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Extending the model of internet standards adoption: A cross-country comparison of IPv6 adoption

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ABSTRACT

Internet standards are very important for the effective operation of organizations. This study extends on the model of Internet standards adoption by examining the effect of organizational factors on adoption of Internet standards across different cultures. We propose attitude, top management support, and participation as important organizational factors influencing Internet standards adoption. Surveys were conducted in Australia and China, and the results show that organizational factors indeed play an important role in Internet standards adoption. Moreover, the effects of organizational factors are significantly different between the two countries. Discussion and implications of these findings are provided to conclude this study.

1. Introduction

The Internet is ubiquitous these days. The vast majority of organizations in developed countries are connected to it, and developing countries are catching up fast. Standardized communication protocols are vital for organizations to seamlessly operate on the Internet. Arguably the most important standard is the Internet Protocol (IP), which is responsible for the logical addressing of all connected devices, so they can communicate with each other. However, the address space of IP version 4 (IPv4) has almost entirely been occupied. The remaining IPv4 address blocks were allocated to the five Regional Internet Registries (RIRs) by the Internet Corporation for Assigned Names and Numbers in 2011. Soon after, Microsoft offered US $7.5 million for a block of 666,624 IPv4 addresses [1]. As the demand for IP addresses has grown, an IPv4 address resale market has emerged. Brokers transfer IPv4 address from companies with an excess of addresses to those that need IPv4 addresses but can no longer obtain them from RIRs. Network Address Translation (NAT) helps to conserve IPv4 addresses, but it is only intended to be a short-term solution.[1]

To solve the issue of the IPv4 address shortage in the long term, IP version 6 (IPv6) was developed to provide a vast new address space. The enormous size of the Internet, with millions of connected devices owned by individuals and organizations, has encumbered the adoption of new standards. Indeed, several new standards have been developed, but adoption has stalled; however, the transition from IPv4 to IPv6 is the most prominent example of a new Internet standard, for which adoption was initially slow but has accelerated in recent years [2].

To improve understanding of Internet standards adoption, Hovav and co-workers [3,4] propose a model of Internet standards adoption (ISA). Their work greatly furthers our understanding of the adoption of Internet standards such as IPv6. Despite recent progress, there are still two main limitations in the current literature. First, while Hovav et al.'s [4] ISA model is helpful to understand how usefulness and environmental conduciveness influence the adoption of Internet standards, little is known regarding how organizational factors influence ISA. The previous literature has suggested that organizational factors play an important role in technology adoption. For example, in the context of green information systems (IS), Wang et al. [5] argue that management leadership, green mindset, and past experiences positively influence the intention of organizations to adopt Green IS initiatives. Vykoukal [6] also finds that top management support is positively related to grid assimilation.[2] However, few studies have examined how various organizational factors influence ISA.

Second, previous studies on ISA in general and IPv6 adoption in particular tend to focus on a single country. For example, Hovav et al. [3] examine IPv6 adoption in South Korea, and several surveys have

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[1] NAT allows many devices with private IPv4 addresses, which can be reused in different private networks, to communicate with the public Internet through a NAT gateway. The gateway translates between private addresses and one or more public IP addresses assigned to the gateway. NAT is widely deployed in home networks and some consider it to be an alternative to IPv6. However, we believe that it is not really an alternative as it has a number of drawbacks compared with IPv6. For example, it causes problems with geolocation and geoblocking and it has stifled Internet protocol innovation (any new protocol has to be NAT-friendly).

[2] Grid technology is a specific kind of Green IS initiatives that automatically adjusts the provision of hardware resources based on demand (Vykoukal [6]).

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been conducted to understand the adoption of IPv6 in Australia [7], Croatia [8], and the US [9]. However, none of these studies examined the role of culture on the adoption of Internet standards such as IPv6. To fill those two gaps in the current literature, we aim to examine how organizational factors influence ISA across different countries, using the context of IPv6 adoption in Australia and China.

Our study makes two importation contributions. First, our study extends the ISA model by including organizational factors. In particular, we propose that attitude toward Internet standards, top management support, and participation are important organizational factors that may influence ISA. These three variables are derived from DeSanctis and Poole's [10] adaptive structuration theory (AST) and are adapted to the context of ISA. Attitude toward Internet standards is consistent with the degree to which members agree that structures should be appropriated. Top management support is consistent with members' style of interaction and deals with management style to support ISA. Participation is consistent with members' degree of knowledge and experience and focuses on how organizations seek information on Internet standards. AST is chosen because it is a useful theoretical lens through which to understand the process of technology adoption and has already been applied in different contexts, such as Green IS [5], and social media [11]. By examining the effects of organizational factors on ISA, our study aims to provide further insight into how organizations adopt Internet standards.

Second, our study elucidates the role of culture on ISA. As McCoy [12] posit, as "globalization of businesses and systems continues to increase, our understanding about the adoption and use of IT needs to apply to other cultures," we aim to understand how factors driving ISA vary across different cultures. Australia and China are selected because they are two economically important countries in the Asia-Pacific region with quite different cultures. Further, according to statistics by Google [13], both countries exhibited low but rising IPv6 deployment at the beginning of 2016.[3] Thus, our study contributes to the current literature and provides valuable insights regarding how Internet standards, such as IPv6, are adopted across different cultures.

The rest of the paper is organized as follows. We first review previous literature on ISA and describe the status of IPv6 adoption in Australia and China. Then, on the basis of findings from the literature, we develop research hypotheses and the research model. The research method and data analysis are then presented. Finally, the implications for theory and practice are discussed.

2. Literature review

2.1. Internet standards adoption

Adoption of Internet standards is a complex scenario for organizations [3]. On one hand, organizations make their own decisions regarding whether to adopt certain Internet standards and to what extent. On the other hand, organizations may need to coordinate their adoption decisions with other organizations because they are closely related and interconnected. Therefore, there is an ongoing tension between autonomous decision-making and the need for interrelatedness in the context of ISA [4].

In regards to these two aspects, two perspectives have been proposed to understand ISA. The first perspective is *diffusion of innovation*, which focuses on the value of attributes of the innovation [14]. Among five innovation characteristics proposed by Rogers [14], only relative advantage and complexity consistently relate to innovation adoption [15]. According to Hovav and Schuff [16], as Internet standards represent infrastructure technology, they need new applications to derive relative advantage and drive adoption. Thus, killer applications (new applications that are perceived to have high value) may be important for ISA [16]. However, in their later study, Hovav et al. [3] fail to find any significant relationship between killer applications and ISA.

The other perspective is the *economic perspective*, which deals with the economic value of the innovation to organizations [17]. This perspective examines the influence of the environment on adoption decisions, such as switching costs, resource concentration and power, government sponsorship, and normative pressure [3]. Resource concentration and power, and normative pressure have been found to significantly influence adoption decisions, while switching cost and government sponsorship have no significant effect [3].

By integrating these two perspectives, Hovav and co-workers [3,4,16] develop an integrative model of ISA. They argue that decisions to adopt Internet standards depend on both usefulness of features based on the *diffusion of innovation perspective* and environmental conduciveness based on the *economic perspective*. Their ISA model makes a significant contribution to our understanding of how organizations adopt Internet standards.

However, the ISA model fails to consider the role of organizations in ISA. For example, Hovav and Schuff [16] argue that the dissemination of information through consortia is important in the adoption of Internet standards such as IPv6. Yet, the ISA model does not capture how organizations can obtain relevant information regarding Internet standards to facilitate their adoption decisions.

From the previous literature, this study extends the ISA model by including organizational factors and by trying to understand the effects of these factors on ISA. The key variables considered in the present study include usefulness factors,[4] environmental factors, and organizational factors (Table 1). The usefulness factors we included were *relative advantage* and *complexity* as they consistently relate to innovation adoption [15]. We also added the variable *new features* to deal with killer applications as this is argued to be vital in the context of Internet standards [3]. For environmental conduciveness, we include *normative pressure* as the main variable. *Switching cost* is excluded as no significant effect of this variable is detected in previous literature [3]. *Resource concentration and power* deals with the uneven allocation of important resources [3]. As the demand for IPv4 addresses is probably uneven between countries, resource concentration may not be an issue in certain contexts. For example, a country whose main industry is agriculture may not demand as many IPv4 addresses as another country focusing on Information Technology (IT) industries. Therefore, instead of using resource concentration and power, we select *IPv4 running out* as a control variable to capture the degree to which organizations are facing an IPv4 address shortage.

2.2. IPv6 adoption in Australia and China

In the following paragraphs, we briefly introduce IP and then provide an overview of IPv6 adoption in the context of Australia and China.

When IPv4 was developed in the late 1970s, 32-bit-long addresses were seen as sufficient to cope with future growth. However, in the late 1980s it became obvious that the Internet would run out of unused IPv4 addresses relatively soon, so IPv6 was developed. IPv6 has 128-bit-long addresses, making the address space so large that it is very unlikely to ever be exhausted. IPv6 was standardized in 1998, but it was not deployed by most organizations for many years, largely because (1) IPv6 is incompatible with IPv4 and requires a costly infrastructure upgrade and transition techniques that allow IPv4 and IPv6 to coexist and (2) IPv6 lacks attractive new features, apart from the large address space,

[3] Note that on a per capita basis Australia has a much larger allocation of IPv4 addresses than China.

[4] As the ISA model is developed by combining diffusion of innovation and the economic perspective, useful factors from the ISA model are from innovation characteristics proposed by Rogers [14]. Here, we use the name "useful factors" instead of "innovation characteristics" to be consistent with the terminology of the ISA model.