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Critical factors in e-business adoption: Evidence from Australian transport and logistics companies

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ABSTRACT

This study develops a discrete variable investment model and applies it in the study of the decision to adopt e-business by transport and logistics companies. The data analysis is carried out in two phases; in the first phase, factor analysis is conducted to identify the principal components influential to the e-business adoption decision; in the second phase, logistic regression is conducted to further analyse the effect of individual components on the adoption decision. The analysis of the data obtained from a survey of Australian transport and logistics companies has found various factors influential to the adoption decision. The first factor relates to service quality improvements brought about by e-business adoption including a higher level of competitiveness, service differentiation, value adding, improved customer services and supply chain integration. The second factor concerns the financial aspect of e-business adoption including large initial investment expense, financial constraints, and costs of operation and maintenance. The third factor concerns expectations about market demand in terms of volatility and growth in demand for freight and logistics services. The analysis and results shed light on the behaviour of transport and logistics companies and the sector's view toward e-business adoption. For example, the decision to adopt e-business should take into account not only the benefits but also the costs of adoption, running and maintenance as well as financial constraints. The model developed by the study can be applied to any sectors or industries, in which companies face discrete investment choices.

1. Introduction

Competition and opportunities in the era of global trade, investment and outsourcing have induced transport and logistics companies to look for different ways to grow and improve their competitive advantage. E-business offers a solution that allows companies to instantaneously share databases, forecasts, inventory and capacity plans, product information, financial data, and almost anything else that they may need to be operationally efficient and effective. Since transportation and logistics involves activities associated with the movement of products and information to, from, and between the members of the supply chain, e-business can help them achieve efficient coordination and integration of all these activities. In a highly competitive business characterised by time constraints and information management, technological effort especially the use of information and communication technologies (ICT) has become vital for services differentiation and diversification (Evangelista and Sweeney, 2006). The result is that competitive advantage in the transport and logistics sector has been shifted to creating value chains whose activities are directly or indirectly assisted by e-business (Disney et al., 2004; Gunasekaran et al., 2002; Landers et al., 2000; Marchet et al., 2009).

E-business has a number of applications that vary in complexity and could be defined as the use of the internet or any other electronic medium for the execution of transactions, the support of business processes and the improvement of collaboration opportunities with other businesses or clients (Matopoulos et al., 2007). Examples of e-business applications include, but are not limited to virtual logistics (Clarke, 1998), virtual warehouse (Landers et al., 2000), electronic marketplaces or logistics brokerage systems (Gudmundsson and Walczuck, 1999). In addition, Karthik et al. (2004) have shown that business to business (B2B) e-commerce enhances time-based delivery performance, while Quirós Romero and Rodríguez's (2010) have found e-procurement has a positive influence on firm efficiency although the effect is insignificant for e-selling.

According to Evangelista and Sweeney (2006), e-business has created new trends in the transport and logistics sector. First, the increasing dissemination of ICT has resulted in the integration of traditional services, such as transportation and warehousing, with information-based services such as tracking and tracing (T&T), booking, freight rate computation, routing and scheduling. Second,

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the adoption of e-business has allowed transport and logistics service providers to assume a new role in the supply chain as intermediaries or online e-market places. As web-based intermediaries they add value to transport and logistics services through greater efficiency and information transparency. By running internet portals, they bring together buyers and sellers of transport and logistics services. Third, this has resulted in the emergence of a new category of logistics service providers called fourth party logistics (4PLs) which enable customers to outsource the management of the entire logistics network to a single organisation and to re-engineer supply chain processes.

Porter (2001) argues that e-business can have pervasive impacts on all aspects of market competition because "the basic tool for understanding the influence of information technology on companies is the value chain – the set of activities through which a product or service is created and delivered to customer". These activities include pre-sale enquiry handling, order payment, warehousing and storage, shipping to post-sale service, whose cost and value can be improved substantially through effective use of ICT.

Despite its great benefit, there are costs associated with e-business. It is logical to expect that the decision to adopt e-business should be based on the weighing of its benefits mentioned earlier against its costs including those of ICT equipment and facility, training, maintenance, customer services, etc. The adoption decision should also consider various barriers to e-business adoption such as business uncertainty, financial constraints, incompatibility with the logistics partners' network, data security, accessibility by customers as well as inconvenience caused by the resulting operational changes. This suggests that making the decision to adopt e-business is complex and involves various factors. Therefore, it is imperative to examine the factors that influence the decision to adopt it. Especially this is because no analytical framework has been developed for this purpose.

This paper aims to develop an empirical model and applies it to analyse the decisions to adopt e-business among transport and logistics companies in Australia. The Australian transport and logistics sector has been chosen for application of the model because it has not been able to effectively support the growth of international trade (Nguyen and Tongzon, 2010), and investment in ICT, especially e-business could be the key to improving the efficiency of this sector (Logistics Association of Australia, 2004). Although e-business adoption is quite prevalent among international logistics service providers, the current level of e-business adoption among the Australian transport and logistics companies is relatively low. The sector has the lowest rate of broadband connection compared with all other industries (Australian Bureau of Statistics, 2008). The next section reviews the literature on e-business adoption in the transport and logistics sector. Section 3 presents a discrete variable model of investment. Sections 4 and 5 explain the data collection and analysis methods respectively, and section 6 discusses the findings, contributions and limitations.

2. Literature review

There has been increasing research interests in e-business adoption primarily due to the combination of three factors. First, as globalisation, international trade and outsourcing continue to be one of the key drivers of economic prosperity, there has been increasing demand for transport and logistics services as well as the need to promote this sector, which have resulted in more research interests. Second, the last two decades have seen constant growth in information and communication technologies whose applications have transformed the operation and management of businesses in different sectors including the transport and logistics sector. And third, there is a potentially great need for the transport and logistics sector to use ICT applications because its operations typically spreads across regions and entities, and as such the management of information flows is critical to operational efficiency. As shown below, the second and third have also led to a number of studies looking at the benefits ICT can bring to the sector.

Porterfield et al. (2010) studied the relationship between electronic information exchange and firm performance using econometric analysis of firm-level data. They found information exchange facilitates coordination through sharing order cycles and information and helps foster closer relationships and improve performance. Tan et al. (2010) used structural equation modelling to study the impact on firm performance, caused by the three constructs: electronic data interchange (EDI) capacity, information alignment and relational alignment. The analysis results indicate that EDI capability has a positive impact on information and relational alignment. Information alignment has a positive impact on relational alignment. Relational alignment has a positive influence on firm performance. However, support was not found for either EDI capability or information alignment having a direct effect on firm performance; both affect performance only indirectly via their impact on supply chain relational alignment. Evangelista and Sweeney (2006) studied the use of ICT among small 3PLs and found that the most important benefits of using ICT are error reduction, service quality improvement, customer satisfaction and integration in the supply chain. Similarly, Davies et al. (2007) examined the effect of information exchanges and ICT usage on transport operations of road transport companies in the UK. The results of their survey of 49 general haulage operators revealed that, while many of smaller haulage operators remain dependent on traditional communication and process systems, larger operators, who control the majority of vehicles and freight movements, are progressively developing new ways of working supported by ICT adoption.

The literature has also identified various factors inhibiting e-business adoption. These include large initial cost (Evangelista and Sweeney, 2006; Gunasekaran and Ngai, 2008), running cost and customers not interested or not used to the new service or feature (Australian Bureau of Statistics, 2008; Evangelista and Sweeney, 2006; Samar and Robert, 2004), company size (Davies et al., 2007; Nurmilaakso, 2008), staff's IT skills (Australian Bureau of Statistics, 2008), compatibility and standard of the new system/service, management's support and security (Gunasekaran and Ngai, 2008), uncertain or lower return on investment due to the higher competition level resulting from better access to market information and online brokerage system (Gudmundsson and Walczuck, 1999), and higher product return rate due to online customers unable to inspect the physical conditions of the product (Samar and Robert, 2004).

Despite many studies on different aspects of e-business in the transport and logistics sector, only a few of them have focused on the behaviour of transport and logistics companies in e-business adoption. Gunasekaran and Ngai (2008) conducted an *ex-post* analysis of the success of e-procurement adoption. In their study, the key factors influential to the success of e-procurement were primarily identified based on the literature and divided into four groups including the perceived benefits, perceived barriers, critical success factors in e-procurement and organisational performance with e-procurement. They found the impacts of e-procurement on company performance include improved short-term and long-term organisational performance, networking and lower cost.

Matopoulos et al. (2007) studied the factors influential to e-business adoption decision that can be divided into three groups, "sector factors", "supply chain factors" and "intra-enterprise factors". The results of their interviews with companies in the retailing and manufacturing sectors in Greece revealed that e-business adoption is more affected by supply chain factors and

sector factors rather than intra-enterprise factors. Furthermore, e-business impact is more related to the dimensions of time and quality rather than cost improvements.

Nurmilaakso (2008) examined the effects of organisational and technological factors on the two dependent variables separately, one being the level of e-business application in 4570 European companies and the other concerning the migration from EDI-based to XML-based e-business frameworks in 329 European companies. The result of linear regression of the first dependent variable shows that companies with a wider scope, having more enterprise information systems or exchanging standardised data apply e-business applications more extensively. The results of the logistic regression of the second variable suggest that a larger company or a company with higher skills or having more e-business functions is more likely to replace EDI-based with XML-based e-business frameworks in supply chain integration.

In their study on the factors influencing companies adopting Radio Frequency Identification (RFID) technology, Andrew et al. (2008) surveyed 612 European supply chain managers and 128 respondents who have begun RFID trials. Their survey results showed that customer mandates have a significant influence on the adoption of RFID. Customer mandates also have impact on the anticipated benefits of a faster sales cycle and of enhanced systems integration, though the relationships are complex. By contrast, greater cost reduction benefits are anticipated in manufacturing and logistics where mandates are less common.

Regarding the methodological aspect, Duan et al. (2012), Oliveira and Martins (2010), Nurmilaakso (2008) and Forman (2005) have applied the discrete variable approach to analyse the e-business adoption decision. However, these studies are largely empirical research. In Duan et al. (2012), Oliveira and Martins (2010), the analyses were based on the technology-organization-environment (TOE) framework with the explanatory variables being the perceived benefits and obstacles, technology readiness, trading partner collaboration, and technology integration. In Nurmilaakso (2008) the explanatory variables belong to two categories, namely organisational factors including the company size, scope and skills, and technological factors reflecting the current use of ICT by the company, while in Forman (2005) the explanatory variables are the benefits of the adoption, the current use of ICT, and geographical dispersion of the company operations.

Other approaches have also been used to study e-business adoption. Matopoulos et al. (2007) used six in-depth case studies to identify factors influential to e-business adoption, which were classified into three groups, the intra-enterprise, sector, and supply chain factors. However, since only qualitative data obtained from six in-depth interviews were used, the study results and their applicability are rather limited. The same approach was also applied in Smart (2010), and Kauremaa et al. (2010). In Andrew et al. (2008) the Kruskal-Wallis test and ANOVA were conducted to analyse the effect of various factors on the success of RFID (Radio Frequency Identification) adoption rather than the adoption decision. Similarly, in Gunasekaran and Ngai's (2008) study on the success of e-procurement adoption, the success factors were identified primarily based on the literature and only descriptive statistics of variables were used in the data analysis.

The above review indicates that explanatory variables in the analysis of the adoption decision in existing studies were identified mainly on an empirical basis, which has resulted in inconsistency in variable selection (see Table 1). The current paper tries to fill this gap in the literature and takes the view that the decision to adopt e-business is essentially an investment decision; companies cannot make such a decision without considering the financial requirements, costs and benefits and their ultimate goal is to make profit.

3. Discrete variable model of investment

This section develops a discrete variable model of investment which will then be applied to analyse the decision to adopt e-business in the next section. The fundamental difference between this and other models is that the former focuses on investment decisions as discrete choice/variables, while the latter focuses on the optimal level of investment (Chirinko, 1993) and therefore is not applicable to analysis of the adoption/investment decision. Theoretically, the binary variable model is equivalent to the continuous variable model with investment expense as the dependent variable. To see this intuitively (and informally), suppose the following simple form of a continuous variable model:

$$I_i = \alpha + \beta X_{1i} + \gamma X_{2i} + \varepsilon_i, \tag{1}$$

where I is investment expense/cost, X(s) are exploratory variables, α, β and γ are coefficients, and ε is the error term for firm i. Then, without losing any information, one can always write the "binary" version of the above model with investment expense/cost now being an exploratory variable, as:

$$P_{(\phi=1)} = f(\alpha' + \beta' X_{1i} + \gamma' X_{2i} + \theta I_i + \psi_i), \tag{2}$$

where α', β', γ' and θ are the coefficient, and ψ is the error term.

The advantage of the binary variable model is that, although it only predicts the investment decision, the model does not require data on the amounts of investment expenditure, cost and profit, etc. which companies are often unwilling to provide. It can be applied to survey data to predict companies' investment/adoption decision, while the *continuous* variable model cannot use survey data on companies' views to predict investment expenditure. The current study does not reject the continuous variable model. Rather, it proposes the discrete/binary variable model as an effective, alternative tool for behavioural research, i.e. to identify the factors/constructs that influence the investment decision. The rest of this section elaborates on this point.

Let ϕ_j, $j=1, 2, 3, \ldots J$, denote the alternative investment options or projects available to a firm. The principle of project evaluation based on the net present value (NPV) criteria suggests that an investment option is preferred if it has a larger NPV (McCarthy, 2001; Quinet and Vickerman, 2004; Weston and Copeland, 1988). This implies the following general logistic function for the probability of the firm taking an investment option j:

$$P(\phi_j) = \frac{\exp[V_j]}{\sum_{j=1}^{J} \exp[V_j]}, \tag{3}$$

where V_j is the firm's net worth, which is the net present value of its cash flow (on the infinite horizon) associated with the investment option j. For convenience, we can assign J to the decision to do nothing. Dividing both the numerator and denominator by exp $[V_J]$ gives:

$$P(\phi_j) = \frac{\exp[V_j - V_J]}{1 + \sum_{j=1}^{J-1} \exp[V_j - V_J]} = \frac{\exp[\Delta_j]}{1 + \sum_{j=1}^{J-1} \exp[\Delta_j]}, \tag{4}$$

where the first equality indicates that whether or not the firm prefers the option j ($j<J$) over the option J depends on how these options contribute to its net worth relatively. The second equality translates this relativeness into a change in the firm's net worth, Δ_j. Note that when there are only two choices, i.e. adopt e-business or do nothing, Eq. (4) becomes:

$$P(\phi = 1) = \frac{\exp[\Delta]}{1 + \exp[\Delta]}, \tag{5}$$

where $\phi=1$ when the firm decides to adopt, and $\phi=0$ when the firm decides to do nothing. In addition, the term Δ_j and Δ in Eqs. (4) and (5) respectively represent a change in the company net worth. Following Jorgenson's (1963) specification of the firm's

Table 1
Summary of recent studies on e-business adoption in the transport and logistics sector.

Authors	Main focus	Methodology	Key findings
Oliveira and Martins (2010)	Adoption of e-business by firms in the telecommunication and tourism sectors	Factor analysis and logistic regression using firm survey data	The perceived benefits and obstacles of e-business, technology readiness, competitive pressure, and trading partner collaboration are the determinants of the decision to adopt e-business.
Smart (2010)	Study of factors influencing e-procurement adoption	In-depth interviews with managers of three industrial firms The three cases presented and explored individually to identify relevant factors conducive and inhibitive to e-procurement	The research identifies many factors that induce and mitigate e-procurement. However, only a limited number of those were known to firms that adopted e-procurement.
Marchet et al. (2009)	Evaluating the degree of ICT adoption on transport companies	Semi-structured interviews with the management of Italian freight service companies Qualitative methods/case studies	ICT is adopted at a low level, mainly for operational routine activities but not at a higher level for activities such as planning, accounting and design. The integration level among applications is also relatively limited.
Andrew et al. (2008)	Evaluation of the success of radio frequency identification (RFID) adoption	Survey of 612 European supply chain managers, focusing on the 128 respondents who have begun RFID trials Kruskal-Wallis test	A significant influence on operational deployment is the presence of mandates from key customers requiring the technology's use. Customer mandates also impact the anticipated benefits of a faster sales cycle and of enhanced systems integration, though the relationships are complex. By contrast, greater cost reduction benefits are anticipated in two industries where mandates are less common. Perceived organisational innovativeness positively impacts return on investment from RFID. Companies adopting a "slap and ship" approach are less likely to anticipate pricing benefits than those integrating RFID into enterprise systems.
Gunasekaran and Ngai (2008)	Identifying the success factors and barriers to the implementation of e-procurement	Survey of firms in Honh Kong Descriptive statistics used to evaluate four factors including perceived benefits, barriers, critical success factors and company performance	Some critical success factors include adequate financial support, availability of interoperability and standards with traditional communication systems, top management support and commitment, understanding the priorities of the company, and having suitable security systems.
Nurmilaakso (2008)	Investigating the use and adoption of e-business applications	Linear and logistic regression applied to two data sets for 4570 and 329 European companies respectively	Larger companies or companies with higher skills or having more e-business functions are more likely to replace EDI-based with XML-based e-business frameworks in supply chain integration. Companies having more enterprise information systems or exchanging standardised data has more e-business functions in supply chain integration.
Davies et al. (2007)	Assessing the impact of ICT on UK general haulage companies	Survey of 49 general haulage operators in their attitude to and adoption of ICT developments	While many of the smaller haulage operators remain dependent upon traditional communication and process systems, the larger logistics companies, who control the majority of vehicles and freight movements, are progressively developing new ways of working supported by ICT adoption.
Matopoulos et al. (2007)	Identifying factors that influence e-business adoption and its impact on logistics processes in the Greek food industry	Six in depth case studies	E-business adoption is more affected by supply chain and sector factors, rather than intra-enterprise factors. The impact of e-business on logistics process is affected by the frequency of its use and is greater at the company-customer interface. Finally, e-business impact is more related to the dimensions of time and quality, rather than cost improvements.
Evangelista and Sweeney (2006)	ICT adoption in small logistics service providers in Italy	Survey of 153 companies divided into three groups of haulage service providers, logistics providers and advanced logistics providers F tests and Chi-square tests of independence	The most important benefits of using ICT are error reduction, service quality improvement, customer satisfaction and integration in the supply chain. The most important reasons for not investment in ICT are related to financial factors including the size of investment, implementation and running costs. Other factors are related to human resources (staff IT skills). The lack of technological standards also inhibits the adoption of ICT.
Forman (2005)	Internet adoption among companies in the financial and service sectors	Discrete choice modelling (logistic regression) using survey data with more than twenty explanatory variables	The decision to adopt the internet depends on the benefits of its adoption, current use of ICT and geographical dispersion of company operations.

net worth, we have:[1]

$$\Delta = \frac{dV_t}{dK_t} = E\left\{\frac{d}{dK_t}\left[\sum_{t=0}^{\infty}\left(\frac{1}{1+r}\right)^t \tau[P_tY_t - w_tL_t - qI_t - G(I_t)]\right]\right\}, \quad (6)$$

where $E[\ldots]$ denotes the expected value, K_t is capital stock, I_t is investment, r is the discount/interest rate, τ is a parameter representing government policies, tax, etc., P_t is the output price, Y_t is the output quantity, L_t is the variable input quantity, w is the unit cost of the variable input, q is the unit price of capital, and $G(I_t)$ is the adjustment cost of investment. According to the neoclassical theory of investment, the adjustment cost $G(I_t)$ must be *convex* in investment, i.e. increasing disproportionately with I_t to ensure that the investment amount cannot be infinity (Tobin, 1969). While this condition is necessary for

[1] Since the use of the term Δj or Δ makes no difference to the relationships presented below, the subscript j is dropped for convenience. For the purpose of deriving the equation for empirical analysis, discrete discounting is applied.

investment dynamics to exist, as will be shown below, it can also be used to reflect hindrances to investment such as financial constraints where a larger investment poses a higher financial risk and is therefore subject to a higher cost. Taking the derivative of the term in the bracket with respect to K_t gives

$$\Delta = E\left\{\sum_{t=0}^{\infty}\left(\frac{1}{1+r}\right)^t \tau\left\{\left(\frac{dY_t}{dK_t}P_t\right)\left[\left(\frac{dP_t}{dY_t}\frac{Y_t}{P_t}\right)+1\right]-q-G_I\right\}\right\}. \tag{7}$$

Rearranging (7) gives:

$$\Delta = E\left[\sum_{t=0}^{\infty}\left(\frac{1}{1+r}\right)^t R_t\right], \tag{8}$$

where:

$$R_t \equiv \tau\left\{\left(\frac{dY_t}{dK_t}P_t\right)\left[\left(\frac{dP_t}{dY_t}\frac{Y_t}{P_t}\right)+1\right]-q-G_I\right\} = \tau\left[MR_t\left(\frac{1}{\varepsilon_t}+1\right)-q-G_I\right]. \tag{9}$$

In Eq. (9), MR is marginal revenue, and ε is elasticity of demand with respect to price respectively. Eq. (8) can be further rearranged to get:

$$\Delta = \left(1+\frac{1}{r}\right)\overline{R} + \sum_{t=0}^{\infty}\left(\frac{1}{1+r}\right)^t E\left[R_t-\overline{R}\right], \tag{10}$$

where:

$$\overline{R} \equiv \lim_{T\to\infty}\frac{\sum_0^T R_t}{T}, \tag{11}$$

which can be replaced by the means of marginal revenue, $\overline{MR}$, demand elasticity, $\overline{\varepsilon}$:

$$\overline{R} \approx \tau\left[\overline{MR}\left(\frac{1}{\overline{\varepsilon}}+1\right)-q-G_I\right]. \tag{12}$$

For illustration purposes, assume a quadratic function of adjustment cost:

$$G(I_t) = \frac{c}{2}I_t^2, \tag{13}$$

where c is a positive constant. Substitute (12) and (13) into (10) to obtain:

$$\Delta = \left(1+\frac{1}{r}\right)\tau\left[\overline{MR}\left(\frac{1}{\overline{\varepsilon}}+1\right)-\overline{q}-cI\right] + \sum_{t=0}^{\infty}\left(\frac{1}{1+r}\right)^t E\left[R_t-\overline{R}\right] \tag{14}$$

Substituting (14) into (4) gives:

$$P(\phi_j) = \frac{\exp\left[\left(1+\frac{1}{r}\right)\tau\left[\overline{MR}\left(\frac{1}{\overline{\varepsilon}}+1\right)-\overline{q}-cI\right] + \sum_{t=0}^{\infty}\left(\frac{1}{1+r}\right)^t E\left[R_t-\overline{R}\right]\right]}{1+\sum_{j=1}^{J-1}\exp\left[\left(1+\frac{1}{r}\right)\tau\left[\overline{MR}\left(\frac{1}{\overline{\varepsilon}}+1\right)-\overline{q}-cI\right] + \sum_{t=0}^{\infty}\left(\frac{1}{1+r}\right)^t E\left[R_t-\overline{R}\right]\right]} \tag{15}$$

$$\equiv f(r,\ \tau,\ \varepsilon,\ MR,\ c,\ q,\ R) \tag{16}$$

Eq. (16) lists the following key factors influential to the investment decision included in Eq. (15):

- The cost of financial resources represented by the interest rate r,
- Policies represented by τ,
- The firm's perception on the benefit of investment represented by MR and ε,
- Obstacles to investment in terms represented by parameter c as well as investment cost q, and
- Business expectations or expectations about changes in the future represented by the deviation of the future values of R_t defined in (9) from its mean.

The following points are worth mentioning. First, Eq. (15) shows how various factors can affect the investment decision, which is a discrete variable as opposed to the investment expenditure amount, which is a continuous variable. Second, parameter c implies larger investment projects are less attractive and therefore can represent the financial constraint effect. Third, the Eq. (15) contains the future amounts of R_t, which are *not* directly observable. In the Q investment model (Tobin, 1969), this is addressed by using the average-Q variable, which is the ratio of the firm's market value to its replacement cost. As noted by Chirinko (1993), Hayashi (1982) and others, while the model is attractive from the theoretical perspective, its performance is limited because of the potential errors in using the average-Q variable and the multicollinearity problem due to its strong correlation with other variables.

4. Decision to adopt e-business in the transport and logistics sector

This section applies the discrete choice investment model developed in the previous section to study the decisions to adopt e-business of transport and logistics companies in Australia. The model can be applied to study e-business adoption because it is essentially an investment decision, which involves the use of the company's resources and has a long-term effect on its operations, which in turn has impact on the company's financial value or net worth. As noted earlier, similar use of a discrete dependant variable model can also be found in Duan et al. (2012), Oliveira and Martins (2010), Nurmilaakso (2008) and Forman (2005). The relevance of the model is also confirmed by industry practitioners met during the Australian Logistics Council 2008 annual forum. The data are collected from a survey of Australian transport and logistics companies, and logistic regression is applied with the dependent variable being the decision to invest/adopt e-business or to do nothing.

While questionnaire surveys allow researchers to collect extensive information on various aspects of e-business, there are no strict rules on how they should be designed as well as what survey questions should be asked. As there are 34 questions in the survey seeking companies' views on critical factors in making the decision to adopt e-business, the inclusion of all the questions' feedback in regression analysis would render it ineffective due to the multicollinearity problem caused by the correlations between variables as well as the loss of the degrees of freedom. To overcome the above issues, the data analysis is carried out in two phases (Oliveira and Martins, 2010). In the first phase, factor analysis is conducted to identify the key factors representing the three groups of variables explaining the perceived benefits of e-business, obstacles to e-business adoption and business expectation. This helps to effectively extract useful information from the survey data and transform those data into a small number of variables/components. Both the principal component method and maximum likelihood method using the varimax criterion are applied. The factor scores are estimated using the regression method. In the second phase, logistics regression is conducted using the factor scores obtained from the first phase as the inputs to further test the effect of different variables on the decision to adopt e-business. The logistics regression analysis in the second phase is much more manageable due to only a small number of variables involved[2].

Note that the data for the variables specified by Eqs. (15) and (16) mainly concerning firms' cost, revenue, expectations, etc. are not available from secondary sources. Therefore, the current study relies on an industry survey to collect data. There are many

[2] See, for example, Greene (2008) for detail on estimation of logistics functions.

advantages of using the survey instrument. First, it allows for the collection of comprehensive information about the firms. Second, the survey questions can be designed to meet the study's need for information, which is often not the case when using secondary data. Third, factors such as 'business expectation' and 'policy' suggested by the theoretical model cannot accurately be captured by a single numerical index or value. It would be better for the survey instrument to observe them from different aspects.

Despite its advantages, the use of survey for data collection is also subject to some issues. Especially, most companies would not be willing to provide confidential information about their business. Moreover, because survey participation is voluntary, participants are often not willing to spend considerable amount of time to answer questions seeking financial information such as sale revenue, cost and tax. To get around these issues, studies have to rely on *indirect* questions while conforming to the research ethics requirements. As a result, the variables identified by the theoretical model only serve as guidance for the design of the survey questions; the survey cannot ask for exactly what the theoretical model requires.

The questionnaire design was based on the literature as well as several discussions with industry experts and company managers during the Australian Logistics Council 2008 annual forum. There are five sections in the questionnaire asking questions on different aspects of companies and e-business adoption. The first section of the survey questionnaire seeks information on the firm's profile including (i) firm size, (ii) year of establishment, (iii) existing technology, and (v) nature of business.

The second section of the questionnaire focuses on the benefits of e-business adoption as suggested by Porterfield et al. (2010), Tan et al. (2010), Evangelista and Sweeney (2006), Boyson et al. (2003) and Landers et al. (2000). In particular, it seeks companies' views on the benefits of e-business adoption to logistics operation including (i) increased competitiveness, (ii) service differentiation, (iii) added value, (iv) improved customers' satisfaction, (v) more effective integration across the supply chain, (vi) promotion of the company's name and its services online, (vii) improved company's image, (viii) increased market share, (ix) improved operational efficiency, (x) cost savings, (xi) error reduction, and (xii) reduced emissions as a result of more efficient operation.

The third section asks questions about the barriers to e-business adoption identified by Australian Bureau of Statistics (2008), Evangelista and Sweeney (2006), Gunasekaran and Ngai (2008), Samar and Robert (2004) and others. These include (i) large initial investment outlays, (ii) financial constraints, (iii) high running and maintenance costs, (iv) lack of IT skills and technical support staff, (v) unclear return on investment in e-business, (vi) difficulties in selecting the technologies suitable for the company's business, (vii) lack of access to ICT consultant services, (viii) concern about data security, (ix) e-business not suitable for the company's existing services, and (x) existing customers unfamiliar with the use of online services.

The fourth section includes questions concerning companies' expectations about the future of the industry and economy that the theoretical model suggest. These cover the following factors that were identified from the discussions with industry experts and company managers during the Australian Logistics Council 2008 annual forum: (i) the national economy, (ii) production and consumption, (iii) exports, (iv) demand for transport and logistics, (v) future demand for transport and logistics, (vi) business investment environment, (vii) the cost of financial funds, (viii) the costs of the factors of production, (ix) government policies, and (x) the effect of regulations, especially those related to emissions control. The final section of the questionnaire includes a question on the company's intention to adopt any e-business applications, including: intranet, Enterprise Business System (EBS), Electronic Data Interchange (EDI), online ordering, online shopping cart facilities, secured online payment, online customer account, online order tracking, and online freight tracking. Appendix B lists the questions included in the survey questionnaire.

Fifteen copies of the survey questionnaire were first sent to industry experts and colleagues for comments and feedback. The questionnaire was then revised before the actual survey was launched. One thousand companies were randomly selected for the survey, from the transport, warehousing, logistics and freight forwarding sector using the Australian Yellow Pages. The survey was conducted from late 2009 to early 2010. Participants were invited to participate by completing the questionnaire and mailing it back or doing it online. Of one thousand invitations mailed out, 116 were returned because the mailing addresses were not current. There were totally 131 companies willing to participate in the survey, of which only 104 actually completed the survey leaving the response rate of 11.8%.

To address non-response bias, following-up calls were made to 20 non-response companies to inquire about the reasons why they did not participate; only a very limited number of companies were contacted because of the time and cost involved. Most replied they did not want to participate because they did not have enough time. None said they did not participate due to any problem associated with the survey questions. Seven were willing to provide quick responses to the key questions in Sections 2–4 of the survey, which were found to be consistent with those provided by volunteer participants. In addition, the respondents' profiles summarised in Tables A1–A4 (Appendix A) are consistent with those of the industry average.

5. Analysis result

5.1. Descriptive statistics of variables

The details of the respondents' profile are provided in Tables A1–A4 of (Appendix A). The data set obtained from the survey contains 104 responses of which 36% are transport service providers, 29% are freight forwarders, 11% are warehousing and storage companies and the remaining 24% are providers of other types of services including logistics, customs services, inventory management, logistics IT services, and others (Table A1). This shows that company distribution is relatively even across different types of service. In terms of the number of years in business, 62% of surveyed companies were established before 1997, 23% of them were established between 1997 and 2002 and 15% were established after 2002 (Table A2). In terms of size distribution, 24% of the surveyed companies have less than 9 employees, 29% have 10–19 employees, 24% have 20–49 employees and 23% are large companies having more than 50 employees. This indicates that participating companies' sizes were relatively evenly distributed; about half of the participating companies are small with less than 20 employees (Table A3). Regarding the current use of ICT, only a small proportion of companies (6%) still use basic IT services. Most of companies use LAN (28%) or web-based applications (29%), and the rest use intranet (13%), enterprise business systems (6%) and EDI (19%) (Table A4). This shows that the use of ICT applications at an advanced level among Australian freight and logistics companies remains limited; this is consistent with the observation of the Australian Bureau of Statistics (2008).

Tables 2–4 reports the survey respondents' feedback to the 10-point likert scale questions (from 0 being "strongly disagree" to 9 being "strongly agree") regarding the three key aspects of e-business adoption, namely the benefits of e-business adoption, factor inhibiting e-business adoption and business expectation. As shown in Table 2, the means of the participants' responses to all

questions, except question 2.12, concerning emissions reduction is larger than 6 out of 9. This indicates that companies are positive about all the benefits of e-business but do not believe that e-business adoption would help to reduce emissions. In the last row of Table 2, Q2_INDEX reports the average of each respondent's feedback on all questions on e-business benefits and therefore its mean of 6.47 reveals the respondents' overall positive view on e-business benefits. It is straight forward to carry out the t-tests to confirm that all the mean values are higher than the middle point of 4.5 at the 1% significance level showing the participants' agreement on the benefits of e-business.

In a similar fashion, Table 3 presents a summary of the statistics of the survey data on factors inhibiting e-business adoption. All the mean values of the responses are significantly higher than the midpoint, suggesting that respondents are aware of those factors that hold them back from adopting e-business. However, most mean values are only less than six. This indicates that participants seem to be less concerned about those factors with adverse effects e-business adoption. One exception is question 3.5 regarding the uncertain benefit from e-business adoption, which has the mean of 6.23 suggesting that the strongest reason for not adopting e-business is uncertainty about its benefit.

Table 4 reveals companies' views on business and market conditions important to their business and investment decision. Since the first part of the survey was conducted in late 2008 and early 2009, it is no surprise that companies were not positive about the economy and the market. Especially, the mean feedback on question 4.1 of 4.41 suggests that companies were not confident about the Australian economy; the mean feedback on question 4.2 of 3.67 rejects the hypothesis that Australia was unaffected by the crisis, while feedback on question 4.7 of 6.03 reflects companies' expectation that interest rates would remain low.

Table 2
Benefits of e-business adoption.

Question	Mean	Std. deviation	Skewness	Kurtosis
Q2_1_Increased_competitiveness	6.67	1.368	−0.406	0.331
Q2_2_Service_differentiation	6.62	1.396	−0.636	1.487
Q2_3_Value_adding	6.74	1.441	−1.020	1.874
Q2_4_Improved_customer_satisfaction	6.67	1.484	−0.981	1.653
Q2_5_Better_supply_chain_integration	6.61	1.548	−1.026	1.404
Q2_6_Advertisement	6.75	1.356	−0.675	0.347
Q2_7_Improved_company's_immage	6.83	1.250	−1.764	7.549
Q2_8_Increased_marketshare	6.27	1.528	−1.133	2.542
Q2_9_Improved_operational_efficiency	6.50	1.631	−0.986	1.626
Q2_10_Cost_saving	6.44	1.594	−1.037	1.907
Q2_11_Error reduction	6.27	1.708	−0.586	0.715
Q2_12_Emissions_reduction	5.33	1.923	−0.553	−0.141
Q2_INDEX	6.47	1.090	−0.851	1.324

5.2. Result of factor analysis and reliability analysis

As mentioned earlier, both the principal component method and the maximum likelihood method using the varimax criterion are used in factor analysis. Factor analysis is conducted using the correlation matrix. Kaiser criterion is used to select the number of factors retained in factor analysis. The number of the first factors is determined such that their eigenvalues are greater than one. In addition, questions with low loadings across factors are excluded to ensure that factor scores are orthogonal. This is checked using the correlation matrix of factors. The factor scores are estimated using the regression method. However the two methods provided highly consistent and similar results; the values of R-square are 0.97, 0.97 and 0.75 respectively for the first three factors obtained from the two methods. Given this, the rest of the paper only reports the results for the principal component method.

Table 3
Factors inhibiting e-business adoption.

Question	Mean	Std. deviation	Skewness	Kurtosis
Q3_1_Large_investment_outlays	5.73	1.967	−0.403	−0.379
Q3_2_Finance_constraints	5.68	1.902	−0.180	−0.268
Q3_3_High_running_&_maintenance_costs	5.56	1.994	−0.229	−0.565
Q3_4_Lack_of_IT_skills	5.88	1.883	−0.527	0.158
Q3_5_Uncertainty_&_risk	6.23	1.902	−0.848	0.763
Q3_6_Inability_to_choose_suitable_IT_tech	5.88	1.824	−0.903	0.740
Q3_7_Lack_of_access_to_IT_consultancy	5.36	2.062	−0.254	−0.196
Q3_8_Data_security	5.74	2.190	−0.458	−0.706
Q3_9_Incompatible_services	5.00	2.328	−0.038	−0.731
Q3_10_Customers_not_interested	5.63	1.865	−0.504	0.115
Q3_INDEX	5.67	1.464	−0.850	1.494

Table 4
Business expectation.

Question	Mean	Std. deviation	Skewness	Kurtosis
Q4_1_Economy_performing_well	4.41	1.574	−0.683	0.566
Q4_2_Australia_unaffected_by_GFC	3.67	1.732	0.176	0.126
Q4_3_Exports_continue_to_grow	4.55	1.336	−0.167	0.243
Q4_4_Stable_demand_for_T&L	4.83	1.491	−0.145	0.414
Q4_5_Demand_for_T&L_grow_strongly	5.33	1.368	0.036	0.206
Q4_6_Business_environment_improving	4.48	1.625	−0.207	0.226
Q4_7_Interest_rates_will_be_lower	6.03	1.825	−0.806	1.403
Q4_8_Real_wages_remain_stable	5.49	1.817	−0.445	0.346
Q4_9_Utility_rates_will_be_lower	4.13	2.010	−0.356	−0.705
Q4_10_Fuel_prices_will_be_lower	4.09	2.044	−0.258	−0.706
Q4_11_Policies_will_be_more_favourable	4.87	2.365	−0.442	−0.700
Q4_12_ T&L_sector_not_affected_by_ETS	4.33	2.367	0.039	−0.742
Q4_INDEX	4.68	0.965	−0.330	0.332

Table 5
PCA factor analysis of e-business benefits.

Factor	Initial eigenvalues		
	Total	% of Variance	Cumulative %
(a) *Total variance explained*			
1	**6.089**	**55.354**	**55.354**
2	**1.547**	**14.067**	**69.421**
3	0.725	6.588	76.009
4	0.623	5.662	81.672
5	0.469	4.262	85.933
6	0.390	3.549	89.483
7	0.349	3.174	92.657
8	0.274	2.490	95.147
9	0.227	2.063	97.211
10	0.181	1.647	98.857
11	0.126	1.143	100.000

Question	Factor name (variable)	
	Service quality improvements (B1)	Efficiency improvements (B2)
(b) *Rotated, rescaled component matrix*		
Q2_1_Increased_competitiveness	**0.861**	0.252
Q2_2_ Service_differentiation	**0.829**	0.244
Q2_3_ Value_adding	**0.885**	0.240
Q2_4_ Improved_customer_satisfaction	**0.839**	0.251
Q2_5_ Better_supply_chain_integration	**0.755**	0.362
Q2_7_ Improved_company's_immage	0.119	**0.680**
Q2_8_ Increased_marketshare	0.388	**0.730**
Q2_9_ Improved_operational_efficiency	0.216	**0.770**
Q2_10_ Cost_saving	0.314	**0.782**
Q2_11_ Error reduction	0.235	**0.817**
Q2_12_ Emissions_reduction	0.269	**0.685**
Cronbach's Alpha coefficient	**0.924**	**0.875**

Table 5a and b presents the result of factor analysis of e-business benefits. In Table 5a, the first two factors have the eigenvalues greater than one, 6.089 and 1.547 respectively. They explain 49.421% of the variance. In Table 5b identify specific e-business benefits that are associated with each of the two factors identified. The first factor refers to 'service quality improvements' (B1) that are associated with benefits covered in questions 2.1–2.5 including the increased competitiveness (0.861), service differentiation (0.829), value adding (0.885), customer service (0.839) and supply chain integration (0.755). The second factor refers to 'efficiency improvements' (B2) that are associated with improved company image (0.680), market share (0.730), operational efficiency (0.770), cost saving (0.782), error reduction (0.817) and emissions reduction (0.685), which are covered in survey questions from 2.7 to 2.12 respectively.

In a similar fashion, Table 6a and b reports the results of factor analysis of the obstacles to e-business adoption. Table 6a indicates the first three factors have the eigenvalues greater than one and explain 83.957% of the total variance. Table 6b shows the loadings and obstacles associated with these factors. The first factor refers to the 'financial obstacles' (O1) that are associated with large investment expense (0.895), financial constraints (0.924), high costs of running and maintenance (0.805). The second factor refers to 'internal technical issues' (O2) that are related to the lack of IT skills (0.775), uncertain benefits (0.870) and inability to choose IT technology (0.834) covered in survey questions 3.4–3.6. The third factor refers to 'external technical issues' (O3) associated with incompatible IT services (0.899) and customers' uninterested in new services (0.878), which are covered in survey questions 3.9 and 3.10 respectively.

Similarly, Table 7a and b reports the results of factor analysis of survey questions on business expectations. Table 7a indicates the first four factors have the eigenvalues greater than one and explain 71.018% of the variables' variance. Table 7b shows the specific survey questions associated with each factor and their loadings. The first factor refers to expectations about the 'business environment and policies' (E1), which concern the survey questions 4.6 on the business environment (0.672), question 4.9 on utility rates (0.716), question 4.11 on policies (0.815) and question 4.12 on the effect of the emissions trading scheme (0.745). The second factor refers to expectations on the 'national economy' (E2) and is related to the survey question 4.1 on the performance of the national economy (0.727), question 4.2 on the effect of the global financial crisis (0.798) and question 4.3 on Australian exports (0.75). The third factor refers to 'market demand' for transport and logistics (E3), which concerns the survey question 4.4 on demand volatility (0.838) and demand growth (0.863). The last factor concerns expectation on 'key input costs' (E4) covered in the survey questions 4.7 and 4.10 on interest rates (0.791) and fuel prices (0.752) respectively.

The factors identified above were also tested for reliability using Cronbach's Alpha. The last row of Tables 5–7b reports the Cronbach's Alpha values for these factors. All the factors identified above, except the last factor, have Cronbach's Alpha larger than 0.70. The last factor representing the effect of key input costs has the Cronbach's Alpha value of 0.455, which is well below the cut off value of 0.70 (Oliveira and Martins, 2010) and therefore should be excluded from analysis in the second phase, logistic regression.

5.3. Result of logistic regression

The results of factor analysis in the previous section have helped to reduce the number of dimensions from 30 survey questions (after removing unhelpful survey questions during factor analysis) to nine factors, one of which is excluded from the second phase analysis because of its low reliability as explained in the last section. Tables 5–7b show the connection

Table 6
PCA factor analysis of obstacles to e-business adoption.

Factor	Initial eigenvalues		
	Total	% of Variance	Cumulative %
(a) – *Total variance explained*			
1	**4.402**	**55.023**	**55.023**
2	**1.307**	**16.343**	**71.366**
3	**1.007**	**12.591**	**83.957**
4	0.410	5.123	89.080
5	0.332	4.153	93.233
6	0.240	3.001	96.234
7	0.194	2.429	98.663
8	0.107	1.337	100.000

Question	Factor name (variable)		
	Financial obstacles (O1)	Internal technical issues (O2)	External technical issues (O3)
(b) *Rotated, rescaled component matrix*			
Q3_1_ Large_investment_outlays	**0.895**	0.215	0.119
Q3_2_ Finance_constraints	**0.924**	0.203	0.195
Q3_3_ High_running_&_maintenance_costs	**0.805**	0.396	0.126
Q3_4_ Lack_of_IT_skills	0.331	**0.775**	0.088
Q3_5_ Uncertainty_&_risk	0.255	**0.870**	0.151
Q3_6_ Inability_to_choose_suitable_IT_tech	0.178	**0.834**	0.335
Q3_9_ Incompatible_services	0.170	0.135	**0.899**
Q3_10_ Customers_not_interested	0.129	0.240	**0.878**
Cronbach's Alpha coefficient	**0.920**	**0.864**	**0.812**

Table 7
PCA factor analysis of business expectation.

Factor	Initial eigenvalues		
	Total	% of Variance	Cumulative %
(a) – *Total variance explained*			
1	**3.574**	**32.495**	**32.495**
2	**1.623**	**14.753**	**47.249**
3	**1.414**	**12.858**	**60.106**
4	**1.200**	**10.912**	**71.018**
5	0.685	6.229	77.247
6	0.630	5.725	82.972
7	0.498	4.524	87.496
8	0.461	4.188	91.684
9	0.390	3.541	95.225
10	0.296	2.687	97.912
11	0.230	2.088	100.000

Question	Factor name (variable)			
	Business environment and policies (E1)	National economy (E2)	Market demand (E3)	Key input costs (E4)
(b) *Rotated, rescaled component matrix*				
Q4_1_Economy_performing_well	0.338	**0.727**	0.184	−0.160
Q4_2_Australia_unaffected_by_GFC	0.239	**0.798**	0.083	−0.010
Q4_3_Exports_continue_to_grow	−0.277	**0.750**	0.119	0.093
Q4_4_Stable_demand_for_T&L	0.161	0.202	**0.838**	0.073
Q4_5_ Demand_for_T&L_grow_strongly	0.117	0.081	**0.863**	−0.071
Q4_7_ Interest_rates_will_be_lower	−0.096	−0.159	−0.063	**0.791**
Q4_10_ Fuel_prices_will_be_lower	0.349	0.229	0.108	**0.752**
Q4_6_ Business_environment_improving	**0.672**	0.272	0.247	−0.328
Q4_9_ Utility_rates_will_be_lower	**0.716**	0.393	−0.155	0.237
Q4_11_ Policies_will_be_more_favourable	**0.815**	0.051	0.110	0.104
Q4_12_ T&L_sector_not_affected_by_ETS	**0.745**	−0.131	0.286	0.051
Cronbach's Alpha coefficient	**0.771**	**0.706**	**0.717**	**0.455**

between the survey questions and these factors whose scores are used in logistic regression. Note that although these factors represent the e-business benefits and obstacles and business expectations, they are not necessarily the determinants of the decision to adopt e-business. This is the main focus of the second phase of analysis.

Table 8 shows the correlation matrix for variables included in logit regression. Most of the correlations between factors in the same groups are all zeros as expected. Furthermore, the correlations between variables across different groups are also very low. Thus, the regression analysis will unlikely be affected by the multicollinearity problem.

Table 8
Correlation matrix.

Variable	B1	B2	O1	O2	O3	E1	E2	E3
B1	1	0.000	0.096	−0.090	−0.188	−0.071	−0.138	0.120
B2	0.000	1	0.190	0.278	−0.139	0.158	0.128	0.336
O1	0.096	0.190	1	0.000	0.000	−0.145	−0.022	0.233
O2	−0.090	0.278	0.000	1	0.000	.170	0.042	0.085
O3	−0.188	−0.139	0.000	0.000	1	−0.156	0.007	−0.118
E1	−0.071	0.158	−0.145	0.170	−0.156	1	0.000	0.000
E2	−0.138	0.128	−0.022	0.042	0.007	0.000	1	0.000
E3	0.120	0.336	0.233	0.085	−0.118	0.000	0.000	1

Table 9
Logistic regression result.

Variable	Coefficient	Std. error	Significance (P-value)
Service quality improvements (B1)	0.504	0.262	0.055
Efficiency improvements (B2)	−0.135	0.279	0.629
Financial obstacles (O1)	−0.767	0.258	0.003
Internal technical issues (O2)	−0.097	0.234	0.678
External technical issues (O3)	−0.113	0.233	0.627
Business environment and policies (E1)	0.113	0.245	0.647
National economy (E2)	0.040	0.226	0.861
Market demand (E3)	0.738	0.256	0.004
Constant	−0.275	0.221	0.213

Table 9 reports the logistics regression results including the value of the variables' coefficient, standard error (S.E.) and significance level. As noted by Wooldridge (2006), the goodness-of-fit measure is the per cent correctly predicted. Dependent variable ϕ is assigned the value of one if the estimated probability based on the logit function is at least 0.5, and zero otherwise. Given the estimated values of the dependent variable $\{\hat{\phi}_i: i=1, 2,\ldots n\}$, the calculated goodness of fit measure of 67.3% indicates a very good fit.

The result reported in Table 9 indicates the factors that significantly impact on the decision to adopt e-business are service quality improvements (B1), financial obstacles (O1) and expectations about market demand (E3). In particular, service quality improvements are significant at 10% while both financial obstacles and market demand are significant at 1%. All of the significant variables have correct signs; service quality improvements and market demand are expected to have a positive effect on e-business adoption while financial obstacles are expected to have a negative impact on e-business adoption. The other variables including efficiency improvements (B2), internal technical obstacles (O2) and external technical obstacles (O3), expectations on business environment and policies (E1) and national economy (E2) do not have a significant effect on the freight and logistics companies' decision to adopt e-business. Further tests also indicate that company size and the nature of freight/logistics service are not found to be significant.

6. Implications and conclusions

While there are many investment theories, they mainly concern investment expenditure as a continuous variable rather than the decision to invest as a discrete variable. This study develops a discrete variable model of investment, which is then applied to study the effect of various factors on the decisions to adopt e-business of Australian transport and logistics companies using company survey data. The data analysis is conducted in two phases. In the first phase, factor analysis is conducted to identify the principal components that represent various factors influential to the e-business adoption decision. In the second phase, logistics regression is conducted to further analyse the effect of individual variables on the adoption decision.

Regarding the theoretical contribution, the study has developed a general investment model that helps to guide empirical research where the investment decision can be regarded as a discrete variable, as exemplified by Duan et al. (2012), Oliveira and Martins (2010), Nurmilaakso (2008) and Forman (2005). Eqs. (15) and (16) provide a framework for analysis of the effect of various factors on the investment decision; if an industry survey is used to collect information to be used as proxies for financial variables (because their data are not available from secondary sources), then the key part of the analysis would be to test the relationship between the binary dependent variable (adoption/investment decision) and these variables based on the above functional specifications. Therefore, the main objective of exploratory factor analysis (EFA) would be to reduce data dimension and extract the data for relevant factors as the candidates for testing the theoretical model. This means the empirical research is better conducted in two phases; the first one involves EFA and the second one involves logit regression. Furthermore, the theoretical model shows that variables relevant to the investment decision are not only costs (including capital, running, maintenance and financial costs) and the benefits (in terms of increases in revenue, market share, competitiveness, etc.) but also business expectation, financial constraints and government policy variables, which have not been adequately covered in previous studies. The theoretical framework presented in the study is much different from the technology-organization-environment (TOE) framework that has been used in Duan et al. (2012) and Oliveira and Martins (2010).

In terms of empirical contributions, the study has applied the two-phased data analysis method to study the e-business adoption decision of companies in the freight and logistics industry. Although Duan et al. (2012) and Oliveira and Martins (2010) also used a similar analysis procedure, they do not focus on freight and logistics. More importantly, their studies do not take into account the role of business expectation, financial constraints and government policies that have been included in the current study.

The combination of factor analysis and logistics regression provides an insight into transport and logistics companies' decision to adopt e-business. Although companies can benefit from e-business (Duan et al., 2012; Gunasekaran and Ngai, 2008; Oliveira and Martins, 2010), the study has found two main benefits of e-business adoption, namely service quality improvements and efficiency improvements. However, only the former has a significant influence on firms' adoption decision.

It has also been found that financial obstacles, especially initial investment outlays, financial constraints and the high costs of running and maintenance significantly influence the decision to adopt e-business. On the other hand, the lack of IT skills

(Australian Bureau of Statistics, 2008), uncertainty and risk (Gudmundsson and Walczuck, 1999), inability to choose suitable IT technology, lack of access to ICT consultant services, data security, incompatible services and customers uninterested in the new service (Australian Bureau of Statistics, 2008; Evangelista and Sweeney, 2006; Samar and Robert, 2004) are not found to significantly affect companies' decision to adopt e-business.

The study has found a significant effect of future demand on their e-business adoption decision, which has not been identified in the literature on e-business adoption. In particular, it has been found that Australian freight and logistics firms' expectation about market demand significantly affects their e-business adoption decision. However, companies' expectation about the national economy, exports, interest rates and government policies do not appear to have a significant impact. In addition, the study found no evidence that firm size and business nature (Davies et al., 2007; Nurmilaakso, 2008) significantly affect the adoption decision.

Regarding the implications for business management, the method and findings can be applied to assist the decision making process. Examples are choosing between second-hand ships and new-buildings, investment in a container gantry crane required to serve a specific berth, whether to invest in a ship for a particular trade route, etc. given the specific trade or operational conditions faced by the company. The results of analysis imply that, to make an effective e-business adoption decision, freight and logistics companies may want to pay more attention to the following effects:

- Increased competitiveness of the company
- Service differentiation
- Value adding
- Improved customer satisfaction
- Better supply chain integration

On the other hand, they may not be concerned about the impact of e-business on the company's image, advertisement, error reduction, market share and cost savings.

The effect of the financial obstacles is also noteworthy. Firms should take into account not only the benefits but also the costs of adoption, running and maintenance as well as financial constraints. Financial constraints concern issues in mobilising financial funds for e-business investment. The existence of this effect implies that companies may have to rely on their own savings instead of external sources. Alternatively, financing cost would increase with the level of the firm's default risk.

Regarding the study's limitations and implications for future research, the main issue with using a survey to collect data is that, due to research ethics requirements and firms' unwillingness to provide confidential information, the survey cannot ask direct questions concerning financial variables such as revenue, profit, cost, etc. indicated by the theoretical model. Therefore, the study has to use non-financial data as proxies for financial variables. Regardless how the theoretical model can be expanded, there is always a gap between the number of variables it can accommodate and the number of actual factors that can be covered by the survey questionnaire. For example, business expectation is better represented by extensive information obtained from the survey. This explains why exploratory factor analysis is essential in dimension reduction to ensure that information obtained from the survey can be used in the next phase of analysis. The use of factor scores obtained from factor analysis is subject to the loss of information; the smaller number of factors is retained, the more information is lost. This makes the test of the theoretical model even more challenging. In addition, the theoretical model can, to a large extent, be seen as being derived from the neoclassical theory of investment, which takes a very different approach compared with the real options theory. The application of the latter would result in a very different approach to the empirical study that will be considered for the future research. Finally, rather than using EFA to reduce the dimension number and extract data for relevant common factors for analysis in the second phase, future research can also use confirmatory factor analysis (CFA) as a more rigorous method to rationalise the selection of the common factors.

Appendix A. Summary of the survey results

See Tables A1–A4

Table A1
Business nature.

Business nature	Frequency	Percent	Valid percent	Cumulative percent
Transport	37	35.6	35.6	35.6
Warehousing & storage	11	10.6	10.6	46.2
Logistics network/4PL/ LLP	3	2.9	2.9	49.0
Freight forwarding	30	28.8	28.8	77.9
Customs services	10	9.6	9.6	87.5
Inventory management	2	1.9	1.9	89.4
Logistics consultancy	3	2.9	2.9	92.3
Logistics IT services	6	5.8	5.8	98.1
Others	2	1.9	1.9	100.0
Total	104	100.0	100.0	

Table A2
Year of establishment.

Period	Frequency	Percent	Cumulative percent
After 2002	16	15.4	15.4
Between 1997–2002	24	23.1	38.5
Before 1997	64	61.5	100.0
Total	104	100.0	

Table A3
Number of employees.

Staff range	Frequency	Percent	Cumulative percent
Staff less than 9	25	24.0	24.0
Staff 10-19	30	28.8	52.9
Staff 20-49	25	24.0	76.9
Staff over 50	24	23.1	100.0
Total	104	100.0	

Table A4
Current use of ICT.

Type	Frequency	Percent	Cumulative percent
Basic IT service	6	5.8	5.8
LAN	29	27.9	33.7
Intranet	13	12.5	46.2
Enterprise business system	6	5.8	51.9
EDI	20	19.2	71.2
Web-based applications	30	28.8	100.0
Total	104	100.0	

Appendix B. Survey questionnaire

I. Company's profile

1.1. Type of services:

□ transport	□ warehousing & storage	□ logistics network/4PL/LLP	□ freight forwarding
□ customs services	□ inventory management	□ logistics consultancy	□ manufacturing related services
□ logistics IT services	□ others		

1.2. Year of establishment:

1.3. Number of employees: Full-time employees: Part-time employees:

1.4. Please indicate the types of information and communication technology currently used by your company:

□ Local Area Network (LAN)	□ Intranet
□ Enterprise Business System (EBS)	□ Electronic Data Interchange (EDI)

□ Web-based applications, such as online ordering, shopping cart facilities, secured payment, customer account and order tracking

II. Benefits of e-business adoption to logistics operation

Please give your opinion about the following benefits of e-business adoption in transport and logistics:	strongly disagree ⟷ strongly agree
2.1. Increased competitiveness	⓪①②③④⑤⑥⑦⑧⑨
2.2. Service differentiation	⓪①②③④⑤⑥⑦⑧⑨
2.3. Value adding	⓪①②③④⑤⑥⑦⑧⑨
2.4. Improved customer satisfaction	⓪①②③④⑤⑥⑦⑧⑨
2.5. Better supply chain integration	⓪①②③④⑤⑥⑦⑧⑨
2.6. Advertisement	⓪①②③④⑤⑥⑦⑧⑨
2.7. Improved company's image	⓪①②③④⑤⑥⑦⑧⑨
2.8. Increased market share	⓪①②③④⑤⑥⑦⑧⑨
2.9. Improved operational efficiency	⓪①②③④⑤⑥⑦⑧⑨
2.10. Cost savings	⓪①②③④⑤⑥⑦⑧⑨
2.11. Error reduction	⓪①②③④⑤⑥⑦⑧⑨
2.12. Emissions reduction	⓪①②③④⑤⑥⑦⑧⑨

III. Main factors inhibiting e-business adoption in logistics operation

Please give your opinion about the following main factors inhibiting your company from e-business adoption:	strongly disagree ⟷ strongly agree
3.1. Large initial investment outlays	⓪①②③④⑤⑥⑦⑧⑨
3.2. Financial constraints	⓪①②③④⑤⑥⑦⑧⑨
3.3. High running and maintenance costs	⓪①②③④⑤⑥⑦⑧⑨
3.4. Lack of IT skills	⓪①②③④⑤⑥⑦⑧⑨
3.5. Uncertainty & risk	⓪①②③④⑤⑥⑦⑧⑨
3.6. Inability to choose suitable IT technology	⓪①②③④⑤⑥⑦⑧⑨
3.7. Lack of access to ICT consultant services	⓪①②③④⑤⑥⑦⑧⑨
3.8. Data security	⓪①②③④⑤⑥⑦⑧⑨
3.9. Incompatible services	⓪①②③④⑤⑥⑦⑧⑨
3.10. Customers not interested in the new services	⓪①②③④⑤⑥⑦⑧⑨

IV. Business expectations

Please rate your opinion about the potential and risks associated with transport and logistics business in the coming years.	strongly disagree ⟷ strongly agree
4.1. The Australian economy is performing well despite the current economic crisis	⓪①②③④⑤⑥⑦⑧⑨
4.2. The world economic crisis has an insignificant effect on Australia	⓪①②③④⑤⑥⑦⑧⑨
4.3. Exports continue to grow	⓪①②③④⑤⑥⑦⑧⑨
4.4. Demand for transport and logistics will remain stable	⓪①②③④⑤⑥⑦⑧⑨
4.5. Demand for transport and logistics will grow strongly in coming years	⓪①②③④⑤⑥⑦⑧⑨
4.6. The business investment environment is improving	⓪①②③④⑤⑥⑦⑧⑨
4.7. Interest rates are likely to be lowered	⓪①②③④⑤⑥⑦⑧⑨
4.8. Real wages will remain stable	⓪①②③④⑤⑥⑦⑧⑨
4.9. Utility rates will likely be lowered	⓪①②③④⑤⑥⑦⑧⑨

4.10. Fuel prices will likely be lowered in the coming years	⓪①②③④⑤⑥⑦⑧⑨
4.11. Changes in government policies will be more favourable to the transport and logistics companies	⓪①②③④⑤⑥⑦⑧⑨
4.12. The emissions trading scheme will unlikely have a significant impact on the profitability of transport and logistics companies	⓪①②③④⑤⑥⑦⑧⑨

V. *e*-Business investment

5.1. Is your company going to invest in e-business facilities such as the following in the near future? □ Yes, □ No

Intranet	Enterprise Business System (EBS)	Electronic Data Interchange (EDI)
Online ordering	Online shopping cart facilities	Secured online payment
Online customer account	Online order tracking	Online freight tracking

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