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Understanding the determinants of RFID adoption in the manufacturing industry

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ABSTRACT

Radio frequency identification (RFID) is one of the most promising technological innovations, with the potential to increase supply chain visibility and improve process efficiency. It allows remote identification of an object using a radio link. However, it has yet to see high rates of adoption in the manufacturing industry. Thus, effort is required to identify determinants affecting RFID adoption in the manufacturing industry. Based on the technology–organization–environment (TOE) framework of Tornatzky and Fleischer (L.G. Tornatzky, M. Fleischer, The processes of technological innovation, Lexington Books, 1990), nine variables (relative advantage, compatibility, complexity, top management support, firm size, technology competence, information intensity, competitive pressure, and trading partner pressure) are proposed to help predict RFID adoption. Data collected from 133 manufacturers in Taiwan is tested against the proposed research model using logistic regression. The results and implications included in our study contribute to an expanded understanding of the determinants that affect RFID adoption in the manufacturing industry.

1. Introduction

Radio frequency identification (RFID) is a generic term for technologies that use radio waves to automatically identify individual physical objects. Once goods are attached with RFID tags, their whereabouts can be tracked automatically by radio readers, providing greater inventory visibility, improved business and control processes, and enhanced supply management efficiency [1,2]. Therefore, many businesses are in various stages of applying the advantages of RFID to experimental projects to improve operational efficiency and to gain competitive advantage [3]. The RFID technology market is thus a rapidly growing market, with a total value that is expected to top US$7 billion by 2008 and increase to US$26.88 billion by 2017 [4].

While RFID has been discussed in the literature as a technology that can provide several advantages, both strategic and operational, to its adopters, the RFID adoption rate is not growing as fast as expected [2,5]. This suggests more effort is necessary to understand the process of adoption of the technology and to identify factors affecting the RFID adoption decision [6]. The technology–organization–environment (TOE) framework is a reasonably theoretical basis for analyzing technology adoption at the firm level [7]. Using the TOE framework, this study developed and validated an adoption model for RFID technology in the manufacturing industry.

The rest of this paper is organized as follows. Section 2 introduces the background of RFID and the literature review of TOE framework and prior RFID adoption studies. In Section 3, we present the research model and hypotheses. This is followed by the description of the research methods used in data collection and measure purification. Section 5 presents an analysis of the data. The last two sections offer a discussion and conclusions, respectively.

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2. Background

2.1. RFID

RFID stands for the radio frequency identification, a generic term for technologies and systems that use radio waves to transmit and automatically identify people or objects. A generally possible context for an RFID system is shown in Fig. 1. The RFID system typically consists of three basic components: tags (transponders), readers, and middleware [8,9]. It is always connected to an enterprise application system for data processing in support of business activities.

A tag usually comprises a microchip and an antenna that are attached to or embedded in an object [10,11]. The microchip contains identification information and may have other application data (e.g. price, cost, location, and manufacture date, etc.) [12]. The antenna's functions are to send and receive data, and power up the tag by absorbing radio-frequency energy [10,11,13]. The RFID tags come in various forms and functional characteristics. The cost and functions of one tag depend on its form, operating frequency, data capacity, range, power supply, presence or absence of a microchip, and read/write memory [8,14]. The RFID tags are usually classified according to their power supply, usually in the form of a battery. “Passive tags” do not have their own power supply, and therefore all energy required for the tag operations must be drawn from the reader's radio signals [14]. “Active tags” typically have internal read and write capabilities, their own power supply, and can transmit their signals over a long distance [10]. “Semi-passive tags” fall somewhere between the two types of tags mentioned above. Semi-passive tags have their own power supply for the microchip's standby operation but not for broadcasting a signal to the reader; they draw energy from the reader during active communication [8,11].

The reader, also called an interrogator, is a device that consists of a radio-frequency module, a control unit, and one or many antennas to read/write the information stored in the RFID tags by transmitting and receiving radio-frequency waves [9,15,16]. Basically, the reader instructs antennas to generate the proper radio-frequency field. The area is called the interrogation zone within which a reader can read the tag. When a passive tag moves into the zone, it draws power from the reader's radio-frequency and sends out the programmed response [8,13]. Active tag does not reflect the signal from the reader [10]. Because an active tag has its own power supply and transmitter, it does not have to wait for the reader's signal and can send its data at certain intervals as defined by the system [17].

In order to make application systems independent of various types of readers and their different connection interfaces, and free from filtering, processing and cleaning huge amount of data, there is a need of an intermediate layer between the RFID readers and the enterprise application systems [8,18]. The requirement is fulfilled by the middleware. The middleware functions may include: (1) reader and device management: provide a common interface to configure, monitor, deploy, and issue commands directly to readers; (2) data management: filter raw data and pass on only useful information to the appropriate applications; (3) application integration: provide integrated RFID data and connect disparate applications within the enterprise; and (4) partner integration: provide collaborative solutions like business-to business integration between trading partners [10,13,18].

RFID is based on radio wave propagation. Radio waves have the ability to penetrate matter, enabling the system to read a tag in a good that is not visible. This permits the user to identify or track such goods without scanning a barcode [1]. By providing precise data on product location, product characteristics, and product inventory levels, RFID promises to eliminate manual inventory counting, warehouse mispicking, and order numbering mistakes. Manufacturers can benefit from RFID in such areas as inventory visibility, labor efficiency, and improved fulfillment, and supply chain management efficiency [2,9]. These advantages will bring opportunities for improvement and transformation in various processes of the supply chain.

2.2. The technology–organization–environment framework

Tornatzky and Fleischer [7] proposed the technology–organization–environment (TOE) framework to study the adoption of technological innovations. They argue that the decision to adopt a technological innovation is based on factors in the organizational and environmental contexts, as well as characteristics of the technology itself. This framework thus envisions a threefold context for adoption and implementation of technological innovations: technological context, organizational context, and environmental context.

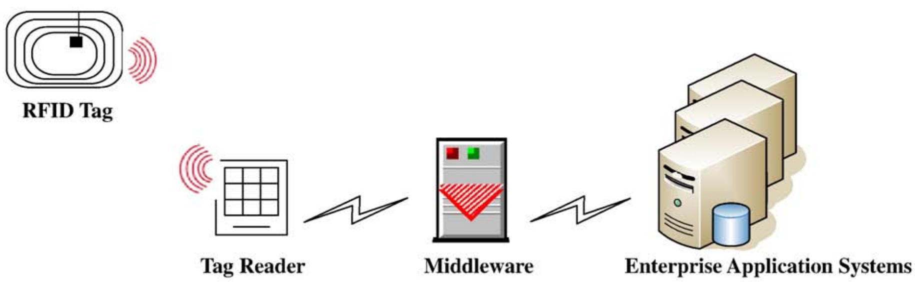

Fig. 1. RFID system context.