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Top management and the adoption of energy efficiency practices: Evidence from small and medium-sized manufacturing firms in the US

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A B S T R A C T

Barriers to energy efficiency have been extensively discussed in the energy literature, but little is known about positive drivers. This paper investigates the role of top managers and more specifically of top operations managers on the adoption of energy-efficiency practices, based on 5779 energy efficiency recommendations made to 752 small and medium-sized manufacturing firms under the US Department of Energy's IACs (Industrial Assessment Centers) Program, through which teams of students and faculty from engineering schools provide free energy assessments. Top operations managers possess knowledge of production processes, for maximizing the effective manufacture and distribution of goods. We find that their involvement significantly increases the adoption of energy-efficiency initiatives, while involvement of general top managers without an operational role has little or no effect. Involvement of top operations managers increases the percentage of recommended energy savings that are implemented by 13.4% on average and increases the probability of adoption of more disruptive individual recommendations related to process and equipment change from 31% to 44%. Our findings imply that, in order to advance energy efficiency in SMEs (Small and Medium Enterprises), it may be advisable to target managers who are sufficiently senior but still in a clearly operationally-focused position.

1. Introduction

Global atmospheric concentrations of GHG (greenhouse gases) have significantly increased from the pre-industrial values of 280 ppm [1], exceeding 400 ppm during part of 2013. One key strategy proposed by the IPCC (Intergovernmental Panel on Climate Change) to combat this increase is energy efficiency, which they estimate can reduce industrial CO_2 by over 2.5 Gt of CO_2-e per year in 2030, nearly 4% of overall CO_2 emissions in 2030 [2]. However, scholars have shown that several barriers prevent firms from implementing (apparently) profitable energy savings measures [3–6]. Barriers can be classified [4,7] into those related to economic market failure (such as imperfect information and split incentives), economic non-market failure (such as hidden costs or access to capital), behavioral (such as inertia, credibility and trust, or values) and organizational (such as power or culture). The various economic factors are relatively well-documented; for instance, the negative effect on implementation likelihood of an additional dollar in upfront costs is greater than the positive effect of an additional dollar in annual savings [3,8]. More recently several studies have pointed out the importance of "hidden costs" [5,6,9] and of potential production disruption [6,10–12] as additional barriers. Although behavioral and organizational factors are increasingly mentioned, they are not yet as well-documented. In their survey of foundries and brick and tile makers in India, Nagesha and Balachandra [13] (p. 1978) find that "Most of the entrepreneurs do not appear to have the aptitude, knowledge and dynamism required to tackle technology-related problems such as energy efficiency". On the positive side, Rohdin and Thollander [6] report that a key driving force for adoption of energy-efficiency measures in the non-energy intensive sector in Sweden was the presence of individuals with ambition.

Several programs have been implemented to address some of these barriers in the US [3,14], Italy [4] and Sweden [6,10], which involve outside teams that perform energy audits for small and medium-sized firms to identify profitable energy-efficiency opportunities. More recently, in 2012 the European Union adopted the

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directive 2012/27/EU on energy efficiency which requests member states to develop programs to encourage SMEs to undergo energy audits [11]. One such program in the US, is the Department of Energy's (DOE) Industrial Assessment Centers (IACs) program [3,14] which started in 1976 and has provided cumulative energy savings of 1280 trillion BTU by 2005 [15]. This program encourages improvements in industrial energy efficiency by supporting teams of students and faculty from participating engineering schools to conduct free energy, waste, and productivity assessments for small and medium-sized manufacturing firms. The teams perform a one-day on-site energy audit, after which they submit their analysis and recommendations to the firm. The IAC maintains a database of all assessments and recommendations made (including implementation status) since the 1980s, now totaling approximately 16,000 assessments with 121,000 recommendations [16]. However, underinvestment in energy efficiency persists, as implementation rates for the IAC program are generally around 50% even though the payback of projects is usually less than two years [8,17]. Given the observation that individuals can help or hinder a firm's adoption of energy-efficiency, it is natural to ask whether the position of the lead individual involved within the firm matters. Specifically, does it make a difference whether that individual is a top manager, a top operations manager, or someone else? If yes, does the effect of top management involvement vary with the type of recommendation made? While the lack of top management interest in energy efficiency has been suggested as a probable barrier to adoption [18,19], their exact role remains largely unexplored.

In this paper we examine the role of top (general) managers and top operations managers in the adoption of energy-efficiency recommendations. Top (general) managers have titles such as owner, President, and CEO; top operations managers have titles such as VP of Operations or VP of Manufacturing. Top operations managers possess knowledge of raw materials, production processes, quality control, costs, and other techniques for maximizing the effective manufacture and distribution of goods, according to the definition by the US Department of Labor/Employment and Training Administration (US DOL/ETA) [20]. Their goal is to improve manufacturing productivity and to reduce cost, which should make them more likely to favor energy efficiency initiatives relative to other top managers. While all top managers are ideally positioned to coordinate decisions and access resources, top operations managers additionally possess more relevant knowledge. It is therefore interesting to test whether these different abilities impact the adoption of energy-efficiency recommendations.

In order to measure the role of top management on the adoption of energy-efficiency recommendations, we used data from the IAC program covering 5779 recommendations made to 752 small and medium-sized manufacturing firms, from three IACs at SDSU (San Diego State University), at LMU (Loyola Marymount University) and at the UD (University of Dayton). In addition, we participated in five assessments and in follow-up interviews with three firms audited by the SDSU IAC, from which we observed that adoption of energy-efficiency measures was driven by, among others, the position within the firm of the manager who was the main contact for the IAC assessment process. Finally, one of us participated in the IAC Directors' meeting in July 2013, to discuss this and related research with all IAC directors and the DOE managers overseeing the IAC program.

This paper makes several contributions to the energy efficiency literature. First, we examine whether recommendations are more likely to be implemented when top managers or top operations managers lead the process than when other employees do. The distinction between top managers and other employees has been examined before in other contexts, but not yet quantitatively in the energy-efficiency domain, and to the best of our knowledge no study to date in any context has specifically examined the role of top operations managers. Of the 752 assessments in our sample, 176 had top management involvement, including 41 with top operations management involvement.

Second, we use four measures for the extent to which firms "adopt" the energy efficiency recommendations presented to them. We use the traditional binary variable indicating whether a recommendation was implemented or not. In addition, we look at the value of recommendations implemented relative to those identified, measuring value either in terms of potential savings or investment needed, where a higher ratio indicates that the firm adopted a greater proportion of the opportunities identified. Finally, we also look at the average payback of adopted recommendations, where a higher score indicates that the firm adopted recommendations that (on average) will take longer to recover investments, which suggests a greater willingness to adopt. These multiple measures allow us to explore whether top managers, top operations managers, and other employees appear to use different criteria in evaluating energy saving recommendations. We do not have data on the firms' budgets, cash flows, or internal costs of capital, which prevents us from using additional measures of adoption.

Third, we distinguish between recommendations that are more likely to be disruptive, and those that can be implemented during routine maintenance, to explore whether top managers, top operations managers, and other employees respond differently to these different types of recommendation.

This paper is structured as follows. Section 2 reviews the relevant literature and introduces our hypotheses. Section 3 describes our methods, summarizes our observations from the mini-cases and interviews, and presents our data and statistical analysis. Section 4 presents our results. We conclude in Section 5 with some of the limitations of this study.

2. Literature and hypotheses on the role of top managers in energy efficiency

In this section we first review selected literature on adoption of management programs and on energy efficiency, then formulate our specific hypotheses on the role of top managers and top operations managers in the adoption of energy efficiency practices.

2.1. Literature on energy efficiency and on the role of top managers

The energy-efficiency literature proposes several explanations for the underinvestment in energy efficiency [3–6]. One potential explanation relates to organizational failure which occurs when firms face the "split incentive" problem where the economic benefits of energy conservation do not accrue to the agent trying to conserve energy [21]. Another explanation can be traced to the alleged shortsightedness of management [22–24], which could explain why energy efficient investments require shorter payback periods or higher returns than other investments [22,25,26]. It is also possible that energy conservation may not attract top management interest [18,19]. Additionally, it may be costly to acquire information about energy efficient solutions [27]. The DOE's IAC program aims at reducing the information acquisition costs by providing free energy assessments to small and medium-sized firms. Anderson and Newell [8] find that implementation decisions in the IAC program depend more on initial cost than on annual savings, and Muthulingam et al. [28] find that the sequence in which recommendations are presented also matters. However, a comprehensive explanation of adoption rates remains elusive, and the role of top management and top operations managers' involvement has not yet been explored.