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An institutional analysis of technological learning in Iran's oil and gas industry: Case study of south Pars gas field development

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ABSTRACT

This aim of this study is to identify elements in the institutional setting which affect technological learning outcomes in large socio technical systems. By drawing on fieldwork and empirical evidence from Iran's oil and gas industry, a multiple-case study has been conducted. It is found that the institutional regime of this sector jeopardizes technological learning scenarios through 4 overarching aspects: Cost, Time, Risk and Management structure, which we call "the CTRM square". It is also revealed that the locked-in institutional structure of the sector creates a "negative co-evolution" among actors leading to impairment of technological learning. Our data shows that the characteristics of large socio-technical regimes in developing countries act in favour of such impairment. These regimes create strong commitment in stakeholder groups. Such commitment establishes dominancy around technological routines, which is the result of low absorptive capacity of stakeholders and their lack of awareness regarding new technological scenarios. In some cases, political conditions surrounding a project as well as personal gains lead to the stakeholder's deliberate action against a new technological scenario. The negative co-evolution contributes to the supply side change of strategy in order to safeguard their market position which ultimately engenders dominancy of obsolete technological routines in the firms diminishing technological learning in the oil and gas industry.

1. Introduction

Oil and gas have been the main sources of supply of energy to the global markets for several decades, and the consensus is that they will continue to keep this leading role into the current century. Considering such significance, development in this industry becomes a high priority since it is the driving engine of meeting the world's energy demands through increasing production by exploration of new reserves and use of advanced technology to extract additional resources from the abandoned reservoirs because of high cost of extraction.

Oil and gas industry is considered to be a large socio technical system as it involves several complex exploration, development and production megaprojects. Iran, as a country rich in oil and gas reserves,[1] has carried out many megaprojects like the South Pars gas field development phases with a total capital of approximately 40 billion USD. These projects should help Iran to make progress in towards development (Soofi & Ghazinoory, 2013).

Despite the considerable investment, it appears that little technological learning (TL) has taken place in the industry. It is estimated that this industry's yearly requirement reaches to about 2.5 million pieces of equipment, about 70% of which is being imported from foreign sources. This equals to 7 billion dollars of capital which is paid to foreign resources.

As an example of inadequate TL in the petroleum and natural gas industry in Iran, we cite the inability of the Iranian Oil Company in TL in spite of renewing for 35 times, the license to use the sulfur recovery technology from abroad. The inadequate technological learning of the firms in the industry has created a puzzle. This paper aims to solve this puzzle by identifying the reasons for such poor learning performance.

While studies point out that TL can improve the economics of industries; a simple contradicting incidence in the oil and gas industry of Iran is the sulfur recovery license. Our data reveals that this license has repetitively been purchased from foreign sources 35 times without any domestication achievements or any reduction in procurement costs. Such issues make TL a stimulating phenomenon and this paper intends to investigate what happens to it in the oil and gas industry of Iran.

A rich literature about technological learning exists. During recent decades, TL has become a crucial challenge for the developing countries in the processes of technological progress and improvement

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[1] In 2010, Iran, which exported around 2.6 million barrels of crude oil a day, was the second-largest exporter among the Organization of Petroleum Exporting Countries.

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(Lundvall, 1992; Nelson & Rosenberg, 1993; Viotti, 2002). Moreover, TL is considered important in different analysis of innovation systems specifically in technology upgrading and development (Lundvall, 1992; van Sark et al., 2010).

The goal of this study is to open the black box of TL in the oil and gas industry of Iran. Socio-technical systems theory will provide a useful lens through which to explore TL. Institutions are the most appropriate area to focus our analysis on, since they are the main determinants of the sector's strategy and orientation. We particularly aim to focus on regulatory institutions. The targets of our analyses are the oil and gas megaprojects since they are single, legitimate aggregations with inter-related sub-sets interacting to realize the complex tasks assigned to them. We aim to broaden the existing studies on the subject by investigating how these megaprojects contribute to TL in socio-technical systems. We explore how they affect co-evolutionary processes of TL in the oil and gas industry.

After this introductory section, Section 2 will provide a review of TL insights in the micro, meso, and macro levels of a socio-technical system. A brief study of institutions as the major determinants of TL is also provided in this section. This will be followed by a case study method described in Section 3, proposing a case study of different phases of the South Pars Gas Field Development Project. Section 4 presents the results of our institutional analysis based on the major characteristics of the institutional regime of oil and gas industry. In Section 5, findings and results are discussed and study limitations are explored and in Section 6, final conclusions are presented.

2. Technological learning and institutions: a multi-level review

One main point regarding TL is that it is associated with system improvement. As TL is among the accomplishments that occur in systems (Lundvall, 1992), a logical point of departure for addressing the goals of this study is a review of socio-technical systems literature. In the present context, we explore three consistent research strands that are relevant to TL.

2.1. Determinants within micro studies

The first strand examines TL determinants at the micro level (firm level), focusing on the criteria affecting firms technological base. Bell (2007), in a study of the developing countries, proposes some common principles for learning and capability development in the firms including: Human resources and training, use of technology and operation, R&D, design and engineering practices, international scientific and technological co-operation, technical standards, and metrology (Bell, 2007).

Absorptive capacity of the firm is another key determinant. Absorptive capacity is the firm's ability to pinpoint organization needs, information value and external knowledge or acquiring and applying required external knowledge for economic purposes (Cohen & Levinthal, 1990). It is significant for internal and external knowledge transfers in a firm level (Szulanski, 1996).

Finding it highly relevant, seminal literature on TL focuses on factors driving absorptive capacity in the firm level. They point to knowledge, personal absorptive capacity, diversity of backgrounds (Cohen & Levinthal, 1990); organizational training level (Vinding, 2000; Roth et al., 1994); R&D investments (Veugelers, 1997; Vinding, 2000); presence of gatekeepers (Lerch et al., 2010); organizational structure (Welsch et al., 2001; Jansen et al., 2005); intra-organizational communications and team work (Cohen and Levinthal, 1990; Jansen et al., 2005); organization bureaucracy (Nonaka & Takeuchi, 1995); organization culture (Lloyd, 1998); organization size (Welsch et al., 2001); organization inertia and human resource management (Davenport & Prusak, 1998).

Technology related factors include scale of technology complexity (Calantone & Gross, 1990; Lin & Berg, 2001; Lia & Tsai, 2009; Simkoko, 1992); technology life cycle (Lin & Berg, 2001) and technology document-ability (Lin & Berg, 2001; Lia & Tsai, 2009).

2.2. Implications within meso level

The second strand examines TL through a systematic lens. This research level explores how the complex nature of industries and sectors affect technology development/upgrading/adoption processes (Ngar-yin Mah et al., 2012; von Bock und Polacha et al., 2015; Spinardi, 2015; Geels, 2004; van Sark et al., 2010).

The insights within systemic (meso) studies of innovation refer to the capital, engineering and infrastructure assets integral to the socio-technical systems (Gil et al., 2012; Miller et al., 1995; Hobday, 1998), which are mostly the outcome of megaprojects in that system. However, less attention has been paid to the demand side as well as social factors. Potentially, the deliverables of a megaproject provide an opportunity window for the new/domesticated technologies to enter the socio-technical system (Geels, 2004), and therefore shapes and is shaped by the system (Gil et al., 2012). These projects deal with a variety of stakeholders e.g. the client, contractors and subcontractors, vendors, consultants and the user side as well. Hence, decisions to initiate and pursue a learning opportunity in the project require multi-lateral reconciliations. Difficulties to reach jointly inter-firm, multi-lateral agreements can be compounded by uncertainty and ambiguity in the project requirements (Miller & Lessard, 2000), inadequacy of codified knowledge, limited opportunities for prototyping (Cacciatori, 2008), lack of routines for inter-project transfers of tacit knowledge (Gann & Salter, 2000; Prencipe & Tell, 2001), and inadequate feedback loops between project teams and operational staff (Geyer and Davies, 2000).

Other intersecting meso-level factors are the infrastructure (e.g. Information Technology) (Holsapple & Joshi, 2000; Nazmun et al., 2006; Mohamed, 2010); values and norms institutionalized within the system (Waroonkun & Stewart, 2008; Mohamed, 2010); and the linkage among different entities and stakeholder groups. Multilateral interactions among these groups provide orientation and coordination to the activities of different actor groups; hence, projects account for the performance of socio-technical systems on multiple dimensions such as technology, scientific knowledge, markets, infrastructure, culture, industry networks and sectoral policy (Elzen et al., 2004).

2.3. Macro implications

The third strand applies a macro assessment of TL in the socio-technical system. While some studies have underlined the changes imposed by socio-political and technical forces (Ferlie et al., 2005; Bijker, 1995; Miller et al., 1995; Geels, 2004; Peine, 2008), others have revealed how effects are made by economic forces (Markard & Truffer, 2008; Watson, 2004).

In the macro studies, we encounter technological trajectories located in a socio-technical landscape, consisting of a set of deep structural trends. As Elzen et al. (2004) argue, the socio-technical landscape comprises several factors. First heterogeneous, slow-changing variables namely cultural and normative values, broad political coalitions, long-term economic developments and accumulating environmental problems. Second, shocks and surprises (Elzen et al., 2004) like wars and in the context of this paper, rapidly falling oil prices and sanctions. Landscape is an external context for the firm and socio technical levels. While micro and meso factors can be changed (to some extent) by actors within the system, it is not easily possible to alter landscape factors (Miller et al., 1995; Elzen et al., 2004; Kemp & Rotmans, 2001).

2.4. Institutions in innovation studies literature

Many of the innovation studies highlight institutions as a key element associated with technological processes; institutions play a key