



# Adoption of Mobile Technology in the Supply Chain: An Exploratory Cross-Case Analysis

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## ABSTRACT

*The increasing utilization of mobile commerce technologies in e-business raises the question of their use in supply chain integration and management. This article presents a multiple case study investigation of the adoption of mobile technology in the supply chain. A technology-organization-environment framework of the contextual influences on technological innovation adoption is used to inform an analysis of three companies' adoption and use of mobile data solutions for sales automation, freight tracking, and service support. Analysis of the three case studies found that the relative advantage of the technological innovation and the information intensity of the company were the most important factors influencing adoption. Other factors that appeared to influence adoption included the compatibility of the technology with the company's business approach, the presence of top management support, and the degree of organizational readiness. Environmental factors such as competition within the industry or business partner influence seemed less influential for these pioneers of mobile technology use in supply-side activities.*

*Keywords:* IT adoption; IT innovation; mobile commerce; supply chain management

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## INTRODUCTION

Supply chain management (SCM) can be defined as "the process of managing relationships, information, and materials flow across enterprise borders to deliver enhanced customer service and economic value" (Mentzer et al., 2001, p. 10). Information technology (IT) is pervasive in SCM, and with the development of e-commerce it is playing an increasingly strategic role as supply chain activities are conducted, linked, and integrated electronically (Bhatt & Emdad, 2001). Companies are seek-

ing to gain competitive advantage and create responsiveness to markets by adopting IT that enables them to utilize and manage information and knowledge within and across the extended enterprise (Lau et al., 2006). Of relevance to this article is the relatively recent but rapid development of mobile commerce and its application to SCM.

Mobile commerce is the conduct of e-commerce through mobile or handheld computing devices (e.g., mobile phones, PDAs, and tablet PCs), using wireless technologies and telecommunication networks (Siau, Lim, & Shen, 2003).

Such mobile technologies facilitate communication, Internet access, data exchange, and transactional capabilities largely independent of time and location. The result is increased real-time interaction between companies, employees, supply chain partners, and customers, enhancing operational efficiency and providing new opportunities for customer service (Shankar & O'Driscoll, 2002).

A number of studies have examined the potential for mobile commerce to be applied to SCM. Mobile technologies are envisaged to have the most impact in areas of SCM such as e-procurement; materials handling; warehousing; inventory management; logistics and fulfilment; asset tracking; sales and field force automation; and dispatch management. For example, it has been argued that mobile applications integrated with a company's enterprise systems can provide greater visibility into supply chain operations, leading to real-time order status information and more responsive service management (Kalakota, Robinson, & Gundepudi, 2003). When deployed to mobile employees such as sales representatives or technical field service teams, mobile technologies can automate data collection, deliver necessary information to employees wherever their location, and reduce the time needed to update data from the field for the rest of the company, resulting in improved workforce productivity, process efficiency, data accuracy, and service quality (Rangone & Renga, 2006).

The idea that mobile commerce can transform SCM is reflected in the development of concepts such as "untethered" (Shankar & O'Driscoll, 2002), "adaptive" (Kalakota et al., 2003), and "responsive" (Lau et al., 2006) supply chains. However, there are few empirical studies that focus on the adoption and implementation of mobile commerce in the supply chain activities of companies—those that do have tended to report on financially modest or relatively simple applications that support mobile activities (operational mobility) rather than the mobile transmission of data (transmission mobility) (Rangone & Renga, 2006). In contrast, this article examines the adoption of

more complex mobile applications that support transmission mobility as well as operational mobility, and integrate with existing company information systems and have the potential to change operating procedures and activities.

Since the organizational adoption of mobile commerce technologies in the supply chain is not well understood, we use an exploratory case study approach to provide an analysis of three New Zealand companies' development and use of mobile data solutions. We draw on the IT innovation adoption literature to inform our analysis. The next section summarizes this literature and presents a conceptual framework based on technological, organizational, and environmental factors influencing the innovation adoption decision. We then outline the research method used in the study before presenting our analysis of the three case studies. The final part of the article synthesizes some conclusions from the cross-case comparison and discusses the implications for research and practice in this area.

## ORGANIZATIONAL ADOPTION OF IT INNOVATIONS

There is a long-standing interest in the adoption of IT innovations in the study of information systems. In this article we are concerned with the primary adoption of an innovation by an organization, rather than its secondary adoption by individuals in the organization. By organizational adoption of an innovation we mean a process beginning with initial awareness and evaluation of a new technology or product, followed by a decision to purchase and implement the innovation, and finally its acceptance or assimilation within the organization (Frambach & Schillewaert, 2002).

Researchers have utilized a number of approaches in attempting to explain why organizations adopt IT-related innovations. Probably the most common approach used is one based around the identification of a set of contingency factors that collectively explain the innovation adoption decision or outcome (Fichman, 2004; Frambach & Schillewaert, 2002; Jeyaraj, Rottman, & Lacity, 2006). Many

contingency or factor studies of IT innovation adoption tend to follow a “technology-organization-environment” model pioneered by DePietro, Wiarda, and Fleischer (1990). The number of empirical studies following this approach provides support for its usefulness and, following calls to extend this framework to other innovation domains (Chau & Tam, 1997; Thong, 1999; Zhu, Kraemer, & Xu, 2003), we have used it to organize our exploratory study of the contextual influences on the organizational adoption of mobile commerce technologies in the supply chain.

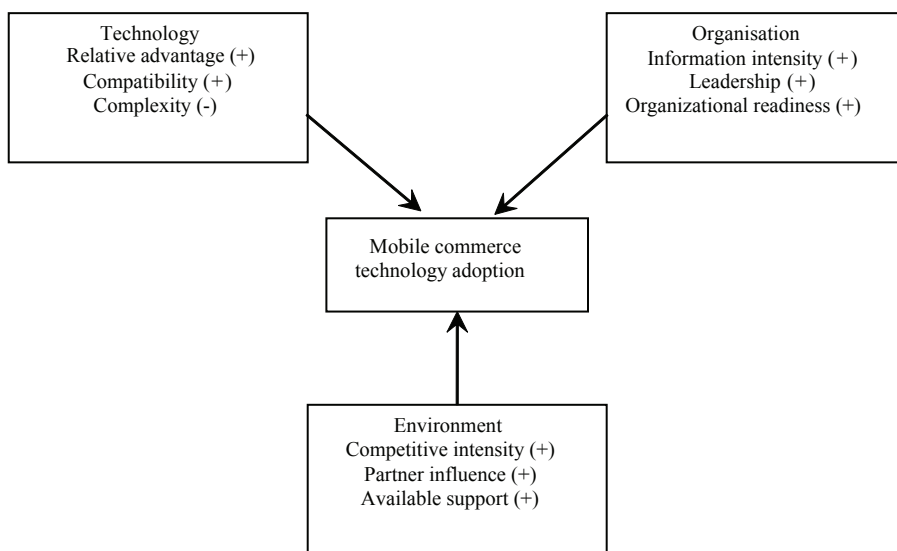
The **technology-organization-environment** model proposes that organizational innovation adoption is influenced by three elements of context: (1) the perceived attributes of the technological innovation, (2) organizational characteristics, and (3) environmental conditions. Prior studies of innovation adoption have identified a complex and rich group of potentially relevant factors within each of these three elements—too many for a single study to examine (Frambach & Schillewaert, 2002; Russell & Hoag, 2004). The adoption

model we use in this study is shown in Figure 1. It includes three high-level factors for each contextual element, which we believe have an influence on organizational adoption of mobile commerce technologies in the supply chain. Each factor is discussed hereafter.

### Technology Attributes

Tornatzky and Klein (1982) found that three perceived attributes of the technology or innovation itself were consistently associated with innovation adoption behaviors: the relative advantage of an innovation over its predecessor; its compatibility with the organization’s needs and existing systems; and its complexity to understand and use (Rogers, 2003). Potential adopters typically evaluate the *relative advantage* of a technological innovation in terms of whether the costs of adoption are outweighed by the benefits likely to be received (Premkumar, Ramamurthy, & Nilakanta, 1994). This evaluation may be in economic or in more subjective terms; what is important is that an organization perceives the new technology as advantageous in comparison with existing or

Figure 1. Contextual influences on mobile commerce technology adoption (+ and - indicate a positive or negative influence on adoption, respectively)



alternative technologies. Relative advantage may depend on how satisfied the organization is with their existing technological solution (Chau & Tam, 1997).

The more *compatible* a technological innovation, the less changes or adjustments needed and the lower the possible level of resistance to the technology when it is adopted (Teo, Tan, & Buk, 1997). Organizational compatibility involves the congruence of an innovation with organizational culture, values, and operating practices. For example, Flanagin (2000) found that some organizations adopted IT innovations at an early stage that they considered compatible with their perceived industry leadership or reputation. Technological compatibility reflects the ability of the adopting organization to successfully integrate the new technology with its existing IT infrastructure and legacy systems (Dedrick & West, 2004; Premkumar et al., 1994). Finally, the *complexity* of a technological innovation, as well as the processes and activities involved in its adoption, may negatively influence adoption (Ramamurthy, Premkumar, & Crum, 1999; Russell & Hoag, 2004).

### Organizational Characteristics

Factors related to the organizational context that may facilitate or inhibit adoption of an innovation are usually defined in terms of various characteristics of the organization, its employees, and available internal resources. Thong (1999) suggests that organizations that are more *information-intensive* in their products or services are more likely to adopt IT innovations based on their greater potential for strategic use for IT and perception of IT as a source of competitive advantage. This may be reflected in the centrality or strategic importance of IT to the organization's business and operations (Chwelos, Benbasat, & Dexter, 2001; Dedrick & West, 2004), the level of IT use or sophistication of the organization (Flanagin, 2000), or the organization's view of itself as innovative towards IT (Dedrick & West, 2004; Teo et al., 1997).

An organization's *leadership* may influence IT adoption decisions through senior

management's willingness to innovate and explore the possibilities of new technologies (Thong, 1999). In particular, the commitment, involvement, and support of senior managers can provide direction, ensure adequate resources are made available, and signal the importance of the adoption (Premkumar & Potter, 1995; Ramamurthy et al., 1999; Russell & Hoag, 2004; Teo et al., 1997). Other members of the organization (often IT professionals) may act as internal champions for an innovation, raising awareness of the innovation and its benefits with managers and potential users (Premkumar & Potter, 1995; Russell & Hoag, 2004).

The *readiness* of an organization to adopt and introduce a technological innovation relates to the existence of adequate financial, human, and technical resources within the organization (Chau & Hui, 2001; Chwelos et al., 2001; Dedrick & West, 2004; Iacovou, Benbasat, & Dexter, 1995). Of particular importance is the level of internal technical expertise available to implement the new technology (Chau & Tam, 1997; Premkumar & Potter, 1995; Zhu et al., 2003). Adoption may depend also on the ability and confidence of employees to operate IT-related innovations (Thong, 1999).

### Environmental Conditions

The environmental context constitutes the arena in which adopting organizations conduct their business (DePietro et al., 1990). The higher the *competitive intensity* in an industry, the stronger the pressure on an organization to adopt innovations in order to gain or maintain competitiveness (Chwelos et al., 2001; Ramamurthy et al., 1999). Competition also leads to environmental uncertainty, increasing the propensity for innovation adoption (Chau & Tam, 1997; Thong, 1999).

Business or trading *partner influence*, whether supportive or coercive, can also motivate an organization to adopt an innovation (Chau & Hui, 2001; Chwelos et al., 2001). Examples include external pressure from a trading partner (Iacovou et al., 1995), the presence of established trading relationships (Ramamurthy et al., 1999), and the readiness

(or not) of business partners (Chwelos et al., 2001; Zhu et al., 2003).

The perceived level of *available support* from vendors (Chau & Hui, 2001), government (Damsgaard & Lyytinen, 2000) or third parties (Dedrick & West, 2004; Doolin, McLeod, McQueen, & Watton, 2003) for an IT innovation and its implementation is sometimes an important influence on an organization's adoption decision. Perceived support may also relate to infrastructural support for the use of an innovation. For example, a lack of standards may act as a barrier to the diffusion of a relatively complex IT innovation, such as electronic data interchange (EDI) (Damsgaard & Lyytinen, 2000).

## METHOD

The research objective was to provide an empirical exploration of why organizations might adopt mobile commerce technologies in their supply chain activities. Because our understanding of this technological innovation context is relatively undeveloped and lacks a strong theoretical base, we used an exploratory case study approach (Benbasat, Goldstein, & Mead, 1987). Further, a case study approach facilitates our focus on the contextual conditions of mobile commerce technology adoption (Yin, 2003). We applied the preliminary model of mobile commerce technology adoption, shown in Figure 1, to three case studies of organiza-

tions that had adopted mobile data solutions in their supply chains.

Our primary source of data was semi-structured interviews conducted during 2004 with key informants in three New Zealand companies. The interviews were based on a common set of questions designed to elicit information on the company and its operations, its use of IT, the decision to adopt mobile technologies, the perceived benefits of the technology, factors facilitating or inhibiting adoption, the implementation process, and any implications of adoption for the company. The interviews were audio-taped and transcribed for qualitative data analysis. This involved both within-case and cross-case thematic analysis organized around the theoretical propositions identified previously (Yin, 2003). The interview data were supplemented with secondary data sources, including publicly available information on the companies and their activities. Table 1 summarizes the interviews and background details of the three case study companies.

In the following sections we present our analysis of the three case studies. Each case is structured around a brief description of the company and the mobile data solution studied, followed by a discussion of the three types of contextual influence identified in the research model outlined in Figure 1: attributes of the technology itself, organizational characteristics, and wider environmental or industry conditions.

Table 1. Case studies

	FoodCo	FreightCo	PowerCo
<b>Business</b>	Food manufacturing and marketing	Freight, logistics and warehousing	Electricity network and distribution
<b>Company size</b>	900 employees	1200 employees	280 employees
<b>Turnover</b>	NZ\$220 million	NZ\$890 million	NZ\$870 million
<b>IT team</b>	4 employees	20 employees	20 employees
<b>Application</b>	Mobile sales automation	Mobile freight tracking	Mobile service support
<b>Interviewees</b>	IT Manager Systems administrator Commercial manager	IT manager Logistics manager Stock controller	IS manager Customer service manager



Selected quotes from the interviews are used to illustrate the analysis.

## MOBILE SALES AUTOMATION AT FOODCO

FoodCo is a New Zealand subsidiary of a multinational food company. It manufactures and distributes a range of product lines to a large retail customer base via mobile sales representatives. The company emphasizes speed and efficiency in order taking and fulfilment as essential to maintaining customer satisfaction. FoodCo has a small IT department for routine maintenance of the company's information systems. It was a pioneer in New Zealand in the use of barcode scanners to capture order information at the point of customer contact and the transmission of this data to its sales office, first by dial-up modem over a landline and then by car phone over a cellular phone network. In 1999, the company decided to upgrade its system and outsourced development of a customized mobile data solution used by the sales force via laptop computers. This system has been progressively updated since then both in terms of software and hardware. The major motivation for the adoption of a mobile sales automation technology was "to move key strokes out of the office into the field" (IT Manager).

Sales representatives now use battery-operated tablet PCs to download updated product information, customer information, sales promotions, territory management information, stock levels, and replenishment dates. Inputted order and invoicing information is transferred to the company's sales office where the information is processed via the company's enterprise resource planning (ERP) system and the required goods are dispatched as quickly as possible. Customer information and in-store negotiated promotion details can also be updated in real time. Other functionality includes a supermarket shelf management function and a sales effort screen, which provides information on sales targets and volumes and allows sales representatives to track their performance at product level. Data is transmitted over a general packet radio service (GPRS) wireless network,

although the units also have built-in modems for use with a landline and infrared ports for use with mobile phones if alternative data transmission mechanisms are needed.

### Technology Attributes

FoodCo clearly perceives a relative advantage in their mobile data solution: "The benefits have certainly been there and pretty much delivered to our expectations" (Commercial Manager). The mobile data solution effectively automates the sales process, eliminating the paper work, which sales representatives were previously doing. Lightweight tablet PCs have replaced the "huge, big briefcases of paper" (Systems Administrator) previously carried by sales representatives. The added information and functionality provided by their mobile data solution enables FoodCo's sales representatives to undertake promotion management, conduct in-store deals, and manage customer relationships on a one-to-one, real-time basis. This was seen as enabling a shift in their role: "We see the [mobile] unit becoming even less an order entry unit and much more of a business management tool" (IT Manager).

The mobile data solution has enabled FoodCo to improve the efficiency of its order processing and logistics. Timely receipt of sales orders means that planning associated with warehouse picking and truck delivery loads can begin earlier: "We are becoming more and more focused in that area of getting that whole process more and more efficient. And having the orders coming in effectively within five minutes of them being taken into [the ERP system], ready to be picked, has been beneficial to us" (Systems Administrator). The mobile data solution is also considered to be a source of competitive advantage through the way that it integrates and synchronizes information regarding customers, products, and distribution, enabling the company to manage its key customer accounts more efficiently: "Historically we were very good at transactions and you've got good competitive advantage by being able to transact better than anybody else.

But now it's not about transactions, it's about knowledge management" (IT Manager).

The current tablet PC technology is considered to be a significant improvement over previous units in terms of weight, screen size, and processing power. While some transmission and coverage issues had been experienced with the cellular network originally used to transmit the data, data is now transmitted over a GPRS wireless network selected because of its continuous availability, connection stability, high speed, and relatively cheap (data-driven) rates. Ironically, the speed and efficiency of the wireless transmission led to an unintended increase in projected data costs as sales representatives began transmitting data after every sales call (until reined in).

In terms of its compatibility, FoodCo's mobile data solution matched the business approach of the company in a number of ways. For example, the units allow sales representatives to manage customer relationships with key accounts in person rather than from head office. Similarly, sales representatives take a proactive role with small retailers: "It's all about presence in the marketplace and being there in front of them and actually influencing buying patterns" (Systems Administrator). The mobile data solution was also compatible with the IT infrastructure and approach used by FoodCo. The existence of the company's ERP system and the simultaneous rollout of its sales and distribution modules provided the necessary complementary technology for the mobile data solution to function effectively.

Extensive training was required to up-skill the sales force in using both the mobile computer units and the extended range of functionality. The tradeoff of the more powerful, large-screened tablet PC units was their complexity, which made them more prone to breakdown and damage when dropped or mishandled. In addition, the mobile data solution project grew in size and complexity, creating some difficulties in coordination between the various departments involved in its use: "I think the biggest thing was that it ended up bigger than it was ever planned to be ... Sometimes

what you find is that when you revisit it that a lot of the facility there isn't being used to its capability" (IT Manager).

### Organizational Characteristics

The adoption of mobile technology for sales automation reflects both FoodCo's history of IT use (including sales automation) and its innovative attitude towards IT. FoodCo had been actively monitoring and developing the e-business side of its operations since 1999: "[FoodCo] has always been at the front of deploying that kind of technology to the market ... We tend to pick up the new technologies quickly if we can see there's a clear business input" (Systems Administrator). The small IT department within FoodCo actively looks for ways to utilize new and innovative IT in the company's operations. However, the decision to explore new technological options in sales automation was a strategic one taken by FoodCo's senior management. According to the IT Manager, "That type of leadership has always been there ... The current management is very, very supportive."

An unwillingness of some sales representatives to embrace the new technology initially slowed adoption and use of the mobile data solution within the company. Some lacked computer literacy, were reluctant to change established ways of doing things, or were reluctant to utilize the new functionality in front of customers in case they showed their inadequacy. As the Systems Administrator explained, "Some of our reps have been with the company for a long time ... and putting a computer in front of them was terribly daunting." However, with time and training this barrier was overcome, with many of these representatives becoming advocates for using the new technology.

### Environmental Conditions

FoodCo perceive themselves as leaders in their industry, particularly in gaining competitive advantage through the innovative use of IT for knowledge management. In relation to their use of mobile technology, "We were seen to be again, you know, market leading and out there

doing things at the forefront basically” (Systems Administrator). FoodCo’s largest customers, major supermarket chains, were beginning to move their suppliers to electronic ordering and invoicing, and FoodCo’s significant investment in sales automation technology meant that they were well-perceived by these key customers. The proactive contact and support provided by FoodCo’s GPRS wireless network provider was mentioned in our interviews as positively influencing the company’s adoption of a wireless data solution.

## MOBILE FREIGHT TRACKING AT FREIGHTCO

FreightCo is a supply chain logistics provider with operations in New Zealand, Australia, Asia, and the United States. The company offers a full range of logistics services, including managed warehousing, domestic distribution, and international freight operations, linked with IT and information systems. FreightCo operates a nationwide fleet of delivery vehicles in New Zealand servicing a large customer base. It coordinates its distribution operation through a centralized database supplied with real-time freight tracking data from delivery drivers in the field. FreightCo tends to outsource much its development work, with its IT team working on systems maintenance and IT innovations.

The original motivation for deploying a mobile freight tracking system was to “get even more satisfaction to the customers and get in that customer focus” (IT Manager). Drivers scan the barcode of each piece of freight on delivery using a lightweight handheld device with an inbuilt scanner. A consignment note, the date, time and location of delivery, the driver’s identity, and the recipient’s name is uploaded to the company’s central database, where that information is made available via a Web site to customers, who can track the movement and status of their freight consignment in real time. The delivery information is also used as the basis for payment of the owner-drivers. New job information or updates flow back to the driver’s handheld unit from FreightCo’s administrative center. FreightCo was a pioneer

in using systems such as this, transmitting data over a third-party operated trunk radio network via radio telephones in the delivery trucks since 1992. In 2004, FreightCo commenced transmitting data over a GPRS wireless network.

## Technology Attributes

At FreightCo, the mobile data solution implemented for freight tracking removed the need for paperwork and reduced the administrative workload on the distribution fleet drivers, leading to considerable efficiency gains: “Basically we’re piling through the freight, or the paperwork about the freight, in a much more efficient manner ... The piles of paperwork that we would have had would have been enormous” (IT Manager). The automated system also decreases the chance of errors, improves the timeliness of information, and increases the speed at which information becomes available to customers: “[It] gave us the advantage of managing our network much better, in such a way that we knew where the freight was much better, we knew what our timing was, we knew we could monitor when things went wrong.” (IT Manager)

FreightCo sees information and technology as central to its business of providing “intelligent” logistics solutions for its customers. It perceives technology to be the key differentiator in the logistics industry, and sees its ability to provide real-time information across the supply chain to customers as a competitive advantage: “It meant that we had much more to sell. I think we were already the premium provider out there, but it kept us the premium provider. Having been ahead of the technology, like we were, enabled us to continue to charge higher prices” (IT Manager).

The use of a GPRS wireless network for data transmission was seen by FreightCo as superior to the previous trunk radio network used, as it increased the amount of data that could be sent from a mobile unit at any one time (including, for example, customer signatures captured directly on the screen of the handheld devices) and also the overall data transmission capacity available to the company’s distribution



fleets. As the IT Manager observed: “[GPRS] was becoming a necessity ... The more trucks we put on, the more delays we were getting with the data backing up and not coming through ... [GPRS] seems to be unlimited.”

The mobile data solution for freight tracking is compatible with FreightCo’s business model and desire for technology leadership: “We’ve always had this fundamental business model of being the best ... Although many companies may have said, ‘Well, what’s the benefit of ... having the mobile communications today?’, We didn’t look at it like that” (IT Manager). Going mobile also allowed the company to cope with the huge growth that it experienced and continues to experience as a result of its business strategy.

### Organizational Characteristics

As a company, FreightCo is proactive in keeping its IT capability ahead of the business in order to respond to new challenges in the business environment: “we wanted to take ideas to customers before they required it of us, so you know we wanted to be very forward thinking” (IT Manager). IT is essential in linking together and managing the company’s range of logistics services. Expenditure on IT is high and the IT department actively seeks “innovative solutions and ideas” (IT Manager). While adoption of the new mobile technology was initially IT-driven, FreightCo’s management was quick to see the benefits and supported the innovation. As the company’s IT Manager recounted: “We just had a belief that it would be better and we talked directly to the owners of the business and they thought it would be better and away we went.”

Initially, the owner-driver contractors who comprise FreightCo’s distribution fleets resisted accepting the new technology. The required expenditure on new technology may have been one reason for this, although FreightCo did subsidize half the cost of purchasing the handheld units: “There was a lot of resistance by the drivers ... Resistance to change and technology. Yeah, they didn’t want to do it” (IT Manager). However, when FreightCo more

recently acquired a competitor’s fleet, the newly arrived owner-drivers were generally receptive to using the new mobile data solution. The IT Manager suggested that this was because of the benefits to drivers were evident by then.

### Environmental Conditions

The most important environmental influence on FreightCo’s adoption of mobile technology was the competitive intensity of the logistics industry in which the company operates. As noted earlier, FreightCo’s use of information provides them with a perceived competitive advantage: “We wanted to be ahead of the competition like we always are” (IT Manager). The availability and benefits of a supported GPRS network were acknowledged by FreightCo’s IT Manager: “There’s just going to be an exponential expansion ... and you’ve got networks that are prepared to invest the money in it.”

### MOBILE SERVICE SUPPORT AT POWERCO

PowerCo is a large electricity distribution company that uses field crews from outsourced contractors to maintain and repair its electricity network. Good customer service in the form of reliable power supply is important to the company, so response times to the many emergency callouts the company experiences are critical. Around 2001, the company “identified the fact that we needed to get real time information back from the field, we needed to get more accurate information out to the field” (Customer Services Manager) in order to improve the response process. In 2003, after extensive piloting and field testing, PowerCo implemented a mobile data solution purchased from an overseas vendor and then customized for the company by predominantly outsourced developers (the company’s in-house IT team works mostly on system maintenance).

When a fault is reported to PowerCo’s call center or detected by the company’s network management system, details are sent to a field crew’s handheld PDA via a secure GPRS network using a Bluetooth, wireless-capable

mobile phone as a modem. Crews can upload information on the job status, fault location, work required, and billing in real time from the field. Data is captured once and automatically updated on PowerCo's central information systems, including its customer relationship management (CRM) system and geographical information system (GIS). Customer contact representatives can access real-time information in order to accurately and quickly answer customer queries or claims. Service requests are logged against actual network assets and fault location data is uploaded from the field to the GIS, which facilitates monitoring, management, and long-term planning of PowerCo's networks.

### Technology Attributes

The new mobile data solution was perceived as better than the previous system based on two-way radios and various paper-based forms, and its benefits matched PowerCo's expectations. Invoices are now created automatically from data relevant to a service request entered in the field, reducing the need for administrative data entry, decreasing costs and speeding up the invoicing process. Other benefits included a reduction in data duplication or redundancy, with a consequential decrease in the risk of errors in data entry: "So the main drive is reducing paper, data quality, and only capturing data once" (IS Manager). The efficiency of the emergency response process also improved markedly, with faster response times and more accurate information sent to and from field crews: "We were collecting data at the call center but it was never making it to the guys in the field ... Now, everything gets passed through ... so the sort of level of accuracy of information that the guys in the field are getting is much higher" (Customer Services Manager).

The information provided via the mobile data solution has enabled the call center to deal with customers' complaints efficiently and effectively, and to keep them informed of progress in a timely manner. Because information is updated from the field in real time and made accessible to the call center operators:

"We know when they're [field crew] on-site. We know when they've restored power. We know that the job has been completed ... We can follow up all the details ... It's made a huge difference to us in terms of resolving customer complaints because all the information is actually there" (Customer Services Manager). This use of accurate, real-time information to maintain continuous power supply and improve customer service is consistent with PowerCo's role as a network provider of critical energy services.

Aspects of the complexity of the mobile data solution did become issues. For example, the limited battery life of the PDAs (which often stay docked in the field crews' vehicles in order to remain powered) and the range of the Bluetooth wireless connection between the PDA and the mobile phone modem (about 10 meters) effectively shape the crews' use of the technology. PowerCo's IS Manager described how aspects of the mobile data solution were designed to cope with crews periodically moving out of coverage. The crews are able to continue to work with the application off-line, updating the job status and then uploading the data when they come back within range. Screen layout and sequence on the PDAs was also modified to enhance the application's operability in field conditions.

In fact, the mobile data solution was deliberately developed in a way that accommodated the conditions and characteristics of field crews, who were consulted extensively. As the IS Manager recounted: "[The development company] supplied most of the developers and it was young people ... [Their design] might be flashy but it's not always practical ... [so] I arranged for them to go out with a field crew and their whole attitude changed. They suddenly started to think like the field crew and not just like a developer." Nevertheless, some aspects of the mobile data solution remain complex for the field crews to use: "The guys struggle a little bit with the GIS stuff and it's been quite a big learning curve for them, but they're getting there" (Customer Service Manager).

## Organizational Characteristics

PowerCo has invested significantly in adopting new technology. It generates, on a daily basis, large volumes of multidimensional and interrelated asset, customer, financial, and operational data, which is compiled and displayed in a number of formats to allow users to select and drill into various areas for information. Business intelligence provides information analysis and distribution, data visualization, and spatial analysis for decision making and planning: "We're ... an IT focused [company] and we believe in IT solutions too. And it was most definitely a business decision that we needed to, that we wanted to go down that track [in adopting mobile technology]" (Customer Service Manager).

PowerCo's IT team takes a reactive approach to IT solutions for the company, focusing on supporting business requirements rather than "pushing" technology: "We're really in there to try and understand the business needs before we even talk systems" (IS Manager). The impetus for the adoption of mobile technology was from top management: "It was top down. It was a benefit that our executives ... saw. And so, like, everybody's using wireless dispatching in field crews and we should actually also be using it" (IS Manager).

PowerCo uses outsourced field crews, which meant that the contractors had to be convinced to adopt and use the new mobile data solution, including taking responsibility for maintaining the mobile technology itself: "We've provided a certain number of the devices to start with but then from then on they've got to buy their own, they've got to support their own hardware, that type of thing. So we had to sell it into them as well" (Customer Services Manager). However, PowerCo provided them with training. Project team members would go into the field with the field crews, "holding their hands" as they used the mobile technology: "You have to break the habit of what they would normally do" (Customer Services Manager).

The field crews generally accepted and used the new mobile units, despite management's concern that the modern "white collar"

technology might be perceived as out of place in the *blue collar* field environment and that the field crews would *struggle with it*. In fact, although it was technology that most of the crews had not experienced before, "They picked it up pretty quickly ... I think we thought that we'd have more problems teaching them than sort of we did" (Customer Services Manager). The field crews who selected to participate in piloting the system actually refused to return the units at the end of the pilot, wanting to continue using them, and placing unforeseen demands on the company's resources as they continued supporting the pilot while developing the full mobile data solution.

## Environmental Conditions

The outsourced contractors who supply the field crews are an important business partner for PowerCo. The contractors' senior management apparently recognized the potential benefits of using wireless technology for dispatching field crews, and that at some stage they would need to adopt it: "I think they were quite pleased that we made the choice to actually roll it out, that they didn't have to do something themselves ... I think they were pretty supportive. They could see the end result should be beneficial for their business" (Customer Service Manager).

Maintaining "robust connections" between the handheld PDA units and the GPRS wireless network, remains problematic according to PowerCo's IS Manager. The company initially used wireless cards in the PDAs to access the GPRS network, but experienced a high level of disconnections, hence the shift to using dedicated mobile phones as modems. However, there were still problems with disconnections, which appeared to be related to the standard that handles communication between the GPRS network and the mobile application: "That standard is still a grey area. It's not just related to [our application]; we are also talking to other people in the industry and we've found that they lose a lot of connections ... Bit annoying, but we working with [network and application providers] to resolve it" (IS Manager).

Support from the original application vendor also became an issue, as while the application worked satisfactorily on the original handheld units used, it did not necessarily do so on the latest technology purchased by the contractor users: "We're having some problems with newer technology, getting it to be able to support the software ... That's been another issue to stop us rolling it [the mobile data solution] out wider, because there's been changes of device and [the vendor] hasn't necessarily kept up with that side" (Customer Service Manager).

## DISCUSSION

Table 2 summarizes the findings of our cross-case analysis of the adoption of mobile data solutions in the three case studies.

Perceived *relative advantage* appeared to be influential in all three companies' adoption and use of mobile data solutions. The benefits they achieved related to (1) administrative efficiency, in the form of paperwork reduction and time savings; (2) improved data accuracy and timeliness; (3) improved operational efficiency in supply chain operations; (4) enhanced roles for company users of the mobile technology; and (5) competitive advantage. The *compatibility* of the mobile data solution adopted with a focus on customer service observed in all three companies was also a common factor across the three cases. Complexity only appeared relevant in two of the case studies, where it was perceived to increase the level of user training required.

All three companies are *information-intensive* in that information processing is an important part of their business and that IT is integral in managing customer services. The importance of this factor was reflected in the history of IT use in the companies and their proactive and innovative attitude towards IT, and e-business in particular. *Leadership*, in the form of top management support for the innovation adoption, was also a common theme across all three case studies. Even where the initial awareness of the innovation was not management-driven, management adopted a supportive

attitude to the business use of new technology. With respect to *organizational readiness*, an interesting distinction emerged between the positive influence of *technical readiness* and the negative influence of *user readiness*. While the role played by two of the companies' IT teams in actively seeking innovative uses for IT was a positive influence on adoption of mobile commerce technology, the lack of readiness of some intended users to embrace the new technology tended to slow adoption or increase the time and training needed.

Although we expected wider environmental or industry conditions to play an important role in shaping innovation adoption decisions in the three case studies, overall they seemed to play less of a role than technology attributes or organizational characteristics. This may reflect the pioneering status of the three companies in their respective industries in New Zealand with respect to the use of mobile commerce technology in the supply chain. Industry *competitive intensity* was reflected primarily in FoodCo's and FreightCo's desire to be market leaders through the use of IT. *Partner influence* also played some role, with some of FoodCo's major customers innovating with electronic transactions themselves, and PowerCo's subcontractors providing support for the innovation based on their recognition of the benefits of the mobile dispatch technology. While *available support* was a factor in the adoption experience of these two cases, it did not seem to be a direct consideration in terms of the adoption decision itself. FoodCo received proactive support from its wireless network provider, while PowerCo found itself reliant on vendor support because of changing or problematic technology.

## CONCLUSION

This article has presented an exploratory empirical study into why organizations adopt mobile commerce technologies in the supply chain. The evidence from the three case studies suggests that the innovation adoption model presented in the article is likely to be of interest to researchers in this area. However, further research could refine or expand the model in several ways.

Table 2. Summary of innovation adoption findings

	FoodCo	FreightCo	PowerCo
<b>Technology Attributes</b>			
<i>Relative advantage</i>	<ul style="list-style-type: none"> <li>Information integration and synchronization a source of competitive advantage</li> <li>“Manage the business within the supermarket rather than just take an order”</li> </ul>	<ul style="list-style-type: none"> <li>Providing real-time information to customers is a competitive advantage</li> <li>“The piles of paperwork ... would have been enormous”</li> </ul>	<ul style="list-style-type: none"> <li>“Reducing paper, [improving] data quality, and only capturing data once”</li> <li>“It’s made a huge difference to us in terms of resolving customer complaints”</li> </ul>
<i>Compatibility</i>	<ul style="list-style-type: none"> <li>“It’s all about presence in the marketplace”</li> </ul>	<ul style="list-style-type: none"> <li>Freight tracking system is a good fit with the company’s focus on customer service</li> </ul>	<ul style="list-style-type: none"> <li>“The end result is that customers spend less time in the dark”</li> </ul>
<i>Complexity</i>	<ul style="list-style-type: none"> <li>“It ended up bigger than it was ever planned to be”</li> </ul>	<ul style="list-style-type: none"> <li>Not mentioned</li> </ul>	<ul style="list-style-type: none"> <li>Aspects of the mobile data solution had to be modified for field conditions</li> <li>“The guys struggle a little bit with the GIS stuff”</li> </ul>
<b>Organizational Characteristics</b>			
<i>Information intensity</i>	<ul style="list-style-type: none"> <li>“We tend to pick up the new technologies quickly if we can see there’s a clear business input”</li> </ul>	<ul style="list-style-type: none"> <li>If a company’s IT capability stays ahead of the business, the business will always be prepared for new challenges</li> </ul>	<ul style="list-style-type: none"> <li>“We’re an IT focused [company] and we believe in IT solutions”</li> </ul>
<i>Leadership</i>	<ul style="list-style-type: none"> <li>“The current management is very, very supportive”</li> </ul>	<ul style="list-style-type: none"> <li>Management were quick to see the benefits and supported the innovation</li> </ul>	<ul style="list-style-type: none"> <li>Adoption of mobile technology was initially a top-down decision</li> </ul>
<i>Technical readiness</i>	<ul style="list-style-type: none"> <li>IT team actively scans the technological environment</li> </ul>	<ul style="list-style-type: none"> <li>IT team actively seeks “innovative solutions and ideas”</li> </ul>	<ul style="list-style-type: none"> <li>“We’re really in there to try and understand the business needs before we even talk systems”</li> </ul>
<i>User readiness</i>	<ul style="list-style-type: none"> <li>“Putting a computer in front of [some of] them was terribly daunting”</li> </ul>	<ul style="list-style-type: none"> <li>“There was a lot of resistance by the drivers ... to change and technology”</li> </ul>	<ul style="list-style-type: none"> <li>“It’s just technology that they’re not used to”</li> <li>“You have to break the habit of what they would normally do”</li> </ul>
<b>Environmental Conditions</b>			
<i>Competitive intensity</i>	<ul style="list-style-type: none"> <li>“We were seen to be again you know market leading”</li> </ul>	<ul style="list-style-type: none"> <li>“We wanted to be ahead of the competition”</li> </ul>	<ul style="list-style-type: none"> <li>Not mentioned</li> </ul>
<i>Partner influence</i>	<ul style="list-style-type: none"> <li>Major supermarket chains were beginning to move their suppliers to electronic ordering and invoicing</li> </ul>	<ul style="list-style-type: none"> <li>Not mentioned</li> </ul>	<ul style="list-style-type: none"> <li>“The contractors ... were quite pleased that we made the choice to actually roll it out, that they didn’t have to do something themselves”</li> </ul>
<i>Available support</i>	<ul style="list-style-type: none"> <li>Proactive support from wireless network provider</li> </ul>	<ul style="list-style-type: none"> <li>Not mentioned</li> </ul>	<ul style="list-style-type: none"> <li>Continually changing hardware technology requires vendor support for software compatibility</li> <li>Mobile device to wireless network communication standard problematic</li> </ul>



Larger scale survey research could be used to statistically confirm the model's propositions at a more general level. Studies in different organizational or industry settings and for different types of mobile commerce innovations would potentially increase the applicability of the model. The contextual factors used in our model were selected for their perceived relevance to supply chain applications of mobile technology. Other potentially relevant factors could be explored. Finally, our exploratory case study approach does not enable us to reliably assess the **degree of influence on the organizational innovation adoption process** of the various factors in our model.

As Frambach and Schillewaert (2002) note, such models are also of use to practitioners, including both technology suppliers and organizational managers, in marketing innovations to organizations and in gaining acceptance of innovations within organizations. A prominent issue in the analysis of the three case studies was that adopting and implementing a mobile data solution involves more than automating existing processes. This is not a new finding with respect to IT innovations, but the mobility, localization, and immediacy aspects of mobile commerce technologies provide opportunities for process redesign, which imply new ways of doing things for users. Addressing the latter involves extensive and carefully thought out training, but also recognition that changing existing user behaviors may be necessary.

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