On The Influence of Facilitating Conditions on DSS Usage

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Abstract

This paper examines the application of the Technology Acceptance Model (TAM), extended by the addition of Facilitating Conditions, to the use of Decision Support System (DSS) packages in South African organisations. Five facilitating conditions constructs are examined: internal support, external support, top management support, organizational characteristics and DSS package characteristics. The findings show a relationship between the top management support and organizational characteristics constructs and perceived usefulness. An unexpected result is the negative association between perceived usefulness and perceived ease of use of DSS packages. Reasons for these results are discussed in the context of this study and of DSS software.

Introduction and Background

Decision support systems (DSS) have been in existence for many decades in different forms, and have major potential for assisting decision-making in organizations. Their acceptance and usage have been examined in various studies. Davis' (1989) Technology Acceptance Model (TAM) has been applied to many types of information systems and technology, and in this paper an extension of the TAM will be examined, to take into account the possible influence of "facilitating conditions" on the usage of DSS. The paper will first outline the TAM and the concept of facilitating conditions, and then discuss the varied definitions and scope of DSS. A revised TAM model with corresponding hypotheses is then proposed. After covering the research methodology, results of a questionnaire survey amongst South African organizations are discussed, and conclusions drawn.

Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM) introduced by Davis (1989) has found widespread use in the information systems field. Davis' (1989) TAM was adapted from the theory of reasoned action, and modelled the effect of perceived usefulness (PU) and perceived ease of use (PEU) of information technology on each other, and on actual usage through intention to use. The TAM has been extended in various ways by addition of other constructs, generally as antecedents to PU and/or PEU. In their TAM2 extension Venkatesh and Davis (2000) showed that PU was also affected by the social influence processes (subjective norm, image and voluntariness), by cognitive instrumental processes (job relevance, output quality and result demonstrability), and to some extent by experience as a moderating variable. Venkatesh (2000) examined a number of "anchors and adjustments" as determinants of PEU. Given space limitations, readers are referred to Lee, Kozar and Larsen (2003) for a review of research into TAM and its many extensions. More recently Venkatesh, Morris, Davis, G. and Davis, F. (2003) formulated the Unified Theory of Acceptance and Use of Technology (UTAUT) Model by synthesizing eight previous models.

Although much research work has been conducted regarding the adoption of technology, especially concerning task-technology fit and cognitive impacts, not as much exists in the area of facilitating conditions around the technology. Facilitating conditions "are defined as the degree to which an individual believes that an organisational and technical infrastructure exists to support use of the system" (Venkatesh et al., 2003:453). Mathieson, Peacock and Chin (2001) developed an extension to TAM by including a construct called the Perceived Resources available. These included hardware, software, knowledge, time, data, finance, support and documentation.

Decision Support Systems

Power (2003) notes that a succinct definition of a decision support system (DSS) is difficult to locate. DSS has evolved over the last four decades, and is a general term encompassing a wide set of converging technologies which aim to "provide integrated support for managers working alone, in teams and in organisation hierarchies to manage organisations and make more rational decisions" (Power, 2003). Mann and Watson in Sprague and Watson (1993:42) state: "A decision support system is an interactive system that provides the user with easy access to decision models and data in order to support semi-structured and unstructured decision-making tasks."

Power (2003) identifies five categories of DSS applications: communications-driven DSS, data-driven DSS, document-driven DSS, knowledge-driven DSS and model-driven DSS. A decision support system thus covers a large variety of both software and terminology. Included in this arena can be spreadsheet programs, business intelligence, on-line analytic processing (OLAP), data mining, executive information systems (EIS), management information systems, data warehousing technology, query and reporting systems etc. Other DSS characteristics include (Sprague and Watson, 1993; Mallach, 1994; Sauter 1997):

- combining use of analytic techniques with data access and retrieval functions
- exhibiting flexibility and adaptability to accommodate changes in the environment and the decision making approach of the user
- assisting, not replacing, the decision making process
- responsiveness in terms of speed and access to information
- utilising multiple data sources.

Turban and Aronson (2001) include the following under the umbrella term of Management Support Systems: DSS, group support systems, enterprise (executive) information systems, ERP and SCM, knowledge management systems, expert systems, artificial neural networks, hybrid support systems and intelligent DSS. The term "business intelligence" is however currently used more widely in industry than DSS, focusing mainly on OLAP, data mining, business performance management and data warehousing technologies. This coincides largely with Power's (2003) data-driven DSS. There is clearly a lack of uniformity in terminology used, which differs over time, and between academia and industry.

Authors examining acceptance and adoption of DSSs include Chiasson and Lovato (2001), El-Beltagi (2002), Sanders and Courtney (1985), Todd and Benbasat (1999), and Wixom and Watson (2001). Research on DSS adoption locally includes Hart, Davies, Barker-Goldie and Theron (2002), Hart and Porter (2004) and Hart and Jaques (2005). Averweg, Erwin and Petkov (2004) surveyed the state of executive information systems in South African organisations.

The Research Model and Objectives

The objective of this research is to ascertain whether supporting facilitating conditions influence the actual system usage of a DSS package via the PEU and PU as described in the TAM model. Based on a literature survey, the five facilitating conditions constructs shown in Figure 1 are proposed as factors which may influence PU and/or PEU, and can be controlled, monitored or evaluated. The many other factors already found to affect PU and PEU are excluded from this analysis.

Internal support brings in the "perceived resources" concept of Mathieson et al. (2001), while external support deals with vendor-related issues mentioned by El-Beltagi (2002). Top management support, and champions, is an aspect often found in the literature, including Wixom and Watson's (2001) research on DSS-related areas. Organisational support characteristics relate to the organisational and physical structure, as discussed by Chiasson and Lovato (2001) and Hwang, Ku, Yen and Cheng (2004). DSS support characteristics relate to support linked to or provided by the package itself.

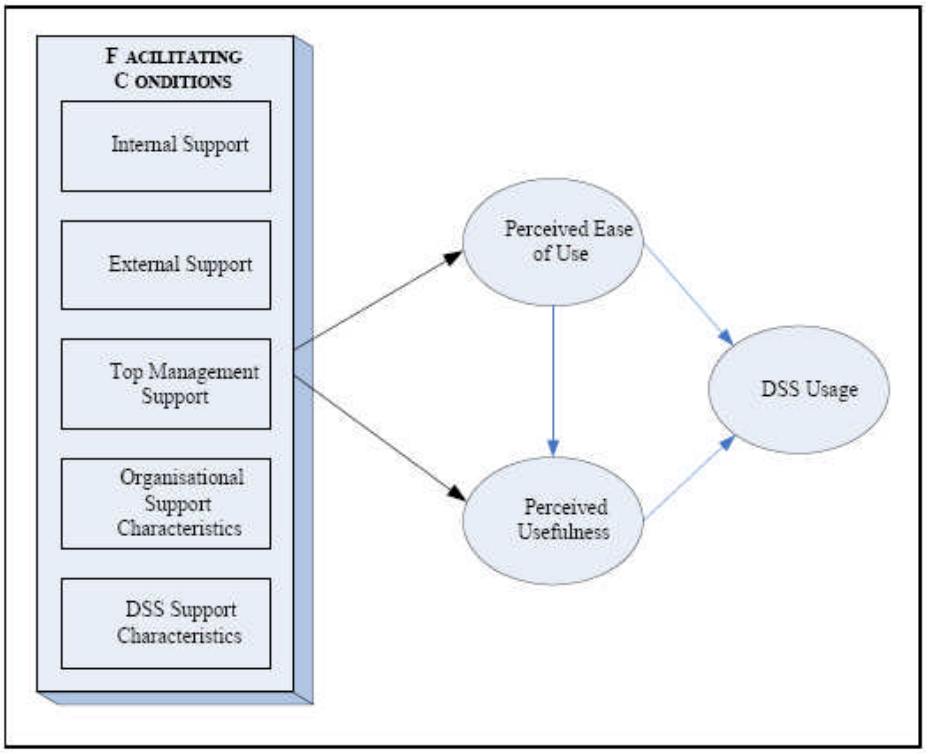

Figure 1: Research Model Extending TAM to Include Facilitating Conditions

Understanding how the constructs influence DSS usage could help management to:

§ establish the proper structure within an organisation to support effective DSS use
§ ensure effective training is provided where necessary
§ ensure suitable organisational support structures are in place
§ ensure support staff are appropriately skilled
§ rate external vendors of potential DSS packages in terms of training and support
§ rate potential DSS packages in terms of the variables identified in this research

Research Hypotheses

The following hypotheses will therefore be tested. They are stated in the alternative (the nulls are that there is no influence in each case).

H1: Facilitating Conditions of Internal Support, External Support, Top Management Support, Organisational Support Characteristics and DSS Support Characteristics have a positive influence on the Perceived Ease of Use of DSS packages.

H2: Facilitating Conditions of Internal Support, External Support, Top Management Support, Organisational Support Characteristics and DSS Support Characteristics have a positive influence on the Perceived Usefulness of DSS packages.

H3: Perceived Ease of Use has a positive influence of Perceived Usefulness of DSS packages

H4: Perceived Ease of Use has a positive influence on actual DSS Usage.

H5: Perceived Usefulness has a positive influence on actual DSS Usage.

Methodology

As most past adoption research has been carried out using questionnaire surveys, and validated instruments are often available, the same approach was deemed to be suitable for this study. The constructs to be used were derived from past research as in Table 1.

The latter seven constructs all consisted of seven-point Likert scale questions, and the three system usage questions were on shorter ordinal scales. (For simplicity the terms “organisational

support characteristics" and "DSS support characteristics" were modified to organisational characteristics and package characteristics). Participants were also asked a few general and demographic questions. A number of academics and practitioners were asked to check the questionnaire for understandability and consistency before it was administered, and the study also obtained ethics approval beforehand.

Table 1: Constructs Used in the Research Model

Construct	No. of Items	Sources of questions
System Usage (SU)	3	Davis (1989), El-Beltagi (2002), Hart & Porter (2004)
Perceived Usefulness (PU)	6	Davis (1989)
Perceived Ease of Use (PEU)	3	Davis (1989)
Internal Support (IS)	5	Mathieson, Peacock & Chin (2001), El-Beltagi (2002)
External Support (ES)	3	El-Beltagi (2002)
Top Management Support (TMS)	5	Mathieson, Peacock & Chin (2001), El-Beltagi (2002)
Organisational Characteristics (OC)	2	Hwang, Ku, Yen & Cheng (2004), El-Beltagi (2002)
Package Characteristics (PC)	6	El-Beltagi (2002)

A snowball-type sampling method was utilised for this research. Firstly, contacts within industry were approached to either distribute the questionnaire on behalf of the researcher, or preferably to forward the questionnaire to their business intelligence (or similar) departments. They were encouraged to forward the questionnaire to corporate DSS users who fell within the domain of the research. Follow-up emails were sent and where necessary, telephone calls were made to encourage responses. Incomplete responses were returned to the respective respondent requesting the full completion of the questionnaire. In all such cases, questionnaires were completed successfully. Confidentiality and anonymity of respondents in any reports was assured.

Data Collection

Altogether 27 responses were received from 13 organisations across the sectors of Banking, Retailing, Education, Finance and Information Technology. This represents a response rate of 18% of the 151 questionnaires distributed. DSS software used was largely of Power's (2003) data-driven and model-driven types, and from well known business intelligence vendors such as Business Objects, Cognos, Hyperion, and Microstrategy, while some comprised modules of a larger system such as SAP. Two respondents gave separate replies to each of two products. Omitting details that could identify participants, responses were coded and captured into an Excel spreadsheet, and also imported into the Statistica package for detailed statistical analysis. Since the number of questions for each construct varied, an aggregated response spreadsheet was derived by calculating the mean score per construct.

General Usage Statistics

Respondents have used their respective DSS for a mean of 2.8 years, although 59% of these indicate having used the system for a period of between only one and two years. Daily use of the DSS was made by 78% of respondents, 7% weekly and 15% monthly. On average respondents spent about 2.5 hours at a time using the DSS package, with 41% taking three to four hours. When asked how they rated their level of DSS usage in decision-making, 15% said "little", 26% "moderate", 44% "high", and 15% "extensive". These figures indicate that the DSS generally plays a prominent role in their business life.

Analysis of Results

Item Reliability

The reliability of the questions for each construct was assessed using Cronbach's alpha. Generally an alpha measure of 0.7 or greater indicates sufficient reliability, although for relatively immature research, an alpha as low as 0.6 is acceptable (Tan and Teo, 2000). Relatively high standardised Cronbach alpha measures were obtained for each of the constructs, as shown in Table 2. One of the PEU questions (Q13) was negatively phrased, and even with scores reversed it had low item-total correlation with the other three items. Deleting it improved Cronbach's alpha from 0.737 to 0.908, and it was therefore discarded from further analysis. Reliability for the two-item construct Organisational Characteristics was determined by incorporating a third 'dummy' variable and using the 'alpha if deleted' measure of the dummy variable. Overall the alpha measures obtained indicate the questions in combination are reliable measures for the constructs under investigation.

Table 2: Standardised Cronbach's alpha for constructs

Construct	No. of Items	Cronbach Alpha
System Usage (SU)	3	0.676
Perceived Usefulness (PU)	6	0.928
Perceived Ease of Use (PEU)	3	0.908
Internal Support (IS)	5	0.916
External Support (ES)	3	0.910
Top Management Support (TMS)	5	0.769
Organisational Characteristics (OC)	2	0.658
Package Characteristics (PC)	6	0.780

Factor analysis was used to see how well the five different facilitating conditions constructs separated. Five factors with eigenvalues greater than 1.0 explained 77.9% of the variance, but with only External Support and Organisational Characteristics forming separate and complete factors. Top Management Support split into two factors, and a fifth factor contained five of the six Package Characteristics items. All but one factor loading exceeded 0.7. Another factor analysis on all eight constructs produced nine factors with eigenvalues greater than 1.0, explaining 86.3% of the variance. PU, PEU, External Support and Organisational Characteristics formed separate factors, while three Top Management Support items combined with all five Internal Support items in another factor. System Usage and Package Characteristics items were fragmented into different factors, or did not load significantly on a single factor. This is not altogether surprising given the small sample size, the variation in the System Usage and Package Characteristics questions, and the relative similarity of some Internal Support and Top Management Support questions. It suggests further research and/or a larger sample is desirable.

Descriptive measures

The means, standard deviations and Spearman correlation coefficients for each of the constructs are as shown in Table 3. The mean System Usage score of 4.28 out of a maximum of 5.33 indicates the respondents make frequent use of the DSS in their daily work, as well as for decision-making. All other constructs are out of a maximum of 7.0, and the high average PU score of 5.77 reveals the perceived worth of the DSS in the context of the job function performed. Interestingly the lowest mean score (External Support) is from sources external to the organisations.

The nonparametric Spearman correlation coefficients are displayed here as they make no assumptions about the underlying distributions. Pearson coefficients were also calculated, and do not differ markedly in terms of level of significance, except for that between PU and System

Usage (see later). The most striking result is the significant negative correlation between PU and PEU. All other correlations of any size are positive, the strongest of these being between Internal Support and Top Management Support, and between Internal Support and Package Characteristics. Package Characteristics is also strongly linked to External Support and Top Management Support, these results all supporting the factor analyses. The only other construct significantly linked to either PU or PEU is Organisational Characteristics (to PU).

Table 3: Construct means, standard deviations and correlation coefficients

Spearman Correlation Coefficients

	Mean	**St.Dev.**	**SU**	**PU**	**PEU**	**IS**	**ES**	**TMS**	**OC**	**PC**
SU	4.28	0.815	1.000	0.226	0.203	0.134	0.276	0.093	0.198	0.266
PU	5.77	1.038	0.226	1.000	-0.396 *	0.011	0.112	-0.144	0.374 *	0.206
PEU	4.80	1.424	0.203	-0.396 *	1.000	0.187	0.026	0.336	-0.050	0.225
IS	4.62	1.650	0.134	0.011	0.187	1.000	0.444 *	0.720 ***	0.234	0.646 ***
ES	4.28	1.303	0.276	0.112	0.026	0.444 *	1.000	0.367	0.180	0.495 **
TMS	4.82	0.990	0.093	-0.144	0.336	0.720 ***	0.367	1.000	0.315	0.500 **
OC	4.65	1.634	0.198	0.374 *	-0.050	0.234	0.180	0.315	1.000	0.328
PC	4.64	1.074	0.266	0.206	0.225	0.646 ***	0.495 **	0.500 **	0.328	1.000

* denotes p<0.05; ** is p<0.01; *** is p<0.001

Table 4 Significant beta coefficients, p-values and adjusted R^2 from stepwise multiple regression

Regression		**PU**	**PEU**	**TMS**	**OC**	**Exper**	**Model**	**Adj R^2**
PU on FC	beta			-0.44	0.60			
	p-val			0.016	0.002		0.003	33.6
PEU on FC	beta							0.0
	p-val							
PU on PEU & FCs	beta			-0.44	0.60			
	p-val			0.016	0.002		0.003	33.6
SU on PU & PEU	beta	0.39						
	p-val	0.044					0.044	11.8
SU on all others	beta	0.39						
	p-val	0.044					0.044	11.8
SU on all & Exper.	beta	0.55	0.44			0.47		
	p-val	0.005	0.021			0.007	0.004	36.7
PU on all & Exper.	beta		-0.29	-0.36	0.53			
(p-in relaxed to 0.09)	p-val		*0.081*	0.039	0.004		0.002	39.5

Stepwise multiple regression

As the hypotheses sometimes tested for the joint effect of more than one construct on a dependent construct, a number of stepwise multiple regressions were run. The mean (construct) scores of the independent variables were regressed against the mean (construct) score of the dependent variable in each case. Table 4 shows all significant results (where the p-value was less than 0.05). Columns are not shown for constructs with no significant beta coefficients, and in the last case the p-in and p-out values were relaxed to p<0.09 for illustrative purposes. These outcomes will now be discussed for each hypothesis.

Testing of Hypotheses H1 to H5

Hypotheses H1 to H5 were tested using the results summarized in Table 3 (correlations) and Table 4 (stepwise multiple regression).

H1: Facilitating Conditions have a positive influence on PEU

As both stepwise multiple regression and individual correlations produced no significant results at a 0.05 level, the alternative hypothesis has to be rejected, and the null hypothesis accepted, i.e. Facilitating Conditions have no influence on PEU. The observation in this sample is contrary to the referenced literature. Venkatesh (2000) and Mathieson et al. (2001), in extending the TAM with the constructs of Facilitating Conditions and Perceived Resourcing respectively, both conclude these constructs have a positive influence on PEU. From Table 3, it is likely that with a larger sample (with increased power), Top Management Support would be positively linked to PEU.

H2: Facilitating Conditions have a positive influence on PU

Of the five bivariate correlations of the facilitating conditions with PU, only that of Organisational Characteristics is significant, at a 5% level. When multiple stepwise regression is used, both Organisational Characteristics and Top Management Support remain in the equation. Organisational Characteristics is positively related, at a 0.2% level of significance, and Top Management Support negatively related at a 1.6% level. This implies that the partial correlation of Top Management Support with PU becomes more negative once Organisational Characteristics is in the regression equation. In a sense it is compensating to some extent for the strong positive relationship of Organisational Characteristics with PU. The equation itself is significant at a 0.3% level, explaining 33.6% of the variance in PU.

H2 cannot be accepted exactly in its present form, and the conclusion needs to be moderated to say that facilitating conditions have a significant positive influence overall on PU, with the positive effect of Organisational Characteristics outweighing the negative effect of Top Management Support. This negative correlation however appears counter-intuitive, and needs further investigation.

Results are to some extent in agreement with the studies by Venkatesh (2000) and Mathieson et al. (2001) in which the constructs of facilitating conditions and perceived resourcing respectively have a positive influence on PU. This also ties in with the conclusion of Chiasson and Lovato (2001) that "organisational factors … play an independent role in the diffusion process".

H3: PEU has a positive influence on PU

Table 3 shows the correlation between the two to be significantly negative at a 5% level (as is also the case with Pearson correlation). When PU is regressed jointly on PEU and the five facilitating conditions, only Organisational Characteristics and Top Management Support are significant at a 5% level (as in H2). The p-to enter value for PEU is 0.081, just too high to enable it to also enter the equation. If the p-to-enter value is relaxed to 0.09, PEU also enters the equation with a negative beta coefficient, and those for Organisational Characteristics and Top Management Support are slightly scaled down. The adjusted R^2 figure increases to 39.5%. In both cases this implies a total rejection of H3, with the expected relationship being significantly reversed. This is discussed later.

H4: PEU has a positive influence on System Usage

The Spearman rank correlation in Table 3 shows there is a positive relationship between the two, which is not significant at the 5% level. Stepwise multiple regression of System Usage on

both PEU and PU shows PU to have a positive beta coefficient which is just significant, at a 4.4% level. The p-to-enter value for PEU is 0.133, so its partial correlation coefficient is not quite big enough to be significant. H4 therefore has to be rejected, and it is accepted that there is not a significant influence of PEU on System Usage. The result obtained contradicts most literature (Davis, 1989; Mathieson et al., 2001; Taylor and Todd 1995; Venkatesh, 2000). The increased statistical power of a larger sample might well however produce a significant positive relationship.

H5: PU has a positive influence on System Usage

The Spearman rank correlation coefficient between PU and System Usage is not significant at a 5% level. However, as mentioned above, multiple regression of System Usage on PU and PEU produces a positive beta coefficient of 0.39, significant at a 5% level. Closer inspection reveals that PU has a high coefficient of skewness of 2.25, and kurtosis of 7.25, caused almost entirely by a single point with a value of 1.83 (the second lowest value is 4.5). As 1.83 is more than 19 standard errors from the mean of 5.77, it could justifiably be regarded as an outlier, making the Spearman figure more credible. This respondent also makes by far the least use of the package, and a scatterplot indicates that if this data point was excluded, the regression line would be much more horizontal (and correlation insignificant). H5 should therefore be rejected, and the conclusion drawn that PU's influence on System Usage is not significant.

Discussion of Certain Results

Effect of PU on System Usage

The conclusion on the effect of PU on System Usage differs from that usually obtained. One item not measured in this study was the degree of voluntariness of DSS use, which may have moderated this result. After the initial analysis, the variable Experience (number of years using the package in question) was also included. When System Usage was regressed on all constructs plus Experience, Table 4 shows that PU, PEU and Experience all entered the equation with positive beta coefficients, explaining 36.7% of the variance. Further analysis is needed on residuals, and the effect of the outlier, but it could provisionally be concluded that PU does have a positive influence on System Usage, when moderated by the effects of PEU and Experience with the DSS package. Acceptance of this hypothesis would then support previous research (Davis, 1989; Mathieson et al., 2001; Taylor and Todd 1995; Venkatesh, 2000).

Effect of PEU on PU

In Davis' (1989) original TAM and subsequent extensions, PEU almost always has a positive influence on PU, and no definite explanation for the reversal in this case can be found. A study of the data could also not reveal any satisfactory cause for the anomaly in the sample. Hart and Porter (2004) found a positive relationship in a local study of OLAP acceptance, but it is possible that many of the DSS packages (or components of them such as data mining) are less structured and / or less intuitive than the OLAP product covered in that study. In an effort to provide an explanation, two respondents, from finance and retail respectively, were interviewed about their perceptions towards the constructs. In summary both indicated the following:

1. Inadequate training, if any, was provided in the use of the packages.
2. The packages proved quite complex to use to obtain the required information.
3. Their perception of Ease of Use was relative to "common packages" such as Microsoft Word and Microsoft Outlook.
4. They constantly needed to consult the manual or obtain assistance from others in achieving their desired goals with the packages.
5. The packages seemed particular in the manner in which they were utilized.
6. Though the packages proved somewhat difficult to use, the information obtained was invaluable in performing their job functions and assisting in their decision-making.

The explanation thus offered for the PEU-PU anomaly is that the lack of adequate training and complexity of package is outweighed by the usefulness of the information obtained from the package in the decision-making process.

Conclusions

The limitations of the small sample size in this exploratory study should first of all be acknowledged. This may have the effect of producing an inconclusive result in some cases, where a larger sample with more statistical power may well have shown a significant relationship. This also means that results should be generalized with caution. In addition, some of the items in the package support construct were too close to those of PEU, and the instrument could be revised slightly in future.

Despite this, there appear to be some interesting results due perhaps to the nature of DSS products. As packages often targeted at the professional user, they do not necessarily have to be perceived as easy to use in order to be useful in the organisation – in fact it appears as if the more useful ones are not regarded as being very user-friendly. This is perhaps to be expected if the comparison is against the typical office or email products. The results usually found for linkages with PEU have not materialized here, although once Experience is included as a moderating variable, both PU and PEU have a significant influence on DSS usage. The only facilitating conditions exerting any significant influence appear to be Organisational Characteristics and Top Management Support, which explain 33.6% of the variance in PU, but do not influence PEU. The inclusion of other factors such as voluntariness, and cognitive and social factors would improve the explanatory power of the model, and might show significant interaction with the facilitating conditions.

Further analysis is proceeding to examine the effect on results of removing the single outlier. It would also be useful to analyse further through interviews the relationship between PU and PEU, as well as that between Top Management Support and PU, and then follow this with a larger study, using a slightly modified and extended instrument. While some tentative implications for management are possible here, it would be preferable to express these once further work has been done.

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