Diffusion and acceptance of wood roof trusses technology in a network of Chinese industry key-players: a structural equation model

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Abstract

Innovation diffusion theory (IDT) and Technology Acceptance Model (TAM) have been recently combined to explain behavioural intention to adopt new technologies. While combining the two increased the variance initially explained by the two theories, their extension to new cultural areas and industries remain less explored. This study seeks to fill the gap by combining IDT and TAM to explain wood roof truss technology acceptance (WRTTA) by Chinese building industry key players. A survey of 201 companies in Beijing, Shanghai and Guandong area is conducted. Findings after factor analysis followed by structural equations models suggest that relative advantage, infomediaries, and firm size are good predictors of perceived usefulness. Perceived ease of use is affected by the size of the firm, peer usage, and training. TAM core constructs are found to positively influence the WRTTA in China.

1. Introduction

Globalization has brought countless shake-ups in various industries with tremendous side effects. Forces behind globalization include overall custom duties and tariff reductions under different World Trade Organization (WTO) rounds of negotiations (Senti, 2000). Beyond tariff reductions, telecommunications and transportation have benefited from technology advancement and markets forces which have drastically reduced their cost (Hufbauer, 1991). Sea freight has been cut by 60 percent roughly between 1930 and 2000 while communication charges have been reduced closely to 0 percent over the same period (Hufbauer, 1991).

For many commodities, transportation costs no longer represent a significant share of their value. The above factors question the old paradigm of psychic distance where nations exchange more easily with those partners which are close to them geographically and culturally. Cost leadership oriented industries are particularly affected by recent changes driven by cost reductions worldwide and emerging new markets with a cheap skilled labor force and solvable consumers. Equally affected are industries operating in tiny home markets no longer protected under global tariff reductions. The next battle ground for forest products companies industry are China and India with the former already being embarked in deep reforms accepting wood roof frame construction in a deforested country.

China's importance as an emerging market has been reinforced by its accession to the WTO which paved the way to deeper reforms. Particular reforms in the construction sector open tremendous opportunities for market development. However, the booming building industry hails from state-run enterprises to private companies in a transition period during which both freshly allowed foreign products and building processes remain innovations. Thus, the introduction of these new products and processes obey to the innovation diffusion theory (IDT) (Rogers, 2003) whose curve of innovators, early adopters, early majority, late majority and laggards is similar to the classical product life cycle with its introduction, growth, maturity, and decline phases.

Among wood products and wood based construction systems, wood roof truss technology is one of the innovations introduced in North America in the late 50s. the objective of the present paper is to develop a wood roof truss technology acceptance model for the Chinese building market. The paper is organized as follows: a literature review, our research question, the methodology used, data collection, analysis, results and discussion, limits, implications, future research and conclusions.

In the literature review section, we first assess the main challenges for the forest products industry in an era of globalization followed by potential solutions which include the penetration of emerging markets with value added products. Secondly, we review the recent reforms in the Chinese economy and its constantly increasing Gross Domestic Product (GDP) as strong indicators of a potentially strong housing market. The review is followed by recent applications of innovation diffusion theory and technology acceptance models with an emphasis on the necessity to integrate models at the organizational level while taking them beyond traditional cultural borders.

Two main research questions and three sub-questions rise from the literature survey taking into account our main research objective. A conceptual framework integrating variables which will lead to responses to our questions is then proposed. We suggest an integrative approach including main streams of research, building on reliable, valid, and previously tested constructs by various authors in innovation diffusion and technology acceptance literature.

The methodology adopted is presented in the third section. The generation, testing and the administration process of a quantitative survey of Chinese building industry key players are described. Based on responses to this questionnaire, we conduct both an exploratory and a confirmatory factor analyses followed by structural equation models to test all the hypotheses. The fifth section is devoted to results discussions before stating the limits, implications and potential future research avenues.

2. Literature review

2.1 Forest products global challenges and emerging markets for innovative construction products and processes

Production and trade of wood products remain concentrated in a few countries. However, Juslin and Hansen (2002) argue that consumption is rapidly shifting from traditional markets to emerging ones. According to Goldman and Sachs (2004), these new, rich and densely populated countries' GDP will collectively and individually outweigh current leaders in a near future. Those countries are composed of Brazil, Russia, India, and China (BRIC). All these factors call for a better exploration of emerging markets as they experience exceptional growth. Brazil and Russia have large forests (478 and 809 millions of ha respectively, www.fao.org) but smaller populations than China. Although large, deforested and densely populated, India has still a long way to go in terms of market reforms. Hence, amongst the emerging markets, China is the most promising because of recent reforms including its accession to WTO, its high deforestation, the largest population of all, and the highest GDP of the group.

However, as Cohen and Mineral (2004) put it, for a large majority of key actors in the Chinese construction industry, i.e.: architects, engineers, developers, and builders, the wood frame construction and related wood roof truss technologies are new. Hence, they should be treated both as a product and a building process innovation. Wood frame construction has been absent in China although old prestigious building such as temples and palaces demonstrate a tradition of wood building in Chinese past. Today's education system and practical experience do not include wood construction. Concrete and steel have been the preferred materials for a significant time. As both steel and concrete are non-renewable materials, policies are changing to reintegrate wood as a building material. In this respect, since January 1, 2004, the National Standard of the People's Republic of China Code for Design of Timber Structures GB 50005 – 2003, edited and published by the Ministry of Construction of People's Republic of China, has been in force. An additional indicator of growing interest in wood products is the current aforestation program of China (SFA, 2000). This also implies that, most of the forests are young and that China will rely on imports for some time to come.

In conclusion, it is easily understandable that the current logging ban aims at preventing more deforestation while protecting the young aforestation program and the environment on one hand. On the other hand, the lifting of the customs duties on forest products imports and the new building code open a market to foreign products and expertise. Furthermore, this market has shown recent interesting growth rate. However, at such an early stage of diffusion, international marketers' main tasks should be to establish how to encourage product acceptance and maximize profit while shortening the introduction phase of the product life cycle.

2.2. Major streams of research

Wood frame construction and wood roof trusses are new technologies for Chinese actors who are rediscovering them after decades of domination by steel and concrete. They can accept or reject these innovations depending on many factors which are worth studying given the opportunities offered in a highly growing market. Two main research streams: IDT (Rogers, 2003) and Technology Acceptance Model (TAM) (Davis, 1989) have benefited from extensive work in fields such as sociology, marketing, information systems technology, etc.

To understand wood roof technology acceptance by a set of Chinese actors ranging from architects to builders, and comprising engineers and developers, this study first reviews the most cited and empirically supported model in information systems (IS) in its core framework: the TAM by Davis (1986). TAM posits that intention to use a technology stems from the adopter's perceived usefulness as well as from his perceived ease of use of the same technology. The intention to use stimulates the actual use. However, antecedents to perceived ease of use (PEU) and perceived usefulness (PU) have received rather little research attention by researchers (Legris et al. 2003).

TAM has undergone different testing in which it proved to be parsimonious and better than competing models. It has also undergone significant improvement either by incorporating new concepts or by integrating other theories In the IS field, TAM by Davis (1989) was extended to TAM2 by Davis and Venkatesh (2000) to include subjective norms and voluntariness. Unified Theory of Acceptance and Use of Technology (UTAUT) by Venkatesh, Morris, B. Davis and D. Davis (2003) is the latest development. The integration process included mainly

IDT to account for external factors and Theory of Planned Behavior to capture previous experience. Yi et al. (2005) provide an interesting review of the integrated models.

According to the correspondence we had with its author, one of the major critics addressed to TAM is towards its pretension to be a general model, thus suitable to applications in other sectors. Critics say its explanation power is then diluted in its general applicability, although, to the best of our knowledge, few studies have taken it to sectors other than information technology. Among critics, the type and the size of the samples lend to very risky generalization. Previous studies surveyed mainly students. Self reported perceptions also lend to less credibility according to some authors. However, TAM's core constructs have undergone testing and retesting and were found consistent, reliable and robust. Further extension to other sectors appears to be needed since most of the studies have been conducted in information systems using samples of students (Legris et al. 2003).

3. Research question and conceptual framework

The prime objective of this paper is to study Chinese actors' main perceptions of wood roof trusses (WRT) as an innovation. We hypothesize that these perceptions can be explained in the framework of TAM, i.e. usefulness and ease of use leading to intention to use. The second objective builds on previously tested constructs in the IDT framework to establish and validate antecedents to the perceptions of usefulness and ease of use so that companies willing to enter the new market with wood roof truss technology and products can gain more insight as to how to increase profitability by shortening the introduction phase. These objectives coupled with the previous literature review on major trends in innovation diffusion and acceptance lead to the following three main research questions and six sub-questions:

- Can we measure and model Chinese building industry key players perceptions of WRT?
- To what extent do Chinese building key industry players' perception of usefulness and perception of ease of use affect their intention to use WRT technology in China?
- What factors affect the perceived ease of use and usefulness of WRT technology in China, including the system features, the actors' characteristics or wider contextual factors?

To respond to our research questions, we developed a conceptual framework based on recent findings in innovation diffusion and acceptance research. The ultimate goal is to properly identify, measure and model antecedents to PU and PEU, two main constructs leading to intention to use and actual use. To determine antecedents to PEU and PU in the Chinese construction market, we draw verified constructs from all the previously mentioned studies exploring different streams of research and paradigms. Constructs related to antecedents are grouped into three categories: systems features, external factors, and adopters' characteristics.

3.1 Variables definition and hypotheses

3.1.1 WRT systems features

Rogers (2003) contends that innovation characteristics are primary determinants in the innovation adoption process. His five attributes include: relative advantage, compatibility, complexity, observability, and triability. Empirical and non empirical studies have used successfully the 5 attributes in predicting innovation diffusion and adoption (Tornatzky and Klein. 1982). According to Rogers (2003), 49 to 87 percent of variance of the rate of the adoption is explained by these five attributes.

Relative advantage is defined as the degree to which an innovation is perceived as better than the one it replaces or competes against. Wood roof truss technology in our case has to compete and prove more advantageous both economically and socially than existing systems mainly based on steel. To be compatible with existing structures, the new technology characteristics have to be consistent with the values, beliefs, and past experiences of the potential adopters. Our conceptual framework includes a compatibility variable. To attain a high probability of adoption, Rogers (2003) contends that an innovation should be easy to understand and use by its potential adopters. The complexity variable is part of the systems characteristics constructs in our model. One of the ways to make sure that innovations are easy to use is to test and experiment with them as suggested by Surry and Gustafsson (1994), at least on a limited basis as posited by Rogers (2003). Our variables include a triability construct derived from these suggestions.

Two additional measures are incorporated in our system feature constructs: risk and uncertainty following the work of Bauer (1967) and Cunningham (1967). A technology perceived as risk free and potentially marketable will gain in adoption probability.

In consistence with the above literature, the following hypotheses will be tested:

H1a	Relative advantage significantly influences perceived usefulness
H1b	Relative advantage significantly influences perceived ease of use
H2a	Compatibility significantly influences perceived usefulness
H2b	Compatibility significantly influences perceived ease of use
H3a	Complexity significantly influences perceived usefulness
H3b	Complexity significantly influences perceived ease of use
H4a	Triability significantly influences perceived usefulness
H4b	Triability significantly influences perceived ease of use
H5a	Cost and risk significantly influences perceived usefulness
H5b	Cost and risk significantly influences perceived ease of use

3.1.2 WRT extrinsic factors

Although important, contextual and environmental factors are often forgotten in the technology adoption literature. One of the foundations of the theory of reasoned action as put forward by Fishbein and Azjen (1975) is the subjective norm. They define it as "a person's perception that most people who are important to him think he should or should not adopt the behavior in question." Innovation does not happen in a closed vacuum. It is a social process in which the effects of all actors have to be taken into account. Broadly defined, the actors in our study include the engineers, the developers, the builders and the architects involved in the Chinese building industry. We anticipate that information is exchanged in that network to fuel innovation and that firms exert reciprocal influences that will facilitate or temper the adoption process. Haunschild & Beckman, (1998) contend that informational transfer in such a network includes market feedback regarding the successes and failures of other firms, which informs organizational change and leads to mimicry. Hausman & Stock, (2003) argue that partners influence innovative decisions made by others within the network.

The role and influence of variables that are exogenous to new technology like management support and external support in adopting a technology are demonstrated by Igbaria et al. (1997). For Lucas and Spitler (1999), social norms and the nature of the job are more important in predicting technology adoption than users' perceptions and beliefs. Social influence is also found in Venkatesh and Davis (2000). As to Rogers' five attributes, the last construct in his diffusion model refers to observability. An innovation will be easier to implement if its results are visible to all potential adopters. The quality of the information transmitted about the new technology will help in convincing potential adopters as Petty and Cacioppo (1986) put it in the elaboration likelihood model. The Bass model by Bass (1969) on new products acceptance is precisely based on the role played by sources of information in influencing potential adopters.

With regard to all the above findings, external factors mentioned in our conceptual framework are related to constructs which are out of the control of both the adopters and the suppliers of the technology to be adopted. They include state regulations, infomediaries, peer usage, competitive pressure, incentives, and external information sources. Thus, we hypothesize that:

H6a	Infomediaries will have a significant effect on perceived usefulness
H6b	Infomediaries will have a significant effect perceived ease of use
H7a	Peer usage will have a significant effect perceived usefulness
H7b	Peer usage will have a significant effect perceived ease of use
H8a	Competition will have a significant effect perceived usefulness
H8b	Competition will have a significant effect perceived ease of use
H9a	State intervention will have a significant effect perceived usefulness
H9b	State intervention will have a significant effect perceived ease of use
H10a	Incentives will have a significant effect perceived usefulness
H10b	Incentives will have a significant effect perceived ease of use
H11a	Information will have a significant effect perceived usefulness
H11b	Information will have a significant effect perceived ease of use

3.1.3 Adopters' characteristics

Personal and/or firm characteristics play an important role in the decision to adopt an innovation. Characteristics for an organization used in our study include formal education of its employees, revenue, number of employees, number of branches, location, and most importantly the list of technologies adopted over time. The last characteristic refers to the innovativeness of the organization, a concept which is often ill-defined. Hirschman (1980), Venkatraman and Price (1990), Citrin et al. (2000), are among the authors who contend that innovativeness predict consumers' intention to adopt or reject new technologies. Adopter's prior use and subsequent experience are verified in Jackson et al, (1991), Venkatesh and Morris (2000), O'Cass and Fenech (2003). The influence of age and education on technology adoption is documented by Pijpers et al. (2001). The level of education and prior similar experience are also found in Agarwal and Prasad (1997). Under adopter characteristics, our study operationalises the number of employees as the rest of the information is difficult to obtain and often generates non imputable missing values. The probability of adoption also depends on firms size (Nooteboom, 1989). In addition to this, number of employees is often considered as a proxy to revenue, number of branches, and level of education if we remain in the same sector. Referring to previous findings in the above literature, we hypothesize that:

H12a	Size *will have a significant positive effect* on perceived usefulness
H12b	Size *will have a significant positive effect* on perceived ease of use

3.1.4 Relationship between perceived ease of use and perceived usefulness

Since its inception, TAM has undergone significant changes and improvements. In one of the revised forms, Pijpers et al. (2001) state that consumers actively evaluate the usefulness and ease-of-use in their decision to adopt or to reject a technology. Another significant change is related to the relationship between these two motivational variables. Venkatesh and Davis (2000), as well as Legris et al. (2003) found that perceived usefulness is influenced by perceived ease-of-use as a technology is perceived more useful once it is easier to use.
Hence, we hypothesize that:

H13	Perceived ease of use *will have a significant positive effect on* perceived usefulness

3.1.5 Intention to use.

Once adopters are exposed to an innovation with its characteristics within specific environmental factors, they develop attitudes. Fishbein and Azjen (1975) define an attitude as "a learned predisposition to respond in a consistently favorable or unfavorable manner with respect to a given object." Their Theory of Reasoned Action provides a mathematical relationship between attitude and the following variables: subjective norm and behavioral intent. Thus, adopting intention stems from attitudes towards an innovation. The Theory of Reasoned Action inspired Davis' (1986) constructs of perceived ease of use and perceived usefulness. Hu et al. (1999) empirically demonstrated that PU is the only significant determinant of the intention to use a new technology while PEOU exerts only a moderating effect on PU. From a different standpoint, adopters and non-adopters were separated in many studies. Thomson et al. (1991) showed the separation of near term and long term is studying the consequences of an innovation adoption. Therefore, the following hypotheses will be tested based on these findings:

H14a	Perceived usefulness *will have a significant positive effect on* intention to use
H14b	Perceived ease of use *will have a significant positive effect on* intention to use

4. Methodology

4.1 Development of the questionnaire

The constructs and contents of the questionnaire were largely drawn from previous theories with an adaptation to the Chinese context and to wood frame construction. The document with inputs from industry representatives was submitted for wording and phrasing to a panel of four different readers. To ensure that no bias was present in our questionnaire, we submitted it to a review process by experts from different backgrounds including two marketing professors, two information systems professors, one forest products marketing professor active in Asian markets, one research methodology professor, one industry specialist in China, one Chinese professor of architecture at a Chinese University, and two researchers close to the forest industry. This panel of experts was asked to answer/comment on unclear item numbers, wording, and to suggest items they felt should be omitted or added.

After the test by a group of experts, the questionnaire underwent back translation cycles from English into Chinese Mandarin. Four blind iterations were conducted. Experts contacted for translation included:

- Two MBA graduates and one forestry PhD student, both fluent in Chinese Mandarin and English;
- Their work was submitted for convergence and enrichment to one MBA graduate running a construction materials business in Shanghai, a post doctoral Chinese student in agricultural science, two Chinese university professors;
- The version obtained from a consensus in step two was proofread by a Chinese graduate student in architecture.
- The final version was submitted to industry specialists in China before mailing to the surveyed companies.

4.2 Subjects and sites selection

This study was carried out in three Chinese locations: Beijing, Shanghai, and the Guangdong area. A compilation of Chinese statistics by McKinsey (2004) reveals that there are “three Chinas” from the richest provinces of the East to the poorest Western area. Data compiled from the China Business Review (2003) reveal that the 201,000 foreign direct investments are positively associated to three important factors: population, per capita GDP, and geographically accessible eastern coast. They are the most economically promising areas according to the Chinese Statistical Yearbook (2002). Our survey combined the following sources to set up a usable database:

- printed edition of yellow pages for the four areas to be surveyed;
- Internet edition of yellow pages for the four areas;
- professional listings by different boards or academies;
- newspapers and advertisements therein;
- lists of companies attending professional seminars on wood construction;
- a commercial database purchased from a third party.

From all these sources, only 970 companies showed usable data related to name of contact person, telephone, postal address, email, and website were selected first. Of these, 670 of them accepted to read and reply to our survey once they received it. Three weeks after the initial postage through China Post, 85 companies had returned reply envelopes while 24 had chosen the website. The final instrument in Chinese Mandarin was mailed to all companies interested in wood frame construction with valid addresses. The following actions were taken to improve response rate: formatting questionnaire, pre-notice, sponsorship, multiple mailings, appeals, promise to share results, steady pressure, subject interest, and prepaid postage. Following Sudman and Bradburn (1974), we designed on site training of personnel meeting the above criteria in order to enhance:

- their role demands (i.e. rules governing the interviewer's behavior);
- their actual behavior (ability to follow rules, comfort with asking sensitive questions);
- the output from their extra-role characteristics (e.g. race, age, social class, geographical origins).

4.3 Descriptive statistics

Out of the 647 questionnaires sent to companies interested in wood frame construction and wood roof truss technologies, 245 were returned. After deletion of unusable questionnaires with missing and outlier data, the final sample comprises 201 respondents. The 31 percent response rate compares favorably with similar studies in industrial settings. The following demographic criteria will be used to establish the descriptive statistics for all the surveyed categories. The domain of activity refers to the four main areas i.e 1 for engineers, 2 for developers, 3 for builders, 4 for architects, and 5 polyvalent companies. The number of employees is reported in categories with 1 for less than 100, 2 for 101-500, 3 for 5001-1000, 4 for 1001-5000, and 5 for more than 5000. The geographical areas covered are 1 for Beijing area (Beijing, GianDao,Tianjin), 2 for Shanghai area (Shanghai, Nanjing, Puning, Suzhu), 3 for Guandong area (Guangzhou,ShengZhen, LianZhou). The 6 waves of respondents refer to responses received before first follow-up call (1), after first reminder (2), face to face in seminars (3 and 4), after second follow-up call (5) and via the website of the survey (6). Skeweness and Kurtosis standard errors between -2 and +2 limits are provided for normality assessment.

INSERT TABLE 1

4.4 Non-response bias test

An often neglected research issue is the non-response bias in mail surveys. Methods to test this bias are rather adhoc and include mainly the following:

- given criteria of a randomly pre-select population compared to all the respondents;
- test of significant differences in characteristics of respondents vs. non-respondents;
- early responders, middle responders, and late responders are compared;
- post survey questionnaires are posted to randomly selected population in the respondents group. Results are compared to those obtained in the survey.

The third method is the most suitable for our survey as there is no public database from which we can derivate pre survey profile of respondents.

INSERT TABLE 2

For seven variables pertinent to this study, there no are significant differences between the five waves of respondents. Hence, we can reasonably assume that there is no non response bias as respondents are similar across the five waves, late respondents being assumed similar to late respondents.

4.5 Structural equations modeling

4.5.1 Structural equations modeling steps

Recent developments in statistics and related software call for improvement of first generation statistical models with two blocks of independent and dependent variables. Reality often goes far beyond the two fixed blocks. Superior to classical multiple regressions and to path analysis, structural equations modelling can help in mapping reality with its latent and observed variables and measuring them as they appear sequentially or simultaneously, and often influencing each others. Contrary to first generation techniques, SEM account for measurement errors and suggest model modifications through a rigorous process relying on multiple indices of fit.

We study the measurement model before the general structural equations model. However, this study being exploratory with adapted constructs from various fields, we first conduct an exploratory factor analysis before the measurement model itself. Hence our structural model is cautiously obtained after three main steps:

- an exploratory factor analysis using SPSS 13.0 to reveal items structure per factor , assess contributions of items to all factors, extract non contributing items, verify the reliability of all factors as well as their multicollinearity;
- a confirmatory factor analysis using LISREL 8.71 to validate the factor analysis derivate structure while accounting for potential measurement errors and assessing goodness of fit of the revealed structural relations to our data;
- a general structural equations model including measurement models obtained after confirmatory factor modeling. As we are in theory generation mode, the general model fitted to our data will be refined to generate a final model after taking into account the eventual modifications indices and residuals and dropping non significant relations.

4.5.2 Exploratory factor analysis

Table 4 summarises exploratory factor analysis results. We first did a principal component factor analysis with varimax rotation to extract factors structure. A measure is loaded significantly on its underlying construct if its factor loading exceeds 0.5 and has a lower factor loading (below 0.4) on other constructs. Hence, for sake of parsimony, we suppressed all factors loading on two constructs as well as those showing loading inferior to 0.5, Items contributing to the constructs are shown with their respective loadings. To pursue the analysis and find factors pertinent for the next steps, Cronbach alpha reliability coefficients were computed for every construct. Results and actions taken are displayed in table 3.

INSERT TABLE 3

4.5.3 Confirmatory factor analysis

The exploratory factor analysis revealed four distinct groups of factors:

- System features with two latent factors: triability (alpha 0.64) and relative advantage (alpha 0.54) for a total variance explained of 73 percent;
- External factors with three latent factors: peer usage (alpha 0.82), information (alpha 0.72) , and training (alpha 0.72) for a total variance explained of 67 percent;
- Perceived ease of use with two indicators and a total variance explained amounting to 80 percent with an alpha coefficient of 0.75;
- Perceived usefulness with three indicators and a total variance explained of 59 percent with an alpha coefficient of 0.65

INSERT TABLE 4

Consequently, four structural measurement models were run to confirm these structures of relations. For all measurement models, content validity was secured in the questionnaire pretest phase to ensure that wording, phrasing, and content match the concepts under study. We assessed convergent and discriminant validity both at the exploratory factor analysis and at the confirmatory levels by retaining only measurement items highly loading on their respective constructs while deleting those under 0.5. The models with their respective standardized coefficients and fit indices are shown in Figures 1, 2, 3, and 4.

INSERT FIGURES 1, 2, 3 & 4

4.5.4 General structural equations model

Measurement models were combined in one structural equations model to test the hypotheses mentioned in our conceptual framework. The LISREL program offers a variety of methods of parameters estimation ranging from the default Maximum Likelihood (ML) to the Diagonally Weighted Least Squares (DWLS) and including Instrumental Variable (IV), Two-Stage Least Square (TSLS), Unweighted Least Square (ULS), Generalized Least Square (GLS), Weighted Least Squares (WLS). For a large sample, the ML estimation method is generally recommended for continuous data following approximately a multivariate normal distribution while its robust version based on an estimate of the asymptotic covariance matrix of the sample variance and covariance are suitable to small samples. In the presence of mixed ordinal and categorical data, it is advisable to use the Diagonally Weighted Least Squares (DWLS) method for polychoric correlation matrices. Like in robust maximum likelihood, an estimate of the asymptotic covariance matrix of the sample correlations is required.

Fisrt author's personal discussion with the LISREL supplier (SSI international) and a review of the above methods suggest that for a small sample like ours (n=201), with the presence of ordinal, categorical, and dichotomous data, the DWLS with asymptotic variances from the asymptotic covariance matrix is the most suitable method of parameters estimation. However, before DWLS, we performed estimation by default ML and results show no statistically significant difference in terms of most commonly used fit indices. For RAMSEA, NFI, CFI, GFI, ML yielded respectively 0.062, 0.897, 0.950, and 0.890 while DWLS results were

0.0426, 0.940, 0.983, and 0.974. Further analyses in this paper were conducted using DWLS method. Table 5 shows the structural equations analysis for hypothesized model using the DWLS estimation method.

INSERT TABLE 5

INSERT FIGURE 5

4.5.5 Post hoc analysis and final model validation

Once a general model is obtained with a good fit to the data, the search for specification of a better model can continue by dropping non-statistically significant paths that are irrelevant to what the researcher will release as the new model. We conducted a 5 step search for specification as shown in Table 7. Between the steps, suggested changes in the modification indices and residual matrices were dealt with as long as they made sense theoretically speaking and the sign and magnitude of the expected changes were deemed acceptable.

INSERT TABLE 6
INSERT TABLE 7

5. Results and discussion

Non significant links rejected across the structural equations modeling process are reported in Table 7. They include triability which impacts neither perceived usefulness nor perceived ease of use, suggesting that in this industry adoption intentions are not based on the possibility to try the product before buying it. Relative advantage defined as the capacity of WRT to favorably compete with substitution products does not positively impact the perceived ease of use. Peer usage has no influence on perceived usefulness. However it is worthy to note it significantly and positively impact on the perception of ease of use, thus confirming an important network effect in the adoption process. Actors apparently learn from each other and rely on their partners' decisions to adopt the new technology, thus increasing the ease of use of the new technology.

Both compatibility and complexity are rejected at the exploratory analysis with the latter suggesting that industry key players do not perceive the new system of building roof trusses as sophisticated even it is not compatible with their current methods mainly based on steel. Coupled to the rejection of triability and risk variables, this is a potential indication of the absence of difficulty in learning and using WRT technology by the respondents. State regulations and incentives are not good predictors either. Current reforms and economic liberalisation are probably behind this situation. Industry key players no longer feel the state regulations as a threat. Potential reasons might also include the fact that most companies are no longer state owned. Contrary to state regulations and incentives, informediaries are needed to boost the introduction of WRT technology. In addition to informediaries, the network effect in the industry is very important as peer usage is among the hypotheses supported at both usefulness and ease of use level. Last but not least, the competition pressure effect is insignificant.

Significant links are shown in the same table in bold. It is interesting to note that core TAM constructs impact significantly on the attitude towards adoption of WRT and its actual use.

Consistent with Davis (1986) findings, there is a positive link between perceived ease of use and perceived usefulness (standardized beta 0.30). Perceived usefulness highly impact the intention to adopt (standardized beta: 0.70), a result superior to what is commonly found in previous literature as reviewed by Lee et al. (2005) (beta 0.17, 0.44, 0.49, 0.52, 0.54). Thus, hypotheses h12a, h12b, h13 and h14a are confirmed. Perceived ease of use does not affect positively and directly the intention to adopt WRT. However, there it exerts an indirect positive impact as shown in the indirect and total effects highlighted in Table 8. Even though, the small standardized coefficient suggests that for Chinese building industry key players, WRT is a relatively easy to use technology. Consistent with multiple previous findings, the intentions to use positively influences the actual use of the system.

With regard to the innovation diffusion theory concepts operationalized as external factors, only relative advantage emerges with a positive influence on perceived usefulness in consistence with Rogers' model. An additional external factor positively influencing the perceived usefulness is related to infomediaries defined as agents transmitting the information on the products to the final buyer. This positive and significant influence is consistent with recent research findings by Pollock and Rindova, (2003), Deephouse (2000), and Rao et al., (2001). Infomediaries coupled to peer usage are also part of the Bass model by Bass (1969). The model assumes that there are two sources of information: mass-media and word of mouth which play a great role in influencing two groups of adopters: innovators and imitators. The importance of information in the process of adoption are also found in the Elaboration Likelihood Model by Petty and Cacioppo (1986) for whom the argument to convince adopters to use new technology relies on quality as transmitted by the information systems

6. *Conclusion*

Our study has two main limits and three types of contribution in this study: theoretical, methodological, and international marketing.

First, self reported perceptions are a potential source of bias when there is no secondary data or previous study to validate the findings. However, this potential bias is attenuated by non response bias test results and precautions taken before our measurement model. Future research could overcome this by triangulating more theories and methods. A qualitative survey could reveal additional information, while confirming our findings

A second limit is related to the sample itself. Although there is no non-response bias, stratified samples by profession including more regions of China could bring a better understanding and increased generalization power to the entire country. Given the importance of the market potential and challenging cultural environment, an extension of the sample to survey more cities and greater number of companies would allow better invariance structure testing across multiple groups. An equally interesting future research avenue is the in depth study of the profiles of adopters and non adopters of WRT in order to assess the probability of adoption based among others on concepts like innovativeness and past technology acceptance experiences.

The main theoretical contribution lays in the extension and integration of innovation diffusion and technology acceptance models to the building industry in China. The measurement models provided are based on reliable constructs which can be easily replicated elsewhere. Previous studies on innovation diffusion and technology acceptance have barely crossed oceans to the developing countries. After factor analyses, Rogers' (1995) innovation diffusion theory concept of relative advantage is the only factor retained after purification and structure generation. Compatibility and complexity were dropped from the analysis due to poor loadings, thus suggesting that for the Chinese building industry key players, the wood roof truss as a technology and a process is compatible with their current practices and therefore not complex to use. Training emerged as an important variable in the context of adoption. The importance of peer usage and the necessity of established infomediaries in the Chinese building industry adoption process was demonstrated. Overall, contextual factors outnumber product and process characteristics for the type of innovation under study in China thus providing interesting insightsd to both theory and marketing professional willing to enter the Chinese market.

Methodologically, conducting research in an environment without reliable secondary data and archives could result in time and money consuming projects with intangible outcomes. These two constraints were overridden by triangulation of collection methods in this study, a concept we highly recommend to future research. The gap in research on relationships between contextual factors and cognitive responses by chains of actors exposed to new products and processes in developing countries is partially filled by our final structural equations model. Relative advantage, infomediaries, and the size of the adopting organization positively impact the perception of usefulness which has a great influence on the intention to adopt new technologies. The ease of use is highly dependant on training and relations between the adopter and the social system in which he evolves. For the intention to adopt, the usefulness perceptions, and the ease of use perceptions, our final model accounted respectively for the following variances 45 percent, 87 percent, and 35 percent. Previous studies by Venkatesh and Davis (1996, 2000) accounted for 35-52 percent variance in use intentions and 40-60 percent in usefulness perceptions. We strongly advise future research to extend our model to other industrial settings.

Last but not least, this study provides practical indications to marketing strategists willing to enter the lucrative Chinese market and reduce their introductory phase of a new technological product life cycle. After factor analyses, Rogers' (1995) innovation diffusion theory concept of relative advantage is the only factor retained after purification and structure generation. Compatibility and complexity were dropped from the analysis due to poor loadings, thus suggesting that for the Chinese building industry key players, the wood roof truss as a technology and a process is compatible with their current practices and therefore not complex to use. Training emerged as an important variable in the context of adoption. The importance of peer usage and the necessity of established infomediaries in the Chinese building industry adoption process was demonstrated. Overall, contextual factors outnumber product and process characteristics for the type of innovation under study in China.

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Table 1: Descriptive statistics

	N	Min.	Max.	Mean	Std. D.	Skewness		Kurtosis	
	Stat.	Stat.	Stat.	Stat.	Stat.	Statistic	Std. Error	Statistic	Std. Error
Domain	201	1	5	4,02	1,19	-1,26	0,17	0,54	0,34
Number of employees	201	1	5	1,84	0,87	1,09	0,17	0,96	0,34
Geographical area	201	1	3	1,50	0,58	0,69	0,17	-0,49	0,34
Wave of respondents	201	1	6	3,38	1,76	-0,11	0,17	-1,65	0,34
Revenue 2003	201	1	4	2,81	0,80	0,07	0,17	-0,87	0,34
Company age	201	1	55	20,60	15,64	0,98	0,17	0,10	0,34
University graduates	201	0	100	45,95	38,52	-0,02	0,17	-1,62	0,34
Used WRT Yes or No	201	0	1	0,21	0,41	1,44	0,17	0,08	0,34
Valid N (listwise)	201								

Table 2: One-way-anova non-response bias test

ANOVA			
	df	F	Sig.
DOMAIN	4	1,56	0,19
REVENUE 2003	4	1,20	0,31
OWNERSHIP STRUCTURE	3	1,21	0,31
PERCEIVED USEFULNESS	4	1,81	0,13
PERCEIVED EASE OF USE LESS T423	4	1,68	0,16
DECENTRALISATION INTENSITY	4	0,90	0,47
WRT ALREADY USED: YES OR NO	4	0,44	0,78

Table 3: Exploratory factor analysis

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.	Loading	Alpha cr.
System features. Variance explained: 73 percent.		
Triability. T242 I would like to use WRT on a trial basis to see how it performs T241 Before deciding on whether or not to adopt WRT, I would like to use it on a trial basis.	 0.873 0.852	**0.64**
Relative advantage. T213 If I were to adopt WRT, it would save energy in heating and cooling T211 If I were to adopt WRT, it would enable me to build more efficiently than steel and concrete	 0.841 0.828	**0.54**
External factors. Variance explained: 67 percent.		
Peer usage. T333 Other people in the construction business think I should adopt WRT T332 Top management in my company think we should adopt WRT T331 My close partners think I should adopt WRT	 0.875 0.820 0.765	**0.82**
Information. . T323 I would consider adopting WRT if relative information was publicized by professional associations T322 I would consider adopting WRT if brokers, designers, and lumber distributors could provide detailed engineering design information T321 I would consider adopting WRT if relative information were available from public sources	 0.816 0.762 0.747	**0.72**
Training. . T372 Training by professional boards in WRT is relevant T362 Partnering with WRT knowledgeable foreign companies would help increase adoption rate T373 Training provided by the Chinese education system about WRT is useful	 0.756 0.722 0.704	**0.72**
Competition pressure. T343 I will consider adopting WRT only when customers ask for it T341 I will consider adopting WRT only when most of our competitors will use it T361 Grants, subsidies and credit facilities would enhance adoption rate of WRT	 0.763 0.699 0.651	0.48
Government and independent information T371 Independent information contained in magazines about WRT is reliable T351 Government acceptance is a prerequisite to adopt WRT technology	 0.700 0.524	0.15
Perceived ease of use. Variance explained : 80 percent T421 Learning would be easy for me T422 It would be easy to use	 0.893 0.893	**0.75**
Perceived usefulness. Variance explained: 59 percent. T413 Enhance my effectiveness T411 Increase market share and profits T412 Increase my knowledge.	 0.779 0.775 0.748	**0.65**

Table 4: ITEMS DROPPED AT THE EXPLORATORY FACTOR ANALYSIS LEVEL

System features
1st iteration
T252 Building with WRT costs more than doing it with steel or concrete structure
T232 WRT benefits are easy to communicate to clients and partners
T231 WRT require a great amount of new learning
2nd iteration
T251 I would rather spend more money on improving our current mode of construction than to try WRT
T223 If I were to adopt WRT, it would fit my actual assets
3rd iteration
T221 If I were to adopt WRT, it would be compatible with most aspects of my actual business
T233 I would have no difficulty in telling others about the results of using WRT
T253 Building with WRT is safe and technically risk free
4th iteration
T212 If I were to adopt WRT, the quality of my work would improve
T222 If I were to adopt WRT, it would fit my building methods
External factors
1st iteration
T352 I would adopt WRT if Government could release more land to build on
T353 Regulations regarding WRT are unclear
2nd iteration
T342 Competitors who have already adopted WRT make good profits

ITEMS DROPPED AT THE RELIABILITY ANALYSIS LEVEL FOR POOR ALPHA CR.

T361 Grants, subsidies and credit facilities would enhance adoption rate of WRT
T343 I will consider adopting WRT only when customers ask for it
T341 I will consider adopting WRT only when most of our competitors will use it

T371 Independent information contained in magazines about WRT is reliable
T351 Government acceptance is a prerequisite to adopt WRT technology

Exploratory factor analysis KMO &Bat sig>0,005, commun.>0,5, fact. Load.>0,5, var.extr.>0,6 ;
12 items dropped

Reliability analysis by alpha cr. >0,5 ;
5 items dropped

Figure 1: systems features measurement model with standardized path coefficients

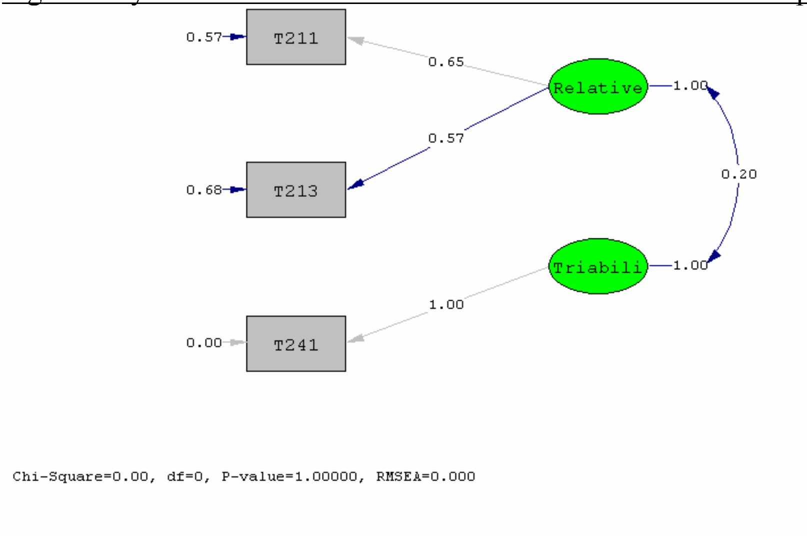

Figure 3: perceived ease of use measurement model

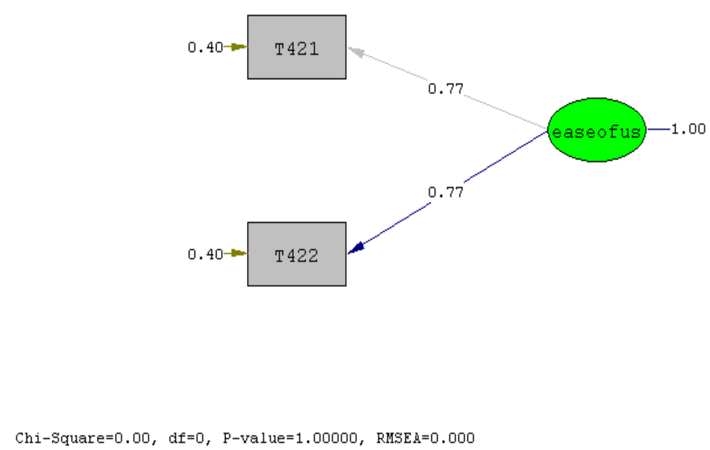

Figure 4: Perceived usefulness measurement model with standardized path coefficients

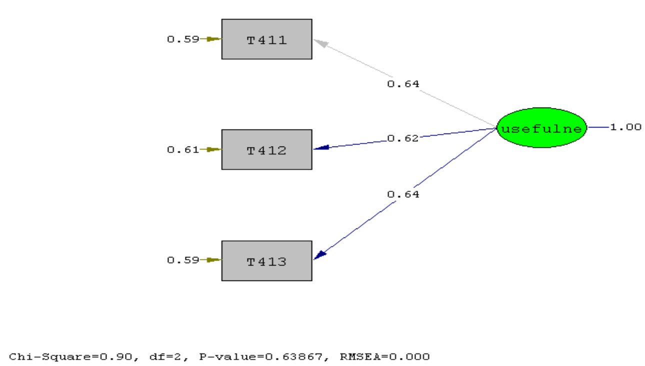

Figure 2: external factors measurement model with standardized path coefficients

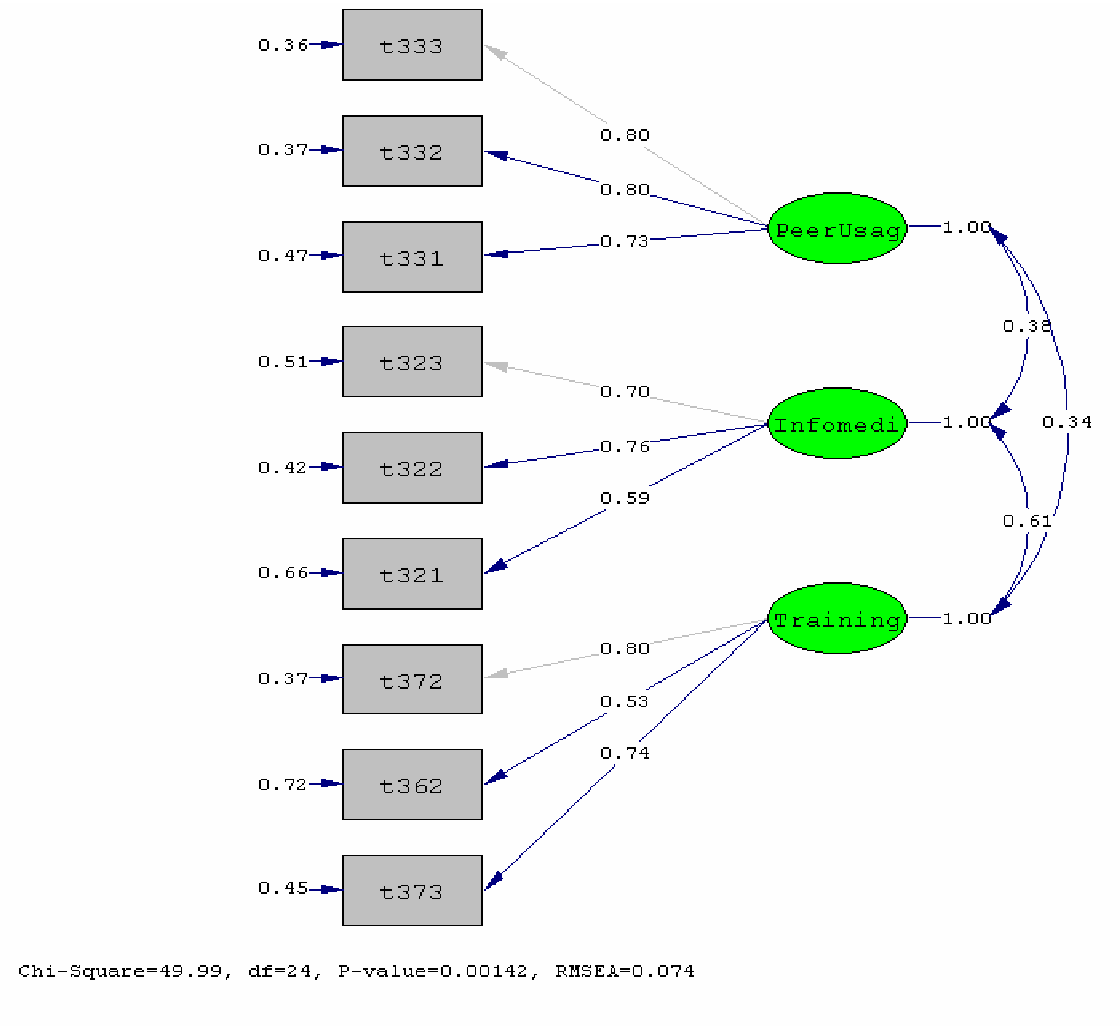

Figure 5: final structural equations model with standardized coefficients

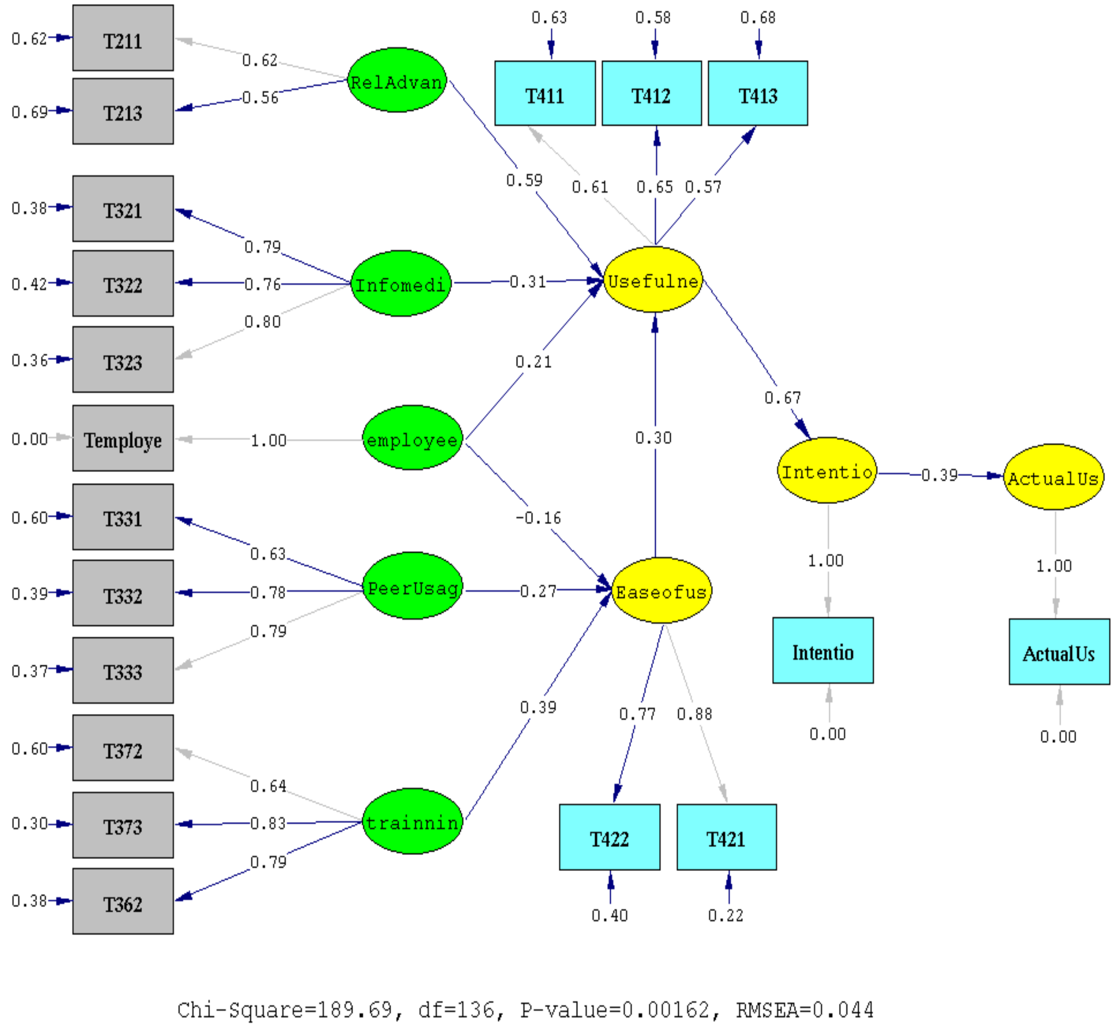

Table 5: Final Model, completely standardized solution. Structural equations analysis for hypothesized model

Hypo-othesis	Structural path	Std. path Coeff	t-value	Supported Rejected	level
H1a	Relative advantage → perceived usefulness	0.587	3.46	supported	
H1b	Relative advantage → perceived ease of use			rejected	SS2
H2a	Compatibility → perceived usefulness			rejected	EFA
H2b	Compatibility → perceived ease of use			rejected	EFA
H3a	Complexity→ perceived usefulness			rejected	EFA
H3b	Complexity → perceived ease of use			rejected	EFA
H4a	Triability → perceived usefulness			rejected	SS1
H4b	Triability → perceived ease of use			rejected	SS6
H5a	Cost and risk→ perceived usefulness			rejected	EFA
H5b	Cost and risk → perceived ease of use			rejected	EFA
H6a	Infomediaries → perceived usefulness	0.309	2.98	supported	
H6b	Infomediaries → perceived ease of use			rejected	SS5
H7a	Peer usage → perceived usefulness			rejected	SS3
H7b	Peer usage → perceived ease of use	0.268	3.91	supported	
H8a	Competition → perceived usefulness			rejected	EFA
H8b	Competition → perceived ease of use			rejected	EFA
H9a	State intervention→ perceived usefulness			rejected	EFA
H9b	State intervention → perceived ease of use			rejected	EFA
H10a	Incentives → perceived usefulness			rejected	EFA
H10b	Incentives → perceived ease of use			rejected	EFA
H11a	Information → perceived usefulness			rejected	EFA
H11b	Information → perceived ease of use			rejected	EFA
H12a	Size → perceived usefulness	0.208	1.97	supported	
H12b	Size → perceived ease of use	-0.162	-2.19	supported	
H13	Perceived ease of use → perceived usefulness	0.304	1.89	supported	
H14a	Perceived usefulness → intention to use	0.673	5.38	supported	
H14b	Perceived ease of use → intention to use			rejected	SS4
H15	Intention to use → actual use	0.388	4.85	supported	
	Training → perceived usefulness			rejected	
	Training → perceived ease of use	0.391	3.15	supported	

Table 6: Structural equations models, specification search and tests

	Initial model	Final Model	1st group half-split	2nd group half-split
	N=201	N=201	N=98	N=103
	Std Factor loading	*Std Factor loading*	*Std Factor loading*	*Std Factor loading*
Relative advantage				
- t211	0.700	0.619	0.725	0.599
- t213	0.616	0.556	0.539	0.618
Triability t241	1.000			
Peer usage				
- t333	0.794	0.792	0.836	0.715
- t332	0.776	0.779	0.882	0.695
- t331	0.634	0.635	0.713	0.557
Infomediares				
- t323	0.809	0.800	0.831	0.784
- t321	0.770	0.790	0.862	0.749
- t322	0.780	0.764	0.735	0.798
Training				
- t372	0.636	0.636	0.713	0.556
- t362	0.786	0.786	0.787	0.788
- t373	0.825	0.835	0.804	0.882
Perceived usefulness				
- t411	0.616	0.605	0.721	0.559
- t412	0.668	0.647	0.715	0.597
- t413	0.589	0.570	0.605	0.570
Perceived ease of use				
- t421	0.878	0.881	0.781	1.011
- t422	0.774	0.773	0.803	0.750
	Fit indices	*Fit indices*	*Fit indices*	*Fit indices*
Satorra-Bentler Scaled Chi-Square	194.868 (P = 0.00258)	189.691 (P = 0.00162)	170.479 (P = 0.0241)	205.127 (P = 0.000118)
Degrees of Freedom	143	136	136	136
Root Mean Square Error of Approximation (RMSEA)	0.0426	0.0444	0.0511	0.0706
Non-Normed Fit Index (NNFI)	0.978	0.977	0.975	0.936
Comparative Fit Index (CFI)	0.983	0.981	0.980	0.949
Adjusted Goodness of Fit Index (AGFI)	0.962	0.962	0.949	0.933

Table 8: Standardized Direct, Indirect, and Total Effects

Construct	Indirect effects on Intention	Total effects on Intention	Indirect effects on actual use	Total effect on actual use
Relative advantage	0.419	0.419	0.121	0.121
Peer usage	0.042	0.042	0.012	0.012
Infomed.	0.203	0.203	0.059	0.059
Training	0.061	0.061	0.018	0.018
Employee	0.114	0.114	0.033	0.033
usefulness		0.661	0.191	0.191
ease of use	0.156	0.156	0.045	0.045
Intention				0.289