sectors itself contributes substantially to the GDP. Despite this importance in the economy and a large set of literature focusing on regulatory issues (e.g., Armstrong and Sappington 2006; Guthrie 2006; Gratwick and Eberhard 2008; Joskow 2008; Delmas, Russo, Montes-Sancho and Tokat 2009; Ménard 2009), utilities and infrastructure sectors have found little attention in management research. This is surprising because the lack of adequate organizational structures, skills and specialized managerial know-how is an emergent issue in different infrastructure sectors and a main challenge for many utility organizations worldwide (OECD 2006, 2007; Urban Land Institute and Ernst & Young 2007).

In many countries, two key issues in infrastructure sectors are the declining service quality and the failure to secure funding for the massive investment needs. These problems indicate that utilities are confronted with substantial challenges in both, operating and managing the built infrastructure and strategic planning to maintain, renew and expand infrastructure assets to meet future demands. As a result, utilities are facing enormous pressure from customers, policy-makers and tax payers to increase efficiency.

Drawing on principal-agent and transaction cost approaches, research on infrastructure sectors has identified regulatory and contractual issues as main causes for inefficiencies and suggested changes in the incentive structures to improve performance (e.g., Joskow 2002; Gómez-Ibáñez 2003, 2007; Irwin and Yamamoto 2004; Armstrong and Sappington 2006; Guthrie 2006). One of the underlying assumptions in the two approaches is that if appropriate incentives and regulatory structures are implemented, performance increases immediately or after a short adaptation process. However, in many countries infrastructure sector reforms are incomplete, have been implemented much slower than expected, experienced resistance from sector players and even caused the reversal of the reform process (OECD 2006; Joskow 2008). Consequently, the performance of utilities often declined further and led in some cases to substantial failures in providing infrastructure services (e.g., repeated electricity blackouts and continuously unreliable supply of clean water). Thus, performance problems tend to become more severe and last for significantly longer time periods than expected by traditional approaches.

In this paper, we propose a capability-based framework to explain performance deficiencies in infrastructure systems. The framework elaborates how a changing external environment may create gaps between the required and available capability structure of utilities and how this, in turn, affects performance and the quality of service delivery. This framework enables in particular to measure the time and effort necessary to close a capability gap by implementing capability related management interventions (i.e., maintaining, reconfiguring, building) to restore and improve the utilities' performance.

A capability gap represents an inadequate availability of knowledge, expertise and experience. This leads to deficiencies in the performance of a utility's tasks. A gap can emerge if the actual capability structure diminishes while a task remains largely unaltered. Or alternatively, a mismatch may occur if changes in a task lead to increased requirements that cannot be met with the available capabilities. The time and effort to correct for the gap depends on specific characteristics of the capability structure that we specify as scale, scope and degree of tacitness.

In our framework, the emerging capability gap explains not only the performance decline but also the persistence of performance deficiencies. The underlying lack of knowledge, expertise and experience tend to have a long-lasting effect because capabilities are not readily available once they are lost or because they are hard to build up. Rebuilding and acquiring capabilities takes even more time and requires specific implementation strategies, if knowledge is highly tacit and based on long-time experiences. In fact, the specific characteristics of a task's capability structure determine decisively what strategies a utility need to implement to regain an adequate performance level. For example, if accomplishing a specific task requires tacit knowledge, it is hardly possible to acquire the capabilities externally. They rather need to be built internally in a learning-by-doing process. Summarizing, we argue that focusing on the underlying processes of transforming capability structures, we may provide more adequate explanations about the persistence of performance deficits even under conditions of allegedly improved incentive structures and context conditions.

Research on the role of capabilities in utilities and infrastructure sectors has been limited so far. There are some exceptions. For example, research has shown that changes in the regulatory environment drive organizational restructuring processes, which affect the resource base of established utilities and result in a short-term decline of efficiency (Dyner and Larsen 2001; Delmas and Tokat 2005; Delmas, Russo, Montes-Sancho and Tokat 2009). Also, deregulation has reduced restrictions allowing utilities to adopt new strategies and build capabilities to improve environmental performance (Delmas, Russo and Montes-Sancho 2007; Delmas, Russo, Montes-Sancho and Tokat 2009). Other contributions have found that public utilities may overcome capability gaps by implementing appropriate strategic planning processes (Dominguez, Worch, Markard, Truffer and Gujer 2009). Yet another stream of research has highlighted how building specific capabilities to manage the regulatory environment influences the performance of utility firms (Bonardi, Holburn and Vanden Bergh 2006; Holburn and

Vanden Bergh 2008; Oliver and Holzinger 2008). We extend this line of research and advance the capability perspective to the research on utility firms and infrastructure sectors.

The topic in this paper is in line with recent calls for advancing management research in public sectors and in contexts strongly influenced by public policy, respectively (Kochan, Guillen, Hunter and O'Mahony 2009; also Kelman 2007). The emerging interest was prominently formulated in a series of articles in an Academy of Management Journal special issue on "Public policy and management research: Finding the common ground" in December 2009 (e.g., Pil and Leana 2009; McDermott, Corredoira and Kruse 2009; Cuervo-Cazurra and Dau 2009). There is a broad literature that has shown that public policy changes the external environment of firms and therefore affects organizational behavior, structure and strategy (e.g., White 2000; Haveman, Russo and Meyer 2001; Russo 2001; Marquis and Huang 2009). We add to this literature by outlining a framework for analyzing in detail how changes of the external environment affect the capability structure of firms, and how this in turn influences performance and triggers specific responses at the organizational level to maintain, reconfigure and build competences and skills.

In the following chapter, we introduce five features that are characteristic for infrastructure sectors. In chapter 3, we briefly review which of the features are of major concern in the principal-agent and transaction cost economics literature. Then, we discuss the sector features that affect the capability structure of utilities and therefore have potentially an impact on performance. Chapter 4 introduces the capability argument in detail and develops a capability-based framework for the analysis of performance deficits in utility firms. In chapter 5, we discuss the implications of the framework for further research on utilities and infrastructure sectors and conclude the paper.

2 Infrastructure Sector Specificities

Infrastructure sectors show several features that are distinct from other industries. The features include high capital needs, substantial economies of scale and scope with the networks forming a natural monopoly, specific investments with strong interdependencies between the different components of large technical systems, and basic service provision. In combination, these features produce implications that make infrastructure sectors different from other sectors (cf. Dominguez, Worch, Markard, Truffer and Gujer 2009, pp. 33-34; Spiller 2010, pp. 148-149; Künneke, Groenewegen and Menard 2010; Markard 2011). These differences have found little attention particularly among management scholars. Table 1 summarizes the features of infrastructure sectors and outlines what implications derive from these features. The table also summarizes the key issues that different theoretical perspectives have identified and what they suggest to address these problems, which are discussed in more detail in the next section.

First, infrastructure developments have high capital needs with long time frames to recover the investment costs, which imply that these investments are related with high uncertainties.

Second, in addition to high capital needs, investments in infrastructure sectors are also highly specific. Physical infrastructures with networks and plants form large technical systems with strong interactions between the different components. Once the systems are built, they can be hardly used in another context than for the applications they were initially established.

Consequently, the asset specificity is very high. This implies—in combination with the long amortization cycles—that there are significant path dependencies.

Third, economies of scale and scope are important features in infrastructure sectors. Economies of scale are particularly relevant in the context of physical networks. The network character is the central feature that economists have used to define utility sectors and distinguish them from other industries. The fixed costs are high and the marginal costs of an extra unit of service delivery are low. Consequently, the average cost is significantly above the marginal cost to provide one unit of the utility good. A monopoly is the only market form that allows a company to operate under this cost structure productively. Besides substantial economies of scale, infrastructure sectors are assumed to have also economies of scope with advantages of coordinating different aspects of the value chain (e.g., generation, transmission, distribution) or different utility services (e.g., water supply, wastewater, electricity) within one organization. However, the extent of economies of scope in infrastructure sectors is still under debate in the literature with unclear empirical results.

Fourth, infrastructure industries provide basic services. One implication is that utilities have in addition to providing services effectively and efficiently also to accomplish other objectives, namely to deliver available, reliable and affordable infrastructure services. Furthermore, environmental concerns are increasingly important, particularly in areas such as electricity, water supply and sanitation. Thus, utilities have to pursue multiple objectives. Additionally, accomplishing these objectives is often closely linked to and embedded in political processes.

Finally, there is a further implication of utilities providing basic services. This is that utility organizations cannot just withdraw, if providing the services is difficult or even economically not viable. In these cases, they cannot strategically change and adopt better business opportunities that are unrelated to the task of providing the basic services. Utilities have also not the option to specialize in the most profitable areas. For instance, a power utility can hardly decide to cut down supply substantially and only generate and supply electricity from the sources with the highest margins. Or a local wastewater utility cannot opt to treat only industrial wastewater and cut down the sanitation services for private households because this would be a more profitable business. This distinguishes infrastructure sectors from other industries, where companies can—in general—change their strategic focus and disinvest in providing specific products and services and decide for other ones. Utilities do not have this option. This implies that they have to adjust their operations and provide services under the given market, business and regulatory environment.

Table 1 about here
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3 Theoretical Approaches

There are two theoretical approaches with a long tradition in analyzing infrastructure sectors and explaining performance deficiencies. Both principal-agent and transaction cost approaches emphasize asymmetric information as underlying reasons for poor service delivery. While principal-agent arguments see occurring problems predominantly due to the monopolistic position of utilities, transaction cost reasoning refers mainly to two other infrastructure sector specificities, namely high uncertainty and asset specificity (see table 1). As a solution, contributions from the two research traditions suggest optimal incentive mechanisms and adequate contractual and institutional designs to mitigate the asymmetric information problems. The implicit assumption is that implementing the right incentives and contractual mechanisms has a direct positive impact on the utilities' performance without a substantial time lag.

We introduce a capability approach to explain performance deficiencies in utility firms and why these problems are more persistent than expected by the traditional approaches. In contrast to contractual concerns, we argue that changes in the infrastructure sector environment can create a capability gap and therefore affect the performance of utility firms. An insufficient capability structure may emerge in our approach due to the impact of the above identified infrastructure sector features, namely high uncertainty, high asset specificity with strong interdependencies, economies of scale and scope, unclear priorities if utilities have to accomplish multiple objectives and limitations in leveraging the firm's capabilities in related business activities (see table 1). By considering these features and explaining how they affect the capability structure of utilities, we broaden the range of infrastructure sector specificities that contribute to performance deficiencies but have remained largely unaccounted for in the literature.

3.1 Principal-Agent Approaches

Traditional principal-agent approaches play a prominent role in analyzing infrastructure sectors (e.g., Baron and Myerson 1982; Joskow and Schmalensee 1986; Laffont and Tirole 1993; Armstrong and Sappington 2007). A main concern of this literature is the natural monopoly situation (cf. table 1). Since monopolies set prices too high, utilities need to be regulated. The need for regulation infers a principal-agent problem with asymmetric information. The regulator tends to be less informed than the regulated monopolist about the demand of the services, the current cost structure and the potentials for a lower future cost structure (Armstrong and Sappington 2006, p. 330; Fremeth and Holburn 2009). Agency theory has suggested various incentive designs, e.g., rate of return and price cap regulation, to deal with the asymmetric information problem. Solving this problem is relevant for price setting, investments, contracting with suppliers, and in the relationship with shareholders. Incentives are expected to have a direct and largely immediate impact on the utilities' performance.

Price setting is one of the key issues in these approaches. The principal-agent literature aims therefore to identify design principles on how to choose an optimal regulatory frameworkthat allows policy makers introducing competition into infrastructure industries or incentivizing the monopolist to disclose the true costs of service delivery. Finding an adequate price setting mechanism is basically the attempt to balance the trade-off between allowing the monopolist supplier sufficient rent and enforcing efficiency at the same time (Armstrong and Sappington 2006, 2007; Puller 2007).

In addition, the role of regulation on investments is another area that has been examined by scholars applying principal-agent approaches (see Guthrie 2006). The argument is that an inadequate regulatory framework may result in insufficient levels of investments. The investments can be too high but more likely to be too low. Thus, inadequate regulatory frameworks explain investment failures. This is in line with the property-rights theory

(Grossman and Hart 1986; Hart and Moore 1990), which predicts that incomplete contracts due to asymmetric information distort investment decisions ex-ante and therefore lead to underinvestments.

Yet another line of principal-agent arguments in the context of utilities regards the procurement of contracts between the utilities and their suppliers along the value chain. Prominent examples of this research are on coal-contracting and the implications of long-term versus arms-length contracts (Michaels 2006). Results from this research indicate that the more specific the coal requirements for power generation are, and hence the more difficult it becomes to mitigate information asymmetries about coal quality, the more likely it is that coal supply and generation are integrated.

Finally, principal-agent approaches are applied to analyze various aspects of the shareholder-management relation. Important topics include the various forms of management contracts between the shareholders, which are often municipal, provincial or national departments, and the utility service providers (Gómez-Ibáñez 2003). Also performance contracts gain increasingly interest and are assessed with a principal-agent lens (Gómez-Ibáñez 2006, 2007).

3.2 Transaction Cost Economics

The transaction cost economics literature has extensively researched phenomena in infrastructure sectors (e.g., Joskow 2002; Spiller and Tommasi 2005). Transaction cost reasoning assumes—similarly to principal-agent arguments—that asymmetric information generates problems, which lead to suboptimal performance outcomes. While agency approaches are concerned with the monopoly situation, the transaction cost argument refers to uncertainty issues and high asset specificity, which are both typical features of infrastructure sectors (cf. table 1). High uncertainty and asset specificity induce hold-up problems. Hold-up problems occur in interactions between different players in infrastructure sectors (e.g., between the generator and coal suppliers, utilities and the regulator, and/or the regulator and policy makers). Adequate contractual and institutional designs are assumed to have a direct impact and be effective immediately.

A key area of transaction cost research in utility sectors is to analyze the trade-off between mitigating hold-up problems through contracts that are as detailed as possible, and at the same time leave enough space for contract partners to adjust to changes caused by the high uncertainty in the sector. For example, the procurement problem refers to the situation in which a utility has to balance the incentive to reduce costs and improve efficiency versus the incentive to remain flexible enough to adapt to changes and therefore avoid costly renegotiations under uncertainty. In this sense, the transaction cost approach addresses the trade-off between static efficiency and dynamic efficiency. Established regulatory frameworks address often only one side of the trade-off. Competitive bidding tends to solve the efficiency problem but fails to respond optimally to ex post adaptation. In contrast, cost-plus approaches tend to respond to emerging changes after signing the contract but efficiency losses occur (see Tadelis 2009).

Similar contractual issues apply to other contexts of managing utilities. This includes investment contracts and processes of contracting out but also to running and operating utilities. Contract partners may approach these issues by choosing between different contract options (see Gómez-Ibáñez 2003, p. 33).

Recent contributions have also applied transaction cost arguments to address the infrastructure sector feature that utilities provide basic services and have therefore often to pursue multiple objectives (Spiller 2010). The concern in this line of research is that governments through regulatory agencies can hold-up utilities by threatening them to change the regulatory framework. Similarly, informed third parties tend to influence the regulatory framework by shaping the policy process to their advantage by exploiting the asymmetric information situation. In contrast to most principal-agent and some of the more traditional transaction cost approaches, this line of literature does not assume that governments and regulatory agencies can contribute to solve asymmetric information, high uncertainty and asset specificity. It rather argues that government agencies are one major source of problems in infrastructure sectors. The implication from a transaction cost perspective is to set up adequate institutional conditions.

3.3 Capability Approach

Organizational resources and capabilities have been extensively discussed in the management literature (e.g., Barney 1991; Teece, Pisano and Shuen 1997; Gottschalg and Zollo 2007; Kale and Singh 2007; Newbert 2007; Barney, Ketchen Jr. and Wright 2011). In line with this literature, we define capabilities as competences and skills to perform distinctive activities and tasks in organizations. More generally, capabilities comprise a set of knowledge that underlies the competences and skills. The central interest of the capability approaches is to understand how firms build, configure and maintain competences and skills to increase efficiency and ultimately improve their performance and competitive position (e.g., Newbert 2008).

Despite the major performance deficiencies in infrastructure sectors, only few studies in the management literature have focused on utility firms, of which even less have paid attention to capabilities in the context of utilities and public service management. Utility-related topics that the management literature has addressed include the impact of regulation on firm performance (Dyner and Larsen 2001; Delmas and Tokat 2005; Delmas, Russo, Montes-Sancho and Tokat 2009), the adoption of differentiation strategies (Russo 1992; Delmas, Russo and Montes-Sancho 2007), new entry into utility sectors (Russo 2001), innovation management (Markard and Truffer 2006), variations in competitive behavior (Zhang and Gimeno 2010), the capacity of managing contracts (Brown and Potoski 2003), the role of strategic planning tools for closing capability gaps (Dominguez, Worch, Markard, Truffer and Gujer 2009) and the effectiveness of political strategies in regulated industries (Bonardi, Holburn and Vanden Bergh 2006; Holburn and Vanden Bergh 2008; Oliver and Holzinger 2008).

We contribute to this literature and conceptualize the systematic influence of infrastructure specificities on utility firms. We argue that infrastructure sector features affect the capability configuration in utility firms in specific ways and lead potentially to the emergence of capability gaps (cf. table 1). As a result, performance declines. For example, high investment needs with long time frames, which are typical for infrastructure sectors, produce high uncertainty for utilities in recovering investment costs and whether the established technologies remain adequate under changing market conditions. From a transaction cost perspective, high uncertainty induces hold-up problems between contract partners with the corresponding frictions and costs. From a capability perspective, high uncertainty implies that there is a large number of possible contingencies about how the business environment develops. Capability gaps tend to emerge because it is unfeasible to build and maintain the required capability structure for all possible contingencies. Even if the asymmetric information situation causing hold-up problems is solved through adequate institutional settings, uncertainty tends still to produce capability gaps in utilities, which result in a diminished performance.

As this example shows, applying a capability perspective provides a distinct explanation for performance problems in infrastructure sectors. It shifts the focus from contractual concerns to the composition of competences and skills as drivers of firm performance. The main argument in this paper is that even if principal-agent and hold-up problems are mitigated, inefficiencies in utility firms may emerge due to capability gaps that result from the influence of specific infrastructure sector features. In the following section, we describe in more detail why different infrastructure sector specificities cause capability gaps to emerge.

We further extend this argument and show that a capability perspective may also explain the persistence of performance deficiencies in utilities. Principal-agent and transaction cost reasoning expects the performance to improve fast, if the implemented contractual and institutional designs are adequate. We assert that it takes—partly extensive—time and effort for a utility to respond to an emerging capability gap and accumulate the required set of skills, competences and experience. Precisely, we argue that the scale, scope and degree of tacitness of capabilities are the central underlying dimensions that determine the required effort and time to close a capability gap. In this sense, we provide an explanation why utilities may show persistent problems in regaining adequate performance levels for the provision of services, even if effective incentive mechanisms are promptly established.

4 A Capability-Based Framework for the Analysis of Utility Firms

This chapter develops a capability-based framework to systematically examine how infrastructure sector specificities tend to influence the capability structure of utilities and creates capability gaps. The framework explains the decline of performance and the persistence of performance deficiencies in utility firms. In chapter 4.1, we introduce two constructs to capture emerging capability gaps. These constructs allow us in 4.2 to explain the emergence of capability gaps as a result of the impact of specific infrastructure sector features. In chapter 4.3, we conceptually identify three characteristic dimensions of capabilities and outline how these dimensions cause capability gaps to persist. Figure 1 presents the developed framework. Based on this framework, we discuss in chapter 4.4 possible responses of utilities to maintain, reconfigure and rebuild capabilities.

We understand capabilities in the context of performing tasks. Tasks and the organizational teams that perform the tasks are the main level of analysis in this paper. Tasks play an important role as a central unit of analysis in several streams in the organization theory (Baldwin and Clark 2000; Murmann and Frenken 2006; Baldwin 2008; Srikanth and Puranam 2011), management (Porter 1986; Siggelkow 2001) and economics literature (Marengo and Dosi 2005). Performing a task requires a bundle of capabilities, i.e., competences and skills that are jointly enacted to achieve a specific output. The output can be the input for another task performed within the same firm or a product or service that the firm sells. With this focus on tasks, we refer to a task's capability structure when we use the notion capability structure in the following sections.

4.1 Conceptualizing Capability Gaps

To conceptualize capability gaps, we introduce two constructs: the actual capability structure (ACS) and the required capability structure (RCS) of a task. The actual capability structure is a firm's existing composition of competences and skills to achieve a defined task at a certain point in time. The required capability structure describes the composition of competences and skills that a firm would need at a certain point in time to achieve the task. If the ACS matches the RCS, a firm has the competences and skills available to perform a task adequately. In contrast, if there are factors altering the relation between RCS and ACS, a capability gap occurs.

This conceptualization is in line with the capability literature. For example, Lavie (2006) introduces similar constructs, namely the actual configuration of capabilities and the corresponding value-maximizing capability configuration, to assess the impact of technological change on a firm's capability structure and the emerging capability gap. This distinction is largely identical with the constructs ACS and RCS in this paper.

A capability gap implies that a task is achieved in a quantity or quality that is lower than defined. Thus, the performance of the task declines. This argument is consistent with the theoretical capability literature (e.g., Lavie 2006; Levinthal and Wu 2010) and empirical findings (Dyner and Larsen 2001; Delmas and Tokat 2005; Delmas, Russo, Montes-Sancho and Tokat 2009) showing that capability gaps and the need to reconfigure capabilities reduce at least initially a firm's efficiency.

It is important to highlight that the required capability structure (and Lavie's (2006) value-maximizing capability configuration, respectively) is a theoretical construct, which enable us to determine conceptually a benchmark to assess the extent of a potential capability gap. The required capability structure as a theoretical construct simplifies the fact that performing a task can be achieved through different combinations of competences and skills. In fact, there is often a range of possible required capability structures, which a firm could implement to accomplish a specific task. However, we believe that for the argument in this paper, it is reasonable to assume that the range of required capability structures can be conceptualized in one representative RCS. This is feasible because we aim to conceptualize the emerging difference between RCS and ACS rather than explaining how firms chose between different possible capability configurations.

Furthermore, the focus in this paper is on the RCS that is closest to the ACS. Our interest is on the mechanisms required to close a capability gap rather than on examining what it would need to implement a fundamentally different capability structure, for example one that is based on radically new technologies or an innovative organizational structure. In the latter cases the RCS tends to be substantially more dissimilar from ACS as we intent to consider in this paper.

4.2 Infrastructure Sector Specificities and Capability Gaps

High Uncertainty

Having the two constructs RCS and ACS defined, we can now explain how the different infrastructure sector specificities contribute to causing the emergence of capability gaps (cf. table 1). One reason for a gap to occur is when the required capability structure changes. This is the case with high uncertainty of the business and regulatory environment. High uncertainty about recovering investment costs and the future technological development are specifically prevalent in infrastructure sectors because networks, assets and technical systems require high investments and have long amortization periods. If uncertainty is relatively low, it tends to be less difficult for a utility to identify and define the required capability structure to perform the defined tasks. High uncertainty makes it more difficult to determine the required capability configuration. This is because a utility has to build, implement and manage capabilities so that they cover an increasing number of contingencies that might occur. Consequently, a utility would need to establish a capability structure with substantial excess capabilities quantitatively and qualitatively. In fact, however, it is barely feasible for a utility to provide an adequate capability structure for all potential contingencies. Thus, the higher the uncertainty of the market and regulatory environment is, the higher is the possibility of a mismatch between RCS and ACS. For example, if carbon emissions policies remain unclear whether to demand in the future from electricity suppliers to mandatorily build renewable generation capacities or establish carbon capture facilities or compensate emissions with tradable certificates (or a combination of these means), then there is a higher possibility for an emerging capability gap than under a policy that precisely defines the implementable means, for which utilities can specifically build capabilities.

Strong Interdependencies

Highly specific investments with strong interdependencies between the components of the large technical systems are another typical feature of infrastructure sectors. The interdependencies are most prominent between the production and network facilities with joint operation creating substantial synergies. Because of these interdependencies, it is difficult to separate the workforce into different functional areas or even across firm boundaries. If functional areas are so strongly separated that joint operations are hardly possible or even restricted, capability gaps emerge. Even if the capability structure is fully available to achieve the tasks in each functional area, the required capabilities may be lacking to understand the interdependencies in detail and jointly operate the separated functional areas. Thus, the more separated functional areas with high interdependencies are, the higher is the potential gap between RCS and ACS. This is for example the case, when the power plant and transmission grid operations are unbundled. Unbundling separates two traditionally closely linked functional areas. It specifically disconnects capabilities that tend to be critical to operate these two functions adequately.

Economies of Scale of Large Technical Systems

Economies of scale and scope are a characteristic feature of infrastructure sectors because of the large technical systems that service providers typically operate. Large technical systems tend to have long life cycles with each life cycle phase requiring a specific capability structure (e.g., planning, building, operating and refurbishing). As the required capability structures change continuously during the life cycle, capability gaps potentially emerge in the shift from one to the other of these phases. Thus, the more relevant economies of scale and scope and the longer the corresponding life cycles of the technical systems, the higher is the possibility of major mismatches between RCS and ACS.

Multiple Objectives

The infrastructure sector specificity of providing basic services implies that utilities pursue multiple objectives. From a capability perspective, tensions occur between the competing objectives because the various objectives require different capability structures. For example, an electricity provider may aim at generating cheap electricity from fossil fuels to serve its power-intensive industrial customers. At the same time, the utility might pursue a strategy to establish itself as a leading renewable electricity provider. Building the required capability structure for one of the objectives may not cover the required capability structure of another one. Thus, the more objectives a utility has to pursue, the more likely is that a capability gap emerges for at least one or several of the multiple goals.

The problem of a capability gap intensifies when further objectives are added. Then, the required capability structure changes substantially. This is the case if utilities or policy makers identify new tasks or shift and expand priorities of existing tasks. For example, in addition to provide secure and efficient infrastructure services, they may demand to deliver services with a specific technology mix to reduce environmental impact, which then requires a different set of capabilities. An illustration is the shift of the Japanese energy policy toward a less nuclear power dominated generation portfolio after the Fukushima disaster. This implies a massive shift in the required capabilities within the electricity sector from knowledge on nuclear power technologies toward expertise in renewable electricity generation technologies. Another example would be the paradigmatic change from central municipal wastewater treatment plants to decentralized systems, which require a different set of capabilities to install, operate and service.

Furthermore, the required capability structure also changes if the task itself remains largely unaltered but the conditions under which it is operated changes. For example, policy intervention may put on halt the building of new production capacities or even cause a decline of a sector's capacities (e.g., electricity generation capacities, water treatment capacities). Tightened production capacities tend to necessitate altered business procedures to supply services. This requires additional capabilities compared to a situation with sufficient production capacities. Additional capabilities include more personnel to run the operations, for intensified surveillance of the production process and increased maintenance activities. Thus, the more new tasks diverge from the current ones and the more the conditions for accomplishing defined task changes, the more likely is a mismatch between RCS and ACS.

A capability gap also emerges when the tensions due to the pursuit of multiple goals affect the actual capability structure directly, so that capabilities are lost. This is specifically the case in infrastructure sectors, if policy and regulatory decision-makers aim at restructuring the sector. For example, they may require that integrated electricity utilities unbundle vertically, outsource business activities and sub-contract with specific supplier groups. These influences tend to render the organizations' actual capability structures inadequate. Thus, the stronger the external impact to change the current prioritization of objectives, the more likely is a temporary mismatch between RCS and ACS.

Pursuing multiple objectives may also lead to unclear priorities. As a result, the capability accumulation may focus on specific objectives but pay less attention to others. Consequently, the actual capability structure diverges from the required capability structure for those tasks. Thus, the higher the ambiguity of the objectives' priorities, the more likely is a mismatch between RCS and ACS.

Limited Options for Strategic Reorientation

In addition to multiple objectives, yet another implication of the infrastructure sector feature of providing basic services is that utilities have limited options for strategic reorientation and specialization. As utilities are commissioned to provide basic services, their freedom in responding to performance deficiencies is limited. In fact, it is only possible through building and acquiring capabilities but largely unfeasible through strategic change and employing the actual capability structure in a different way. Thus, if the range of options for adjustments is highly limited, the more likely is a mismatch between RCS and ACS.

Due to this relative strategic inflexibility, capability gaps may also occur—possibly less often—in the opposite direction. In the case that utilities have more competences and skills available than required, the costs of performing the task tend to be too high. While companies in non-infrastructure sectors aim to fully employ the available capabilities, utilities have limited options to leverage on their organizational resources and capabilities—even if the available capabilities are underemployed. They have hardly the option to change the business model and switch the strategic focus to different products and services, diverge from the delivery of basic goods and specialize in different areas of service supply. Utilities have to provide the services, even if they do not have the sufficient capability structure or if they have a capability structure that could be leveraged more efficiently and could be financially more viable in a different product and service context. The feature to provide basic services restricts utilities to exploit their capabilities within a defined set of business activities and the determined geographical area. This prevents performance improvements, as available capabilities remain unused to improve efficiency by taking advantage of potential economies of scale and scope.

In sum, we have argued that all five infrastructure sector specificities can cause systematic changes of the actual and required capability structures of utilities. The impact of the sector specificities leads to capability gaps with the corresponding negative performance implications. We have shown that taking a capability perspective extends the existing principal-agent and transaction cost approaches. The two conventional approaches have mainly based their argumentation on the assumption that agents behave opportunistically within utilities and across firm boundaries and search permanently to exploit asymmetric information to their own advantage. The logic of our argument is different as it resorts on the coordination problem to build and maintain adequate knowledge structures. In this sense, the presented capability-based approach sheds a different though complementary light on the management and regulation of utility firms. It contributes to a deeper understanding of performance deficiencies in infrastructure sectors, which goes beyond the argumentation that alleviating asymmetric information and opportunistic behavior are sufficient to mitigate such problems. In the following, we extend our argument and explain why the emerging capability gaps may remain persistent—partly over long time periods.

4.3 The Persistence of Performance Deficiencies

A central purpose of our proposed framework is to derive hypotheses about the strength and durability with which a capability gap persists, and when and how to expect utilities to regain and improve performance levels. We argue that there are three main dimensions that characterize capabilities. Based on a systematic analysis of the capability literature, we conceptualize the dimensions as scale and scope of the capability structure, and degree of tacitness. The time and effort needed to close a capability gap depends on which of the three dimensions is primarily effective. Furthermore, we propose that each capability dimensions requires different response mechanisms to regain the adequate capability structure. Table 2 summarizes the three dimensions.

Scale of Capabilities

The scale of capabilities defines the quantitative extent of knowledge required for accomplishing a task. It gives an indication how much of specific competences and skills form the capability to achieve a task. For example, it is a difference whether one engineer or five engineers or 50 engineers perform a task. The scale of capabilities is a construct that captures the quantitative dimension of competences and skills of a task's capability structure.

Changes in the external environment may affect the scale of capabilities. For example, some factors cause people to leave a utility firm. Then, the actual scale declines. Other factors may change a task, so that quantitatively more staff is necessary to accomplish the task. A RCS-ACS mismatch occurs in both cases and results in a decline of the performance.

As maintaining, reconfiguring and building an adequate scale of competences and skills takes time, we expect the emerged capability gap and therefore also the performance deficiencies to persist for a certain period. One reason for persistence is a tight labor market regarding the required competences and skills—particularly in rural areas and remote places. For qualified workers, it is especially in emerging countries attractive and relatively easy to find a position in the metropolitan areas. This is often preferred compared to accepting a job in a utility in rural areas. This aspect is particularly relevant in infrastructure sectors. Water supply and wastewater utilities, for example, cannot choose to relocate their facilities, if they face difficulties in hiring qualified personnel. They have to sustain their operations under these conditions. Firms in other sectors often have the choice to relocate into an area with an adequate labor supply.

In addition, there is a wage difference between the infrastructure sectors and the top salaries in the other sectors, although in a number of industrialized and emerging countries the mean salary in the infrastructure sectors is higher than in most other sectors. Nevertheless, the wage difference to the top level salaries is sufficient to further increase the pressure to recruit qualified staff in infrastructure sectors and attract the best personnel away from managing and operating utilities. In general, the tighter the labor market is regarding the required competences and skills, the longer is the persistence of the gap.

In addition to the conditions in the labor market, a capability gap may also remain persistent if a utility fails to implement internal training mechanisms for building the required scale of capabilities. Internal training is particularly difficult to build up if a utility has only a few or even no sufficiently experienced personnel that would be able to train, work jointly together with new staff members and share their experiences. The lack of an internal workforce with sufficient experience in the respective areas is then a central reason for the persistence of a capability gap.

Scope of Capabilities

The scope of capabilities defines the range of competences and skills to accomplish specific tasks and activities. It gives an indication of how narrow or broad the portfolio of competences and skills are that form a specific capability. In other words, the scope of capabilities captures the knowledge boundaries for performing a task.

We distinguish two constructs defining scope, namely knowledge diversity and knowledge span. Knowledge diversity describes to what extent various educational and professional backgrounds compose a specific capability. For example, a task solely performed by a team of civil engineers differs in its knowledge diversity from a task performed by a team of civil engineers, environmental lawyers and project managers.

Second, the span of knowledge captures to what extent knowledge is employed that exceeds the typical production boundaries to perform a task. This is called excess knowledge and is particularly important when a task needs to be integrated in a larger task network (Brusoni and Prencipe 2001; Parmigiani and Mitchell 2009; Marrone 2010). Integrating tasks requires knowledge that goes beyond the knowledge necessary to accomplish each of the tasks itself. Thus, the production boundaries are not necessarily the knowledge boundaries of a task. For example, integrating components produced by different teams into a single product or service requires each team to have an understanding of the other components and how they interact with each other.

Changes in the external environment tend to affect the scope of a task's capability structure. For example, policy-makers may introduce policies that prompt specific professional groups to leave the utility firms or even the sector. This is the case, if electricity utilities are not allowed to build new power generation capacity or face restrictions regarding a specific technology. Consequently, the affected engineering capabilities are lost to other firms and sectors. The actual scope diminishes. Policy-makers may also require from utilities to pursue additional objectives. For example, it may be mandatory to introduce renewable power generation technologies. If the new technologies are differently integrated in the value chain than the established generation technologies, the required scope of capabilities changes and may create a capability gap with the corresponding decline in performance.

To comply with the imposed changes, utilities need to rebuild the lost knowledge diversity and span, or access additional competences and skills to broadening its actual knowledge scope. Adequate responses include to externally acquiring and internally building competences that facilitate interactions across professional boundaries, and therefore widen the accessibility of a firm's existing capability for other units in the same company. Human resource practices need to be chosen and implemented that foster an organizational structure and culture that enables this type of interaction and coordination. As the processes of establishing corresponding human resource practices are time-consuming, we expect the performance deficiencies to persist for a certain period. We generally expect the capability gap due to insufficient scope of capabilities to last longer than in the case of insufficient scale of the capabilities.

Degree of Tacitness

A central feature of knowledge is the degree of tacitness (Polanyi 1967, 1969). Tacitness plays also a central role in the RBV and capability literature to explain the competitive advantage of firm organizations. The degree of tacitness ranges from codified knowledge to tacit knowledge (Cowan, David and Foray 2000). Codified knowledge can be explicitly formulated and described, e.g., in a document. Tacit knowledge is learnt through experience and learning-by-doing, and defined as knowledge that is not codifiable. It is difficult—if not impossible—to articulate tacit knowledge and make it explicit. Tacit knowledge is acquired through learning and cumulative experience. Therefore it forms a substantial part of individual human skills (Polanyi 1967, 1969; Nelson and Winter 1982) and affects the performance of individuals (Wagner and Sternberg 1985; Armstrong and Mahmud 2008).

To understand the extent to which individual tacit knowledge is important in performing a specific task and to assess to what extent this knowledge is available, individual tacit knowledge can be distinguished regarding individual task-, organizational- and industry-related experience. This can be measured by the tenure of the individual in performing the task, being in the organization and being active in the industry.

Tacit knowledge is similarly important at the group and organizational level. A task performed by a team requires knowledge that is distributed across different individuals forming the team (Nelson and Winter 1982; Berman, Down and Hill 2002). As team members jointly accomplish a task with each member contributing individual competences and skills, they learn about the group process. Through this mutual experience, the team members develop a group tacit knowledge about the specific processes. This includes a group level understanding about who can perform what, when to perform a particular part of the task and how to perform it (Prahalad and Hamel 1990; Lubit 2001). The tenure of a group reflects the level of experience that a team has developed through learning-by-doing processes in performing the task (cf. Berman, Down and Hill 2002, p. 31). It also reflects the culture that a group has built to jointly accomplish the task.

One consistent finding in the literature on team learning and tacit knowledge is that team learning fosters performance. It improves efficiency either by decreasing production cost or time. Team-based tacit knowledge affects task performance in different ways (see also Berman, Down and Hill 2002). Performance improvements are higher, if there are team stability and lower turnover, sustained coordination at the team level (leadership behavior, responsibility, and accountability), communication and mechanisms of knowledge sharing, experience with the organizational context and interpersonal climate and relationships.

In sum, tacit knowledge is a result of learning processes that take place as firm members perform a defined task. This knowledge complements the already existing knowledge in a firm and therefore enlarges the organizational capabilities. The degree of tacitness reflects how strong capabilities depend on learning-by-doing and accumulating-experience-by-working on a task — individually and in a group.

The external environment may affect capabilities by influencing these learning processes and hindering the potential to create tacit knowledge. This influence can take place, for example, through shifting a utility's objectives, not allowing a firm to specialize in specific strategic options, and increased uncertainty. These influences of the external environment may facilitate the turnover of employees and alter the existing communication and interaction patterns. Consequently, the capability structure is affected as tacit knowledge is difficult to build and maintain. The performance of a task tends to decline.

These effects are especially relevant in infrastructure sectors. Large technical systems with long life cycle involve typically cohorts of people that are employed at specific phases of the life cycle, e.g., during the construction of the plants, facilities and networks. If a significant number of personnel leave a utility toward the end of one life cycle phase, a substantial amount of experience about the functioning of the system is lost. It takes some time for a new cohort to rebuild a similar kind of deep understanding of the system. A capability gap persists until such a level of tacit knowledge is rebuilt.

Because of the difficulties to regain a specific set of tacit knowledge, the performance deficiencies tend to persist. The higher the degree of tacitness, the longer we expect the capability gap to endure. In the case of insufficient tacit knowledge, we expect the capability gap to be most persistent. The corresponding performance problems tend to last longer than in the cases, in which the mismatch results from insufficient scope and scale. Figure 1 summarizes our framework.

Figure 1 about here

Table 2 about here

4.4 Responding to Capability Gaps

The above framework allows us to explain how changes in the external environment cause the emergence of capability gaps and result in the persistent decline of a utility's performance. The framework also provides the opportunity to derive insights about possible response processes. To close the capability gap and regain performance levels, utilities have to undertake efforts to maintain, reconfigure and build capabilities (cf. Teece, Pisano and Shuen 1997). Maintaining refers to the need of firms to sustain a given capability structure. Aging organizations, technologies and normal turnover processes make maintaining capabilities a relevant process for companies. Reconfiguring describes capability processes, in which existing competences and skills are arranged in a different constellation to better respond to changes in the environment or in the company's strategic focus. Building capabilities refers to a situation in which an organization has not the adequate capabilities to achieve the envisioned operations and needs to develop these competences and skills. Getting the capabilities in need can be either through building them internally or acquiring them externally. Table 3 summarizes possible responses to capability gaps along the dimensions scale, scope and degree of tacitness.

Utility Level Responses

An insufficient scale and scope of capabilities may emerge because of inadequate remuneration packages and career track opportunities, which limit the general attractiveness of an organization for employees. Other internal reasons are failing human resource (HR) practices to accurately predict and respond timely to general turnover dynamics of the labor force. Factors that specifically undermine a utility's scope include the insufficient provision of an environment for teams with different professional backgrounds to work together and a systematic bias toward a specific organizational culture and professional identity.

A utility may respond to an insufficient scale and scope of capabilities by offering improved remuneration packages, career track opportunities and HR practices. These measures may attract employees to stay with a utility or seek working for it. The expected impact is for the organization to maintain its capabilities or acquire new capabilities externally. A utility may also improve the HR practices to facilitate a supportive environment for the work of multi-professional teams. Further responses include bringing available capabilities from within the organization together and setting up internal training programs to broaden specific skills. Most of these measures of maintaining, reconfiguring and building new capabilities are time consuming strategies to address insufficient scale and scope of capabilities.

An insufficient degree of tacit knowledge may be due to high turnover rates of the workforce. Similarly, frequent and arbitrary rotation patterns within the organization may also cause a lack of tacit knowledge in pursuing specific tasks. HR practices that are limited in motivating and facilitating organizational learning, knowledge sharing and knowledge transfer among firm members with different tenure levels may further contribute to the capability gap.

Responding to an insufficient degree of tacitness requires a utility to maintain a workforce that is balanced in its experience levels. Furthermore, it has to implement an organizational environment and HR practices to allow a constant transfer of knowledge during the daily operation from people with long tenure tracks in the organization and in accomplishing specific tasks to those with shorter tenures. Depending on the task, these learning-by-doing processes may be very time consuming but highly relevant for maintaining capabilities and permanently building the sufficient tacit knowledge anew.

Sector Level Responses

External reasons for an insufficient scale and scope of capabilities are labor market restrictions, a general shortage of training and apprenticeship programs and limitations for labor migration. However, utilities are limited in responding to emerging capabilities gaps caused by external factors. A shortage of sector-wide training and apprenticeship programs can be addressed by implementing internal programs in the organizations. Establishing sector level training programs require time. Thus, building sufficient scale and scope of capabilities at the sector level is a possible response option, although time consuming. Efforts to mitigate a capability gap tend to be effective with a substantial time lag.

5 Discussion and Future Research on Utility Firms and Infrastructure Sectors

5.1 Discussion

The framework developed in this paper offers a capability-based perspective on infrastructure sectors. It applies concepts from management research to the analysis of utility firms. The framework starts from the characteristic infrastructure sector features and enables us to systematically analyze capability-related issues in utilities. The framework contributes to a better understanding of performance deficiencies in infrastructure sectors, and why deficiencies persist longer than expected by conventional approaches.

A capability perspective complements conventional approaches in three ways. First, the principal-agent and transaction cost approach have in common that they understand performance failure mainly as a result of contractual issues occurring in the interactions between utilities and their environment, i.e., suppliers, regulators and governmental institutions. The central concern of these approaches is about how to incentivize optimal contracts, prices and investments. However, searching primarily on the best design structures has been at the expense of understanding the incentivized processes themselves. Contracting, price setting and investing are processes that require adequate skills and competences to be accomplished. Setting optimal incentives is necessary but hardly sufficient, if the required capabilities to pursue the incentivized tasks are inadequately available.

The underlying capability structures of these processes and how they are managed have found little attention so far, although they determine the performance outcome of utilities to a substantial extent. In a capability perspective, it is central to examine these processes and understand how the availability and composition of specific capabilities drives performance. In contrast to traditional approaches, the capability perspective does not assume that an optimal incentive structure produce automatically the required capability structure. Even under optimal condition the capability structure can be inadequate for reasons discussed in the previous chapters.

Second, in addition to paying little attention to the relevant capabilities for a utility's interaction with the business and regulatory environment, some of the processes that are entirely *within* utilities have been rarely addressed. Principal-agent approaches and transaction cost economics predominantly focus on contracts, and therefore on processes that primarily occur in interactions *across* firm boundaries. Key processes within the organization such as how to optimally operate a utility are hardly considered.

Third, the capability perspective adds to the existing literature the insight that the inherent infrastructure sector features tend to have long-lasting impacts on the composition of competences and skills. Whereas traditional approaches assume that firm organizations can adapt immediately on changes in the environment and understand the problem mainly as an issue of setting the right incentives, institutional structures and regulatory designs, the capability perspective argues that maintaining, building and reconfiguring capabilities takes time. Depending on the pace of these processes, capability gaps emerge and may result in major setbacks in the performance of public service delivery.

5.2 Implication for Future Research

The conceptual framework developed above sheds light on managerial processes in utility firms. However, several issues remain unaddressed and require further research. Scholars need to specify the boundary conditions, under which the infrastructure specificities affect the capability structure and assess in more detail the patterns of the impact. It is also important to examine, whether a declining performance is sufficient to trigger response processes or whether there are other enabling factors necessary for utilities to initiate processes to maintain, reconfigure and build capabilities. Moreover, further research has to identify effective strategies to close capability gaps and specify what factors determine the time to mitigate gaps.

Comparative analysis and theory testing offer another potential set of research opportunities. Since we use in our framework the same infrastructure sector specificities as the conventional approaches, it makes the frameworks comparable. The principal-agent, TCE and capability approaches start the analysis from considering the specificities of infrastructures sectors and explain—through different mechanisms—how performance deficiencies emerge. Potentially fruitful could be to empirically assess the explanatory power of the different approaches.

A more conceptual line of potential research is to further advance the developed framework and connect it to organization theory, particularly the boundaries of the firm. Organization theory has a long tradition of analyzing vertical and horizontal integration and disintegration. These topics are highly relevant in infrastructure sectors. On the one hand, there are many utilities that are too small to operate on an efficient scale. To improve performance, merging utilities to larger organizations is a feasible option. On the other hand, most regulatory frameworks require the unbundling of the physical networks—at least to a certain extent—in many countries. Both, merging and unbundling, tend to have profound implications for the capability structure in the sectors. It can be expected that during the merging and unbundling processes the gap between required and actual capabilities structures are at least temporarily widening with the respective consequences for performance. The implications go beyond the processes that have been outlined in the previous sections of this paper. It is expected that capability-related issues occur that are primarily related to the merging and unbundling processes, and which are in addition to the capability processes described in our framework.

The implications of such an approach are that compared to a situation, in which the boundaries of a utility are mainly unchanged, the merging setting causes an extensive pressure on the RCS to operate on a larger scale and coordinate more activities within an organization's boundaries. Thus, the RCS extends substantially in areas that the ACS of the unmerged utilities does not cover. Furthermore, some of the actual capabilities may be brought in from each of the merging utilities, but are hardly needed to be available multiple times in the firm to perform the defined operations.

In an unbundling setting, the separation of business activities divides ACS among different organizations with the consequence of having fewer capabilities than required in the separated units. This tends to create a gap in each organization. Capabilities need to be rebuilt in the unbundled organizations separately, which leads to a duplication of capabilities. Moreover, additional capabilities are required for cross-boundary coordination between the separated organizations. Generally, the merging and unbundling processes tend to lead to capability gaps with the corresponding potentially negative implications. To analyze the nature and implications of these capability gaps in more detail would be an important next step in a research agenda on management research in infrastructure sectors.

Summarizing this paper, a central insight from applying a capability-based perspective is to explain performance deficiencies in utilities as a result of different infrastructure sector specificities influencing the firms' capability structure. Consequently, capability gaps emerge. A second key insight is that performance deficiencies may persist. This is because of the effort and time it takes to regain lost competences and skills, and adjust the capability structure along the dimensions scale, scope and tacitness. To close the capability gap, a utility firm has to initiate processes of capability maintaining, reconfiguring and building. Such responses are hardly effective immediately or even in the short-term. Utilities have to operate with sub-optimal and inadequate capability structures and perform the full range of operations necessary to deliver the basic services. Therefore, a capability gap persists at least temporarily with the corresponding performance implications until the utility firm manages to reestablish an adequate portfolio of knowledge, expertise and experience. We believe more generally that the capability-related perspective offers a more balanced approach for understanding the cause and extent of performance deficiencies. Such an understanding provides a first step toward developing more effective strategies for solving inefficiencies in infrastructure sectors. This new perspective may therefore contribute some potentially important insights and advises for utility managers, regulators and policy-makers.

Figures

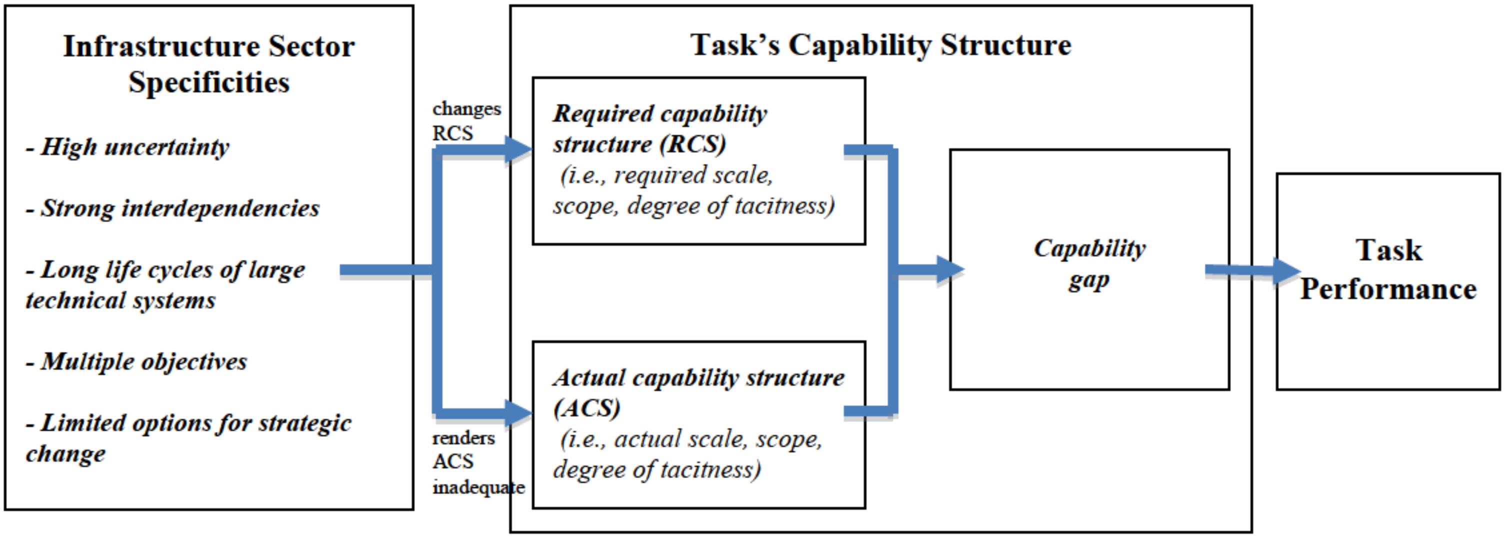

Figure 1: Basic model of the influence of the infrastructure sector specificities on task performance through its impact on the task's capability structure

Tables

Infrastructure sector specificities	Implications	Explanations for performance issues		
		Principal agent approach	**Transaction cost economics approach**	**Capability-based approach**
High investment needs with long time frames	High uncertainty about: - Recovering investment costs - Continued applicability of established technologies	./.	***Hold-up problems*** between contract partners *(Joskow 2002; Spiller and Tommasi 2005)*	Large number of potential contingencies due to changes of the market conditions and the business environment: ***Capability gaps*** because it is unfeasible to build the required capability structure for all possible contingencies
Highly specific investments with strong interdependencies	- High asset specificity - Path dependencies	./.	***Hold-up problems*** between contract partners *(Joskow 2002; Spiller and Tommasi 2005)*	Work force not easily separable into different functional areas or across firm boundaries due to interdependencies: ***Capability gaps*** if functional areas are organizationally too strongly separated
Economies of scale and scope	- Advantages of large utilities - Natural monopoly in networks	***Principal-agent problems*** due to the natural monopoly situation with an impact on: - Price setting - Investments - Procurement *(Baron and Myerson 1982; Armstrong and Sappington 2006; Guthrie 2006; Michaels 2006; Puller 2007)*	./.	Large technical systems tend to have long life cycles with each life cycle phase requiring a specific capability structure: ***Capability gaps*** because required capability structures change continuously during the life cycle
Provide basic services	Multiple objectives	***Principal-agent problems*** because of management contracts between shareholders and utilities *(Gómez-Ibáñez 2003, 2007)*	***Hold-up problems*** as governments and/or interested third parties may threaten to change regulations *(Spiller 2010)*	Multiple objectives compete simultaneously for different capability structures: ***Capability gaps*** because of tensions between competing objectives with different required capability structures; shifts in objectives intensify the gap by rendering the actual capability structure inadequate
	Limited options for strategic reorientation and specialization	./.	./.	Degree of freedom in responding to performance issues is limited as the provision of basic services is given and not available for strategic change (inflexibility of responses): ***Capability gaps*** are more likely to emerge because of the limited range of options for adjustments; responding to performance issues is only possible through building and acquiring capabilities but largely unfeasible through business reorientation and specialization (i.e., employing the actual capability structure in a different way)

Table 1: Features of infrastructure sectors and its relevance in different theoretical approaches

Capability dimension	Characterizing features	Description	Operationalization
Scale ***(Quantity of employed knowledge to perform a task)***	Knowledge quantity	Quantitative extent of specific competences and skills	- Number of the individuals with a specific competence
Scope ***(Variety of employed knowledge to perform a task)***	Knowledge diversity	Extent to which various professional backgrounds compose a specific capability	- Professional background - Educational background
	Knowledge span	Extent to which knowledge is employed to perform a task, which exceeds the typical production boundaries (excess knowledge)	- Professional background
Degree of tacitness ***(Extent of tacitness (tacit vs. codified) involved in performing a task)***	Individual level experience	Extent of knowledge that is based on individual learning-by-doing and experience	- Tenure of individuals regarding a) task b) organization c) industry - Function in the organization
	Group level experience	Extent of knowledge that is based on group learning-by-doing and experience	- Tenure of the group in accomplishing the task

Table 2: Dimensions of capabilities and approaches to measurement

	Responding to capability gaps	
	Utility level responses	***Sector level responses***
Insufficient scale and scope of capabilities	- Remuneration packages - Career track opportunities - Improved HR practices - Supportive environment for multi-professional teams - Facilitating organizational culture for cross-professional exchange	- Internal training and apprenticeship programs for specific competences and skills - Specialized training programs aiming to cross professional boundaries
Insufficient tacitness of capabilities	- Facilitating knowledge transfer from people with long tenure tracks to those with shorter tenure tracks - HR practices enabling systematic learning-by-doing processes	

Table 3: Responses to capability gaps

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