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Aligning modes of organization with technology: Critical transactions in the reform of infrastructures[☆]

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ABSTRACT

This paper is about the alignment of technology and modes of organization in infrastructures in the context of their reform. Since infrastructures are characterized by strong technical complementarities, we explore the resulting 'critical technical functions' that need to be performed in order to guarantee the expected technical performance of the system. We characterize 'critical transactions' as essential to provide adequate support to these functions. We distinguish various modes of organization that can effectively coordinate these critical transactions. We argue that the features of these transactions determine the alignment between organization and technology and should be taken explicitly into account when reforming infrastructures.

1. Introduction

Reforming infrastructures has been high on the agenda of economists and policy makers over the last three decades. Introducing 'more market' has been at the core of these reforms, with the underlying rationale that this is the adequate way to increase efficiency, to stimulate suppliers to serve consumers' needs, and to innovate in products and processes. In addition changes in the allocation of property rights, with the reintroduction of private interests in infrastructures, have often been considered inevitable in order to finance the huge investment needs in sectors like telecom, energy, rail transport, and water. For example, it has been estimated that investments of a magnitude of over $100 billion (in 2003 US dollars) within a decade would be required to halve the percentage of population without access to drinking water and basic sanitation.[1]

Although changes in property rights and the related decision rights may take many different directions, almost all restructuring of very diverse infrastructures seems to follow a similar recipe. Infrastructure firms that have historically developed as

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1 UN Millennium Project (2005).

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vertically integrated monopolies are separated into different entities in order to allow for competition. Monopolistic activities (exploitation of network related services) are unbundled from activities for which it is assumed that competition can be introduced (production and supply of different services). The monopolistic segment needs to be closely regulated in order to safeguard a level playing field. For this purpose independent regulatory agencies are established that typically supervise the access and pricing of the network services. Simultaneously, particularly with respect to the competitive segment, there is a switch from a command-and-control approach to a contractual one.

Following this pattern, liberalization seems essentially a matter of institutional change, i.e. the design of well functioning markets in order to provide sufficient incentives to serve the above-mentioned objectives. Technology is not considered an important factor enabling or frustrating this process of change. Most reforms of infrastructures assume that technology will change autonomously and adapt quite smoothly, thanks to the incentives provided by the new rules of the game.

In this paper, we argue that infrastructures are complex technical systems with a strong degree of complementarity that is enabled through network relationships. Accordingly, all major elements technically interact in a specific manner with each other, which makes it possible to produce certain services like the provision of energy, telecommunication, clean drinking water, or rail transport. These complex technical systems have very peculiar economic features including path dependence, lock-in effects, multiple and possibly inefficient equilibria.[2] Hence, it might be expected that the technological status of various infrastructures influences the opportunities for restructuring and contributes to shape the resulting performance. Building upon the literature on co-evolution,[3] with a view at how transactions are organized or can be organized in that context, we aim to further elaborate on the mutual relations between institutions and technology in infrastructures. Focusing mostly on one aspect of performance, the technical one, we show that the technical functioning of infrastructures needs to be supported by appropriate modes of organization. Insufficient or failing institutional support results in inferior technical performance contributing to unreliable services or in extreme cases even to system outages. There is empirical evidence that the technical functioning of at least some infrastructures did not meet expectations after reforms, particularly when reforms combined unbundling and changes in the allocation of both property rights and decision rights. Refer for instance to the various blackouts in electricity systems,[4] or some train accidents that followed reform of the British rail sector.[5] We take such anecdotal evidence only as an incentive to better understand the role of technology in the process of regulatory reforms in infrastructures. What we intend to do is to identify critical technical functions and to show how they impose properties on transactions that should be reflected in the adequate alignment of the technical functions with the modes of organization. Hence this article takes a theoretical perspective and does not intend to further explore the incidence of specific technical malfunction in various infrastructures.

The core of our argument is that the technical complementarity between the various elements of infrastructure systems most of the time imposes a technical need for coordination with respect to functions like capacity management, system management, interconnection, and interoperability.[6] These technical functions can be considered as critical for safeguarding the technical performance of infrastructures. In the railway sector, for instance, traffic control is very crucial to maintain the technical reliability of the system. A failure of this aspect of capacity management can cause accidents and threaten the technical integrity of the infrastructure. Similar examples are the monitoring of the quality of drinking water (poor quality might cause severe health problems) and load balancing in the electricity sector (blackouts occur if the system is imbalanced).[7] Taking this technical criticality as point of departure, the question arises whether we can identify supporting 'critical transactions' that are essential for the functioning of infrastructures. In other words: if critical transactions are not well coordinated, some technological critical functions of the systems are not satisfied so that the system severely fails to deliver the expected services. We are interested in modes of organization that guarantee the coordination of critical transactions related to critical technical functions of liberalized infrastructures.

In order to explore this issue, we are building on different strands of literature. New Institutional Economics provides an important source of inspiration with its emphasis on the alignment of modes of organization with transactions at stake (Williamson, 1996) as well as with the identification of the key role played by institutional factors in technological changes (North, 1990, chap. 9) and in the reform of infrastructures (Joskow, 1997). However, as acknowledged repeatedly by Williamson, the transaction cost perspective that provides foundations to this approach has not really integrated the technological dimension.

Our paper intends to make a step in this direction. We perceive infrastructures as complex socio-technical systems in which technological, economic, political, and social features strongly interact with each other (Perez, 2002; Van de Poel,

[2] David (1985), Arthur (1988), and Economides (1996).

[3] See, for instance, Nelson (1994), Dosi (1982), Von Tunzelmann (2003), Perez (2002), Saviotti (1996), and Murmann (2003).

[4] For historical trends of large blackouts in North America between 1984 and 2006, see Hines et al. (2009). We argue in this paper that in times of technical distress the institutional support of critical technical functions is essential to safeguard the functioning of the infrastructure system.

[5] Gourvish (2008) provides a comprehensive historical analysis of the reform of British railways between 1997 and 2005. The Hatfield crash on October 17th, 2000 (four people were killed and 70 injured), was a watershed in the reform of this sector from privatization and liberalization back to more stringent governmental monitoring and control. We interpret this as a possible indication that certain critical technical functions are not supported by sufficiently effective modes of organization.

[6] Finger et al. (2005), pp. 240–241.

[7] Load balancing refers to the technical balancing of production and consumption in electricity networks that needs to be guaranteed at every moment of time.