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FACTORS AFFECTING THE ORGANIZATIONAL LEVEL ADOPTION OF ENERGY INFORMATICS PRACTICES

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ABSTRACT

World energy consumption is expected to increase by 56% from 2010 to 2040. Energy efficiency improvements are needed to obtain environmental benefits, as well as economic benefits. As companies are the major consumers of energy, organizational level solutions for energy efficiency would have significant benefits both for environment and economy. *Energy Informatics (EI)* offers a practical solution for energy concerns and leads to both environmental and economic benefits for the companies. However, we still know little about the antecedents of the adoption of EI. Drawing on the motivation-ability framework, the research on organizational IT adoption, and specific characteristics of EI systems, this study develops a theoretical framework to examine factors that affect the adoption of EI practices by companies. In doing so, it will be the first organizational-level EI adoption study, which also provides insights for the IS adoption literature.

Keywords: IS adoption, Energy Informatics, motivation-ability framework, sustainability mindset, green IS

INTRODUCTION

Companies' interest in energy efficiency can be related to the energy consumption trends in the world. The United States EIA (Energy Information Administration (EIA) recently reported that the total world energy consumption is expected to increase by 56% from 2010 to 2040 (U.S. Energy Information Administration, 2013). Although renewables and nuclear power have an increasing trend of use, fossil fuels will be the major source of energy (80% share) in 2040, leading to a significant increase in carbon emissions (U.S. Energy Information Administration, 2013). Because of the environmental effects of carbon emission such as temperature increase, extreme weather events, dramatic natural changes, and sea-level rise, Organization for Economic Co-Operation and Development (OECD) calls for an urgent action to reverse the negative effects on nature and society (OECD, 2012). Energy efficiency improvements are needed to obtain environmental benefits as well as economic benefits of reducing the risk of price volatility which is a result of dramatic increase in energy demand (United Nations, 2010).

According to the energy consumption by sectors data presented in EIA's Annual Energy Review 2011 report, industry is responsible for 21% of the total energy consumption in U.S., while 40% of the total energy is consumed by electric power sector, 28% by transportation sector and only 11% by residential and commercial users (U.S. Energy Information Administration, 2012). As the data reveals, companies are the major consumers of energy. Therefore, organizational level solutions for energy efficiency would have significant benefits both for the environment and the economy.

UPS, the world's largest package delivery company, invests in technologies to minimize their fuel consumption and the impact on the environment (UPS Pressroom, n.d.). Fuel consumption, which accounts for 5.6% of company's operating budget, has always been a concern for the company (UPS Pressroom, n.d.). By installing systems into its vehicles and collecting almost 200 vehicle-related data from the trucks every day, UPS obtained significant savings by improving safety, and reducing emission, mileage, and maintenance costs (Watson, 2010). As in this case, information systems can transform data into valuable insights that help control energy consumption. Understanding the factors that influence companies' intention to use these systems is the main interest of this paper.

The development and implementation of energy informatics applications is one such organizational solution for energy efficiency. *Energy Informatics (EI)* is defined as "*analyzing, designing, and implementing systems to increase the efficiency of energy demand and supply system, by collecting and analyzing energy data sets to support optimization of energy distribution and consumption networks"* (Watson, Boudreau, & Chen, 2010). As it aims to increase the energy efficiency of both energy demand and energy supply systems by optimizing both the energy distribution and consumption networks, it offers a practical solution for energy concerns. Besides the environmental benefits of reducing energy consumption, companies can also obtain economic profits by reducing waste, energy inefficiency, and unused resources (Watson et al., 2010). Despite such benefits, the adoption of EI solutions is in its infancy and our understanding of factors that influence adoption of such solutions is limited (Malhotra, Melville, & Watson, 2013). Watson et al. (2010) conclude that the IS community ignores this important challenge. Although there is an increasing focus on research on EI (Califf, Lin, & Sarker,

2012), we still know little about the antecedents of its adoption (Melville & Saldanha, 2013). Therefore, we ask "Which motivation and ability factors affect the adoption of EI practices by organizations?". Drawing on the motivation-ability framework, the research on organizational IT adoption, and specific characteristics of EI systems, this study develops a theoretical framework to examine factors that affect the adoption of EI practices by companies.

In doing so, the study places itself at and aims to make a contribution to the intersection of three research areas: organizational-level IS adoption, Energy Informatics (EI), and the motivation-ability framework. Organizational-level IS adoption literature will be utilized and further improved by the introduction and conceptualization of new constructs such as *sustainability mindset*, *data collection capability*, and *data analysis capability*. Also, applying the motivation-ability framework in a new context provides insights of simultaneous analysis of both motivation and ability factors. In EI literature, it will be the first rigorous organizational-level adoption study to the best of our knowledge (Califf et al., 2012; Molla, 2009). This study will also contribute to the motivation-ability framework, because studying a theory in different contexts is useful to evaluate the strengths of the theory and make empirical generalizations (Bass, 1995). From a managerial perspective, this study will provide organizations with guidance about the capabilities and motivations needed to adopt EI practices.

THEORETICAL BACKGROUND

Relying on the motivation-ability framework (Merton, 1968), we analyze the factors affecting EI adoption. Specific characteristics of EI practices and existing organizational level IS adoption studies shape our research model. In this section, we start with explaining EI, its specific characteristics, and existing EI adoption studies in the literature. Then, we express our use of the motivation-ability framework and existing organizational level studies in our theorizing.

Energy Informatics (EI)

The impetus for EI is reflected by the equation: Energy + Information < Energy (Watson et al., 2010). It is defined as an environmental friendly practice that improves the supply and demand side of energy processes by the implementation, analysis, and design of an information system (Watson et al., 2010). The framework developed by Watson et al. (2010) includes three eco-goals which are eco-efficiency, eco-effectiveness, and eco-equity. Besides the purpose of solving global warming, which is emphasized by Watson et al. (2010), EI has benefits for society, individuals, and organizations (Califf et al., 2012). Some examples of EI practices are automation technologies that includes sensor networks to turn off fans and lights when unnecessary (Snoonian, 2003), improvement of traffic congestion, road safety, and productivity by using intelligent transportation systems (ITS) (Watson, Boudreau, Chen, & Huber, 2008), and adoption of smart meters, which allows the control and monitoring of energy usage (Kranz, Gallenkamp & Picot, 2010).

There has been increasing research interest in EI (Califf et al., 2012). However, as Califf et al. (2012) suggests, the existing body of research on EI is still limited. Their review also revealed that there are no organizational level adoption studies. However, given that organizations are major consumers of energy (U.S. Energy Information Administration, 2012), their adoption of EI practices is important. Though practitioners have focused on the benefits of EI, these EI benefits cannot be realized unless EI practices are adopted (Califf et al., 2012). Therefore, studying factors that influence the adoption of EI practices is an important undertaking (Califf et al., 2012).

Motivation-Ability Framework

Motivation-ability framework (Merton, 1968) suggests that both motivation and ability factors are present and affect the behaviors, actions, decisions, and attitudes of an entity (Agarwal, Mishra, Angst, & Anderson, 2007). It has been used in different fields, such as organizational behavior (O'Reilly & Chatman, 1994), marketing strategy (Boulding & Staelin, 1995), e-business adoption (Grewal, Comer, & Mehta, 2001), consumer behavior (MacInnis, Moorman, & Jaworski, 1991) and adoption of healthcare IS (Agarwal et al., 2007). It is particularly important for IS adoption research, because prior studies suggested that in the absence of either motivation or ability, information system projects are likely to fail (Grewal et al., 2001). The specific motivation and ability factors examined in extant studies that used this framework were context-specific. We, therefore, turn our attention to the organizational IS adoption literature and to the EI context to identify context specific motivation and ability factors that influence adoption of EI practices.

Motivation

Motivation, in the motivation-ability framework refers to the willingness to make an effort and the persistence in the activity (O'Reilly & Chatman, 1994). Motivational factors play an important role in organizations' adoption of information systems. Key studies of organizational level IS adoption have included a variety of motivational factors. While, institutional pressures (Chwelos, Benbasat, & Dexter, 2001; Iacovou, Benbasat, & Dexter, 1995; Liang, Saraf, Hu, & Xue, 2007; Teo, Wei, & Benbasat, 2003) and perceived benefits (Chau & Tam, 1997; Chwelos et al., 2001; Iacovou et al., 1995; Zhu, Kraemer, Gurbaxani, & Xu, 2006) were found to be common motives across different studies, studies also contextualized motivational

factors to the specific adoption context, taking into account the specific attributes of the organization and the technology. For example, in their e-business adoption study, Zhu et al. (2005) examined the effect of regulatory support which is specifically related to Internet-based e-business. Similarly, in the study of open systems adoption, which requires the implementation of interface standards between system applications, 'perceived importance of standard compliance, interoperability and interconnectivity' was found to be an important motivator (Chau & Tam, 1997). Examining the literature on organizational level IS adoption provides us understanding of common and contextualized motivations that leads to the adoption. In our research, we will analyze two motivation factors: *perceived benefits,* which was consistently found to be an important motivation in IS adoption, and sustainability mindset, which is specific to the context of EI adoption.

Based on the literature, we examine *perceived benefits* as one of the motivational factors. Diffusion of Innovations Theory (DOI) (Rogers, 1983) explains the importance of relative advantage in technology adoption. Relying on DOI, prior studies determined perceived benefits to be one of the major explanatory variables (Chau & Tam, 1997; Chwelos et al., 2001; Iacovou et al., 1995; Zhu et al., 2006). EI practices offer both environmental and economic benefits for the organizations (Watson et al., 2010). Besides that, businesses could aim to reduce uncertainty, promote collaboration, or increase accuracy of decision making by using EI practices (Zhang, Bakshi, Prasanna, & Da Sie, 2006). The goal of obtaining these benefits in the end might motivate organizations to adopt EI practices, so the *perceived benefits* is an explanatory factor in our study.

Although *perceived benefits* was studied as a common motivational factor in prior literature, examining its effect for EI adoption is important. Prior EI literature highly focused on environmental benefits, ignoring the economic outcomes (Califf et al., 2012). However, practitioners primarily focus on the benefits of EI systems, and organizational benefits are critical enough to deserve our attention in research (Califf et al., 2012). Therefore, examining *perceived benefits*, defined as "anticipated advantages that EI practices will provide the organization"(Chwelos et al., 2001), in an important contribution to EI adoption literature by including these organizational benefits. Also, having this major explanatory factor with sustainability mindset in the model will result in a more complete model of EI adoption.

We will include *sustainability mindset*, defined as "a collectively held view that long-term value-creation requires the company to embrace the risks and opportunities of sustainable development" (Grayson & Kakabadse, 2013), in our model as a context-specific motivational factor. Environmental benefits such as contributing to the solution of global warming by reducing energy consumption and carbon footprint are highly emphasized in EI literature (Watson et al., 2010). However, we are not aware of any empirical study that examines the effect of environmental motivations on a companies' adoption of EI practices. In other words, we do not know if companies are motivated by environmental goals in their decisions. By our review of the literature, we expect environmental goals to be motivational for some of the companies, which have a different mindset. As Watson et al. (2010) states, eco-effectiveness, one of the environmental goals of EI, requires a different mindset and business models. Also, corporate social responsibility studies show that institutional and cultural factors play important roles in adoption of sustainability practices (Caprar & Neville, 2012). Therefore, we introduce a new construct that captures this different mindset and culture, which influence organizations' decisions toward sustainability: *sustainability mindset*.

Ability

Ability, in the motivation-ability framework, refers to the capability to perform a certain task (O'Reilly & Chatman, 1994). Organizations' capabilities affect their decisions to adopt an information system, as it is seen in organizational level IS adoption literature. When key studies of the literature are analyzed, we see that IT-related capabilities such as IT sophistication (Caldeira & Ward, 2003; Chwelos et al., 2001) and IT infrastructure sophistication (Armstrong & Sambamurthy, 1999; Chau & Tam, 1997) are important factors of IS adoption in different studies. Besides these, context specific organizational capabilities/resources, such as financial resources for EDI adoption (Chwelos et al., 2001), innovative and learning capabilities for IT platform positioning investments to support adoption (Fichman, 2004), and internal and external sources in IS outsourcing diffusion (Hu, Saunders, & Gebelt, 1997) were also studied.

We will include *IT sophistication* as an IT-related capability; *data collection capability* and *data analytics capability* as organizational capabilities in our model. These three factors are determined by the definition of EI. We expect IT sophistication, defined as "the nature, complexity, and interdependence of IS usage and management in an organization" (Pare & Raymond, 1991), to be an important factor, because EI has IS at the heart of its framework and aims to use IS skills in energy efficiency (Watson et al., 2010). Besides that, EI, which aims to collect and analyze highly granular data, requires specific abilities of collecting and analyzing energy data sets (Watson et al., 2010). The necessity of sophisticated data collection and analysis systems can be understood from the Telematics project of UPS. In this project, they installed firmware into UPS trucks to collect almost 200 different vehicle-related data, such as oil pressure, and seatbelt use. In 2009, they had 10,000 vehicles installed with the system, and collected data which provided 2,000-5,000 readings every day (Richard T. Watson, 2010). Then, they analyzed the extensive data using advanced algorithms in order to gain safety and efficiency insights. Mark Davidson, Region Research Engineer, stated: "…This required us to create algorithms to analyze thousands

of data points…" (Richard T. Watson, 2010). Clearly seen from the UPS case, EI systems require companies to manage complicated data collection and analysis procedures. Therefore, we include data collection ability, defined as "firm's ability to gather and measure information on variables of interest, in an established systematic fashion" (Dodge, Marriott, & International Statistical Institute, 2003), and data analytics ability, defined as "firm's ability to evaluate data using analytical and logical reasoning to examine each component of the data provided" (Dodge et al., 2003), factors, to our research model.

RESEARCH MODEL AND HYPOTHESES

Based on the motivation-ability framework, the research model is shown in Figure 1.

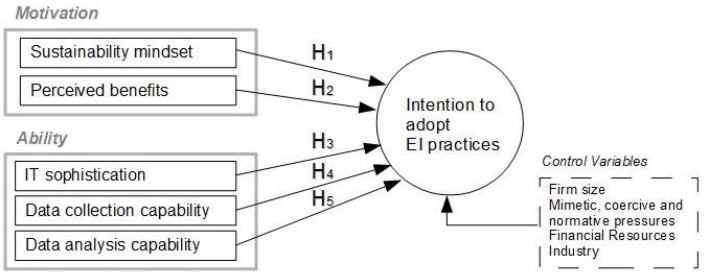

Figure 1: Research Model

Motivation

Sustainability mindset

Sustainability cannot be achieved without a change in mindset and behavior (Lave, 1988). In this current study, the construct of sustainable mindset will be defined in terms of the sustainability culture of the organization, mindset of the top management team, and the previous sustainability practices that are applied in the company. Before company culture and stakeholders institutionalized this mindset, the CEO's role is important in sustainability agenda (Stubbs & Cocklin, 2008). After sustainability mindset is established, the CEO's role is diminishing, but still exists (Stubbs & Cocklin, 2008). Therefore, the top management team's attitude is an important factor in the decision of sustainability practices, especially at the beginning. Organizational culture of sustainability and prior sustainability practices make an organization ready for the change. Because the mindset drives the decisions, companies with sustainability mindset will be more likely to adopt EI practices. Therefore, we hypothesize a positive relationship between sustainability mindset and EI adoption intention.

Hypothesis 1: Sustainability mindset of an organization will lead to a greater intention to adopt EI practices.

Perceived benefits

EI informatics requires investments in sensor networks, flow networks, hardware, software, and training of the employees for the capability of sensing and reporting energy data (Watson et al., 2010) at the implementation stage, so it requires high financial commitment. The return of this investment will be critical concern for companies who intend to adopt EI practices.

The outcomes of the EI practices are unique in the sense that they have environmental, societal, and economic dimensions (Elliot, 2011; Porter & Kramer, 2007). Economic dimensions of EI practices are the cost reduction and the differentiation (Dedrick, 2010). Energy savings lead to significant reductions in cost, and thus lead to economic profits. Another economic profit is the differentiation of the company from the competitors in using environmental friendly systems to attract green-conscious customers and green-conscious stakeholders (Zinkhan & Carlson, 1995). Sustainability practices are found to increase customer loyalty and satisfaction in the literature (Koller, Floh, & Zauner, 2011; Prud'homme & Raymond, 2013). These are some of the benefits of EI practices. When companies expect these benefits as a result of implementation of EI practices, their intention to adopt will be greater. Therefore, we hypothesize as follows:

Hypothesis 2: Greater degree of perceived benefits of an organization from EI practices will lead to a greater intention to adopt them.

Ability

"Energy informatics is concerned with analyzing, designing, and implementing systems to increase the efficiency of energy demand and supply systems. This requires collection and analysis of energy data sets to support optimization of energy distribution and consumption networks."(Watson et al., 2010)

This original definition reveals that EI practices require energy data collection and analysis, as well as a specific IS.

IT sophistication

EI aims to reduce energy by using information systems (Watson et al., 2010). The use of IS in a practice requires capabilities to utilize IT in a firm. From our literature review, we see that a firm's IT capability has been found to be an important factor in the adoption of an IS practice. Similarly in EI adoption, technological expertise of the firm and the role of IT will affect its adoption intention positively. Because the optimization of energy consumption requires a decision mechanism at the higher level of the organization, the role of IT in decision making and in access to information will affect the adoption decision. Besides that, the attitude of top management team toward the role of IT is important in EI adoption. Both the level of technological expertise within the organization, and the level of management understanding and support for using IT to achieve organizational objectives, are captured by the *IT sophistication* construct (Pare & Raymond, 1991). Therefore, we expect the high level of IT sophistication to have a positive influence on EI adoption intention, and hypothesize:

Hypothesis 3: Greater IT sophistication in an organization will lead to a greater intention to adopt EI practices.

Data collection capability

One of the basic functions of EI is to collect data from the sensor network and send them to a flow network to be used in optimization algorithms (Watson et al., 2010). Implementing a sensor network to collect energy data requires financial investment and technical know-how. Also, data storage capacity and the availability of the employees who can validate the accuracy of the collected data are needed. Besides these internal factors, external data collection might be an issue. In most of the EI practices, there is a dependency on environmental data such as weather data or satellite data. Overall, firms need to have data collection capabilities to be able to utilize any EI system. Therefore, we expect a positive relationship between the data collection capability and intention to adopt EI practices.

Hypothesis 4: Greater data collection capability on an organization will lead to a greater intention to adopt EI practices.

Data analysis capability

Examples of EI functions include auto-controlling the energy usage with the optimization algorithms, enabling managers to monitor flow networks to make managerial decisions about the energy usage, and providing customers with an automated control of energy usage. As in the examples, presenting complex energy data in a user friendly way and performing optimization algorithms requires sophisticated data analysis and modeling tools, enough technical resources, and employees who have analytical skills and prior experience in data analysis. Firms having data analysis capability can accomplish certain functions of EI practices that they adopt. Therefore, data analysis capability of the firm is critical for their intention to adopt EI practices and we expect a positive relationship between data analysis capability and intention to adopt EI practices.

Hypothesis 5: Greater data analysis capability on an organization will lead to a greater intention to adopt EI practices.

Control Variables

Relying on organizational level IS adoption studies, four control variables will be included in the model: *firm size*, *institutional pressures* (mimetic, coercive and normative), *financial resources* and *industry*. Firm size was found to influence innovation adoption positively, because of large firm's ability to possess slack resources and skills (Rogers, 1983). We expect a positive relationship between intention to adopt EI practices and institutional pressures, because organizations try to conform to shared norms and behaviors in order not to be questioned in terms of legitimacy and thus not to lose the ability to access resources and social support (DiMaggio & Powell, 1983; Teo et al., 2003). Financial resources of the organizations are expected to influence the intention to adopt EI positively because of having available capital for IT investments (Chwelos et al., 2001). Lastly, industry type was found to be effective in the adoption decision (Zhu et al., 2006). In terms of industry, we control for the energy-intensiveness of the industry, which is high in some industries such as manufacturing and transportation. These factors will be taken into account as control variables in our research model.

CONCLUSION

This research has several implications both for the IS research community and practitioners. First, a contribution to the organizational level IS adoption literature is made by applying motivation-ability framework in a new context of EI. Although different motivation and ability factors were examined in IS adoption, simultaneous analysis of both factors has been rarely studied in the literature. In this research, we show the necessity of both motivation and ability factors in IS adoption, providing insights for future adoption studies. It also contributes to the development of the framework itself, by supporting it in a different context. Second, this is the first rigorous study of organizational level adoption of EI to the best of our knowledge. As explained, it is important to understand the factors of EI adoption to be able to get the benefit of its usage. Third, new constructs, which are sustainability mindset, data collection capability, and data analysis capability, are

introduced into the IS literature to be utilized in future research. Lastly, as a contribution to the practice, this study provides organizations with the guidance for the capabilities and motivations needed to adopt EI practices.

Future research includes the further development and operationalization of new constructs, scale development for the constructs, and survey administration to the representative sample of potential EI practice adopters.

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