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Understanding the energy efficiency gap in Singapore: a Motivation, Opportunity, and Ability perspective

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ABSTRACT

This paper investigates the main barriers to energy efficiency in Singapore-based industries. We first built a theoretical framework based on the Motivation, Opportunity, and Ability (MOA) theory, which is a novel perspective for an energy-related study. To enhance this theoretical framework, we explicitly considered the effects of energy performance measurement on energy efficiency outcomes and their determinants in the MOA framework.

We tested this novel framework using data from an industry survey conducted by the Energy Studies Institute, National University of Singapore. Using a partial least squares method, we found that the desire to cut operating costs and firms' know-how to implement energy efficiency both had a positive, statistically significant impact on energy efficiency outcomes. Know-how itself is driven by firms' know-what, which reflects their awareness and fundamental understanding of energy efficiency. Interestingly, the ability to monitor energy efficiency outcomes moderated the impact of cost-driven motivation. By contrast, firms' corporate social responsibility, regulatory compliance, and opportunity to implement energy efficiency were found to have no significant effect on energy efficiency outcomes in the context of the study.

1. Introduction

The industry sector has a major role to play in the quest for energy efficiency since it consumes nearly one third of the total global primary energy supply and produces about 38% of energy related CO_2 emissions (IEA, 2009). Yet, many researchers have found that energy efficiency is often not a high priority (Thollander and Ottosson, 2010) and that there is still great potential for improvement (Neelis and Pouwelse, 2008; Christoffersen et al., 2006; Rohdin and Thollander, 2006; Thollander and Ottosson, 2010; Lu et al., 2013). For example, the IEA (2006, p. 386) found that the "energy intensity of most industrial processes is at least 50% higher" than the theoretical minimum given by thermodynamic laws. Likewise, two US studies conducted by the Energetics Team and Pacific Northway National Laboratory (PNNL) revealed a waste heat recovery potential exceeding 1.6 quadrillion Btu per year (about 1.6% of US total energy consumption in 2006) (Energetics, 2004; PNNL, 2006). IEA estimates that the average energy-saving potential of the global industrial sector under the Best Available Technology (BAT) scenario is about 18%, while for a country such as Taiwan it is about 14.5% (Lu et al., 2013).

In this study, we focus on energy efficiency issues in Singapore-based industries. The city-state is a place of special interest for such a study as it has no significant natural resources and its open economy is prone to energy price fluctuations. According to IEA statistics, Singapore's total energy consumption in 2012 was about 10 mtoe (million tonnes of oil equivalent), with 5.169 mtoe (about 51.6% of the total) consumed by the industrial sector, 2.521 mtoe (25%) by transit, 1.623 mtoe (16%) by commercial and public services, and 0.647 mtoe (6.4%) for residential and other purposes. It is worth mentioning that, unlike other countries in the region, Singapore's energy — be it conventional or renewable energy — is not subsidized by the government. Thus, it is not surprising that Singapore is the "third-most expensive destination for utility costs"

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in the world (The Economist, 2014, p. 1). Pursuing energy efficiency is therefore crucial for Singapore, since such policies can help it reduce its dependence on foreign energy supplies and mitigate carbon emissions associated with energy use.

Academically, there is a long standing stream of work that attempts to understand the “energy efficiency gap”, first proposed by Hirst and Brown (1990). According to Sorrell et al. (2004), barriers to energy efficiency can be defined as “postulated mechanisms that inhibit a decision or behavior that appears to be both energy efficient and economically efficient” (p. 8). Technical and financial risk, imperfect information, the presence of hidden costs, access to capital, imperfect information, split incentives, and bounded rationality are examples of such barriers (Sorrell et al., 2000). Studies such as Jaffe and Stavins (1994), Weber (1997), Sorrell et al. (2011), and Chai and Yeo (2012), among others, have reviewed and proposed various taxonomies of barriers.

In recent years, researchers have begun to conduct empirical studies to understand the energy efficiency barriers faced. These studies often focused on a particular country or a specific industry sector. Brunke et al. (2014) analysed 21 such studies and found that the majority adopted Sorrell et al.'s (2000) taxonomy when categorizing the barriers. The summary identified a wide range of barriers in different countries, such as “low rates of return”, “long payback periods”, and “auditors assessment inaccurate” in Australia; “other investment is more important”, “technology can only be implemented after existing technology has been replaced”, and “energy costs are not sufficiently important” in the Netherlands; and “other priorities for capital investment”, “hidden cost”, and “technical feasibility wasn't studied before” in Belgium. Similarly, several studies have reported on energy efficiency barriers in Asia. For example, Liu et al. (2014) found that internal factors have a positive influence on industrial energy saving activities in Hyogo prefecture, Japan. The same observation was made in Korea, where internal factors such as the willingness for energy savings, support from top management, and internal training were identified as the main drivers for energy saving activities (Suk et al., 2013). In Zhejiang province, China, informational barriers were identified as the main inhibitors of energy efficiency investments in SMEs (Kostka et al., 2013).

Given that it is fundamentally organizations that adopt (or not) energy efficiency practices, a more organization-centered perspective may help policy makers to better understand the problems faced by companies. Therefore, this study aims to understand the mechanisms underlying an industry's energy efficiency practices by adopting the Motivation, Opportunity, and Ability perspective.

2. Methods

2.1. The Motivation, Opportunity, and Ability theory

The Motivation, Opportunity, and Ability (MOA) theory was first established by Blumberg and Pringle (1982) and has its origins in both industrial and social psychology. The aim of the theory was to understand the drivers of job performance in a parsimonious manner that encompassed the numerous antecedents of performance previously identified in literature, such as leadership, job satisfaction, and job attitudes, as well as observations the authors made while studying coal mine workers. The MOA theory identifies three fundamental determinants in the performance of a given individual (e.g., an employee) or organization (e.g., a firm or a state), which are, namely, the motivation, the opportunity, and the ability. This theory has been used in various fields of research including entrepreneurship (Davidson, 1991), firm-level decision-making (Wu et al., 2004), marketing (Clark et al., 2005), behavior in information systems research (Hughes, 2007), and knowledge management (Siemsen et al., 2008).

2.2. Definition of variables

Since the MOA framework is a *meta-theory* (Gregor, 2006), which enables its application across various fields of study, its dimensions need to be specified within the context of the research. Hence, Motivation, Opportunity, and Ability need to be defined within the context of energy efficiency implementation.

The literature review suggests that cost is an important factor for companies in Singapore when pursuing energy efficiency. Chai and Yeo (2012) reported that GSK Singapore started their energy efficiency initiative in 2002 because they wanted to avoid increasing energy costs as they increased their production volume. HSL, a Singapore SME that won the 2014 Excellence in Energy Management Award (Singapore), started its energy efficiency initiative with the intention to reduce their energy costs (ISO, 2014; HSL website). In the UK, Napp et al. (2012) found that cost benefit is a major driver of updating energy efficiency technologies. Cost motivation is especially high in the industrial sector since energy costs represent a large share of the total production costs. Further, we identified two other sources of motivation: corporate social responsibility-driven motivation and legal compliance (Napp et al., 2012). The wish to implement energy efficiency may indeed arise from an industry's green corporate policy. Alternatively, energy-related regulatory pressure exerted on industries should drive the implementation of energy efficiency projects. In terms of ability, we distinguish firms' know-what and know-how. Their impacts are discussed below in the hypotheses development section. Ultimately, we observed that internal buy-in and ease of implementation are two critical components of a firm's opportunity to embrace energy efficiency. These two important criteria determine whether the implementation of energy efficiency will be successful or not. The sub-dimensions of each construct and their definitions are summarized in Table 1 below.

In addition to the MOA antecedents, we label the dependent variable “energy efficiency outcomes” and define it as *the extent to which energy efficiency projects deliver*. In addition, we define monitoring ability as *the extent of a* firm's ability to monitor the

Table 1
MOA components and definitions.

	MOA components	Definition
Motivation	Cost-driven motivation	The extent to which energy costs reduction motivates efficient efficiency implementation.
	Corporate Social Responsibility (CSR) motivation	The firm's commitment in building a greater society.
	Legal compliance	The extent to which law and regulation pressure motivates energy efficiency implementation.
Ability	Know-what	The extent of firm's understanding of energy efficiency-related matters.
	Know-how	The extent of firm's technical skills and proficiencies to implement energy efficiency.
Opportunity	Internal buy-in	The extent of firm's commitment of production and quality departments for energy efficiency projects.
	Ease for energy efficiency implementation	The extent to which energy efficiency can be easily implemented.

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