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Research

Adoption and implementation of CASE tools in Taiwan

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Abstract

The aim of the research discussed here was to understand computer-aided software engineering (CASE) tool usage in Taiwan. Through a literature review, we developed two questionnaires – one for general respondents, the other for teachers and CASE agents. After pre-testing, 786 questionnaires were mailed out and 226 effective responses were obtained after two follow-up letters. Factor analyses were used to condense factors from 'severity of critical problems in system development', 'severity of perceived problems in CASE usage', 'attitude toward CASE' and 'CASE implementation success determinants'. Several external variables were considered in exploring their possible influence as well as the attitude and organizational features of the organizations that successfully used CASE. Path analyses were used to test an attitude model of CASE adoption and implementation success determinants. The results show that 'the perceived problems in CASE tools' had no statistically significant influence on 'attitude toward CASE' and very little influence on 'perceived CASE improvement for system development critical problems'. In addition, we found that 'methodology use' (including the usage before CASE adoption and consistency with the methodology supported by CASE) was the only statistically significant CASE implementation success determinant. Using only a 'methodology use' variable could provide a way to discriminate the successful adopter from relatively unsuccessful adopter with a 75% correct classification rate.

Keywords: Computer-aided software engineering (CASE); CASE adoption; CASE success; CASE implementation

1. Introduction

The dramatic growth in the use of information technology and its dynamic environment has created a heavy demand for information systems (IS) that become available more rapidly and at reduced cost. However, system development has been recognized as a task with a high level of complexity and has been more of an art rather than a science. Computer-aided software engineering (CASE) provides automation of the software engineering discipline. It may be applied in different phases of the system development life cycle, and has been classified into upper-, middle-, lower-plus cross-life-cycle CASE. It has also generated interest about ways to address IS development and maintenance problem. However, actual experiences with tools have exhibited more ambiguity. For example, Kemerer [12] reported that one year after introduction, 70% of the CASE tools have never been used, 25% have been used by only one group, and 5% widely used, but not to capacity. It is also suggested

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that certain environmental components of a CASE implementation plan will result in a more effective and successful outcome.

This paper reports on a survey of businesses, government organizations, teachers, and CASE agents to understand their attitudes toward CASE and its implementation in Taiwan.

2. Literature review

In our review of literature, research papers (e.g., [4, 21, 22]) were included to determine how organizations currently perform system analysis and design. Some (e.g., [15]) identified key factors to develop IS. Sumner and Ryan [27] not only identified the critical success factors in each stage of IS development, but also reported users' perceived impact of CASE on these factors. They showed that the CASE users did not view CASE as having a positive impact on achieving these factors.

On one hand, some research (e.g., [1, 2, 13, 16, 17, 29, 30]) concluded from empirical (experiments, surveys, or cases) or work experience that CASE tools have the benefits of improving IS development productivity, quality, software reuse, documentation, maintenance, etc. However, on the other hand, some research (e.g., [3, 9, 20]) gave warning that CASE might have negative impacts, de-skilling or limiting the creativity of IS developers, or threatening job security and so inducing resistance.

In a survey of the UK, Stobart, Thompson and Smith [26] identified some problems with current CASE tools, e.g., poor interface or supplier support. Conger [5] suggested three requirements of an ideal CASE environment: integration; artificial intelligence; and multi-user support facilities. One possible reason for not widely using CASE tools may be that they are relatively expensive [11].

A number of research papers (e.g, [6, 18, 23, 24, 25]) also suggested that the key factors for adopting CASE successfully include: methodology use, pilot project use, training, consultant guide, demonstration, power-coercive strategy, top management support, software metrics use, etc. In their study, Urwiler et al. [28], predetermined two success criteria – quality and productivity, and then found that 'methodology use' and 'software metrics' were significant to quality;

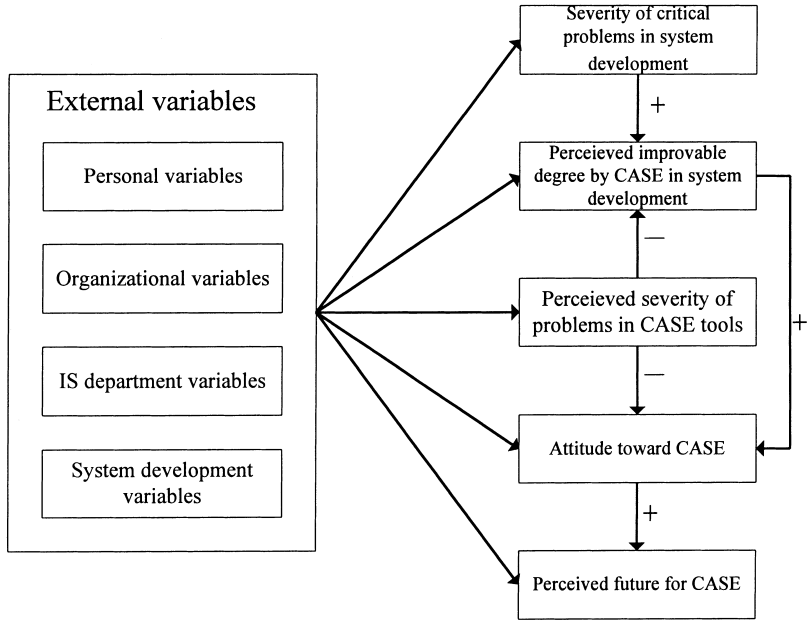


Fig. 1. Research model of CASE attitude.

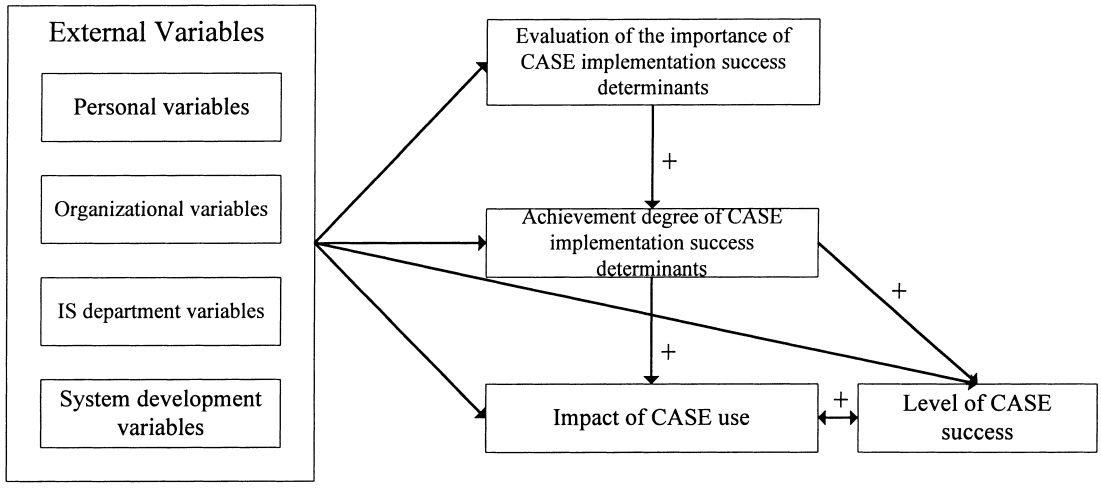


Fig. 2. Research model of CASE success.

'software metrics', 'consultant use', and 'training' were significant to productivity.

3. Methodology

The conceptual models of our research are shown in Figs. 1 and 2 (the first is similar to Davis' technology acceptance model [7], but different in the attitude variable). Their signs show the hypothesized positive or negative association among the internal variables. A number of external variables are grouped as follows:

personal including

- position
- time involved in the IS jobs
- specialty level of traditional system analysis and design, not applying CASE,
- specialty level of CASE tools, and
- career planning preference;

organizational including

- organization type,
- industry type,
- organization size, and
- IS growth stage;

IS department including

- history time,
- number of IS employees,
- number of IS employees responsible for system maintenance,
- number of IS employees skilled at CASE,
- computer hardware used,
- percentage of IS budget spent on sales, and
- percentage of software development expenses spent on the IS budget;

system development variables including

- outsourcing IS or not,
- IS project size,
- type of methodology used,
- CASE tools use or not,
- number of CASE tools used,
- CASE usage time, and
- kinds of CASE used.

For simplification, we might assume that external variables do not significantly influence the internal variables. However, this assumption needs to be tested.

In this study both questionnaire and follow-up interview data collection methods were used. Through literature review, we developed a questionnaire including two versions – one (7 pages) for 'general respondents', the other (4 pages) for 'teachers and CASE agents'. They were first evaluated by four IS experts, and then pretested with fifteen MIS personnel

Table 1

Profile of all respondents	General respondents		Teachers & CASE-industry respondents		All respondents	
Respondent position or occupation	*Number*	*Ratio*	*Number*	*Ratio*	*Number*	*Ratio*
CEO (Chief Executive Officer)	8	4.6%			8	3.5%
CIO (Chief Information Officer)	51	29.1%			51	22.6%
Middle manager in MIS department	57	32.6%			57	25.2%
MIS department personnel (SA, programmer, etc.)	43	24.6%			43	19.0%
Other department	16	9.1%			16	7.1%
Sub-total	175	100%			175	77.4%
Teacher in MIS department of universities			40	78.4%	40	17.7%
Teacher in computer science department of universities			1	2.0%	1	0.4%
Teacher in other departments of universities			8	15.7%	8	3.5%
CASE vendor			2	3.9%	2	0.9%
Sub-total			51	100%	51	22.6%
Total					226	100%
Use of CASE tools [a]						
Currently use	33	24.8%	13	31.7%	46	26.4%
Used before, but abandoned	25	18.8%	10	24.4%	35	20.1%
Currently evaluating CASE	17	12.8%	6	14.6%	23	13.2%
Evaluated before, but dismissed	21	15.8%	9	22.0%	30	17.2%
Never considered to adopt	37	27.8%	3	7.3%	40	23%
Sub-total	133	100%	41	100%	174	100%
Wrong answer	30		8		52	
Not disclosed	12		2		52	
Total	175		51		226	

Number of CASE tools used:
72 valid 'all respondents': average 2.21; 43.1% had used 1, 30.6% had used 2; among them:
(1) 50 valid 'general respondents': average 2.18; 44% had used 1, 28% had used 2.
(2) 22 valid 'teachers & CASE industry respondents': average 2.28; 40.9% had used 1, 36.4% had used 2.

CASE tool usage time:
68 valid 'all respondents': average 3.9 years; 20.6% had used $\leq$1 year, 80.8% $\leq$5 years, among them:
(1) 49 valid 'general respondents': average 4.04 years; 20.4% had used $\leq$1 year, 81.6% $\leq$5 years,
(2) 19 valid 'teachers & CASE industry respondents': average 3.55 years; 21.1% had used $\leq$1 year, 79% $\leq$5 years.

Kinds of CASE tools used:
72 valid 'all respondents', among them:
37 had used upper CASE; 15 used lower CASE; 21 used integrated CASE; 10 used cross life cycle CASE

Specialty level of SA (system analysis) & SD (system design) (rating from 1 to 7):
225 valid 'all respondents': average 5.25; 74.6%'s rating >3; among them:
(1) 174 valid 'general respondents': average 5.21; 73.6% >3;
(2) 51 valid 'teachers & CASE industry respondents': average 5.39; 78.4% >3
t test between (1) and (2): t=0.973, significant level=0.333

Specialty level of CASE tools (rating from 1 to 7):
226 valid 'all respondents': average 3.35; 48.3%'s rating <3; among them:
(1) 175 valid 'general respondents': average 3.09; 57.7% <3;
(2) 51 valid 'teachers & CASE industry respondents': average 4.26; 15.7% <3; 45.1%=3
t test between (1) and (2): t=9.480, significant level <0.001

[a] After cross-checking their usage numbers and usage time of CASE, we detected some respondents as 'wrong answer'. Those were who answered neither 'currently use' nor 'used before', but reported their usage numbers or usage time.

(including MIS graduate students, professionals, and teachers). The internal reliability (Cronbach α) was calculated for the four major sections.[1] According to Guielford, our Cronbach αs were high because all of them were greater than 0.70.

Both versions of the questionnaire were broken into two major parts.

The first contained six sections including questions complied from the literature:

1. 25 questions about attitude toward CASE impacts (pre-tested Cronbach α=0.776);
2. 15 questions about evaluated importance of CASE key implementation success determinants (Cronbach α=0.737) and their corresponding achievement degrees (this half was answered only by general respondents who had already used CASE);
3. 17 questions about evaluated severity of critical problems in system development (Cronbach α=0.734) and the corresponding improvable degrees by CASE;
4. 13 questions about evaluated severity of perceived problems in CASE tools (Cronbach α=0.766);
5. one closed question and one open question about perceived future for CASE;
6. 11 listed reasons for not adopting CASE (some open spaces also provided).

In Sections 1,2,3 and 4 (also the closed question of Section 5), respondents were asked to rate each question on a 5-point Likert scale. But in Section 6, they were asked to rank the reasons in order of importance.

The second part contained demographic questions inquiring of the respondent about his (her) related personal, organizational, IS department, and system development variables (this part was very short for teachers and CASE agents, but longer for general respondents).

Owing to space limitation, the original questionnaire (in Chinese) has not been given here, but it will be provided on request. Readers can also see those questions in the following analyses.

[1]Cronbach α is an index to measure the reliability (coefficient of internal consistency) of an instrument. Guielford [10] suggests that reliabilities beyond 0.70 is high, between 0.70 and 0.35 is acceptable, below 0.35 is low. Nunnally [19] argues that the accepted level of reliability depends on the purpose of the research. For early stages of research, it is suggested that reliabilities of 0.5 to 0.6 suffice, and that increasing reliabilities beyond 0.80 is probably wasteful.

Table 2

Other profile of general respondents	*Number*	*Ratio*
Career planning preference		
Technical oriented	48	28.2%
Business or management oriented	122	71.8%
Sub-total	170	100%
Not disclosed	5	
Total	175	
Organization type		
Government agency	44	25.1%
Government-owned business or utility	17	9.7%
Private business	98	56.0%
Non-profit organization	12	6.9%
Other	4	2.3%
Total	175	100%
Industry type		
Manufacturing	52	29.9%
Finance: banking, insurance	23	13.2%
IS software business	27	15.5%
Other service industry	32	18.4%
Other business	40	23%
Sub-total	174	100%
Not disclosed	1	
Total	175	
Organization size		
Top 100 business	87	64.9%
Small/medium business	24	17.9%
Other	23	17.2%
Sub-total	134	100%
Not disclosed	41	
Total	175	
IS growth stage		
Initial stage	8	4.6%
Expansion stage	22	12.6%
Control stage	87	49.7%
Maturity stage	58	33.1%
Total	175	100%
History of MIS department		
Within 1 year	4	2.3%
1 to 2 years	4	2.3%
2 to 5 years	27	15.7%
5 to 10 years	37	21.5%
10 to 20 years	79	45.9%
More than 20 years	21	12.2%
Sub-total	172	100%
Wrong answer	1	
Not disclosed	2	
Total	175	
Computer hardware used		
Mostly mainframe(s)	39	30%
Mostly min-computer(s)	45	34.6%
Mostly workstations	13	10%
Mostly PCs	33	25.4%

Table 2 (*Continued*)

Other profile of general respondents	*Number*	*Ratio*
Sub-total	130	100%
Wrong answer	44	
Not disclosed	1	
Total	175	
Percentage of IS budget on sales		
≤1%	57	45.6%
1% ≤5%	51	40.8%
5% ≤10%	5	4.0%
10%<	12	9.6%
Sub-total	125	100%
Not disclosed	50	
Total	175	

Table 3

Other profile of general respondents (continue-end)	*Number*	*Ratio*
Percentage of software development expenses on IS budget		
≤1%	54	34.6%
1% ≤5%	50	32.1%
5% ≤10%	21	13.5%
10%<	31	19.9%
Sub-total	156	100%
Not disclosed	19	
Total	175	
Source of IS		
All developed in-house	67	39.4%
Mostly developed in-house	61	35.9%
Mostly out-sourcing	31	18.2%
All out-sourcing	11	6.5%
Sub-total	170	100%
Not disclosed	5	
Total	175	
IS project size within recent 10 years		
1–20 man-months	64	40.3%
21–60 man-months	38	23.9%
61–140 man-months	14	8.8%
More than 140 man-months	11	6.9%
Have all kinds (all of the proportions of the above sizes are close)	32	20.1%
Sub-total	159	100%
Not disclosed	16	
Total	175	
Type of system development methodology used		
(1) None	16	10.8%
(2) Only system flow chart	14	9.5%
(3) Only data flow diagram	10	6.8%
(4) Process-oriented structured SA & SD only	51	34.5%
(5) Data-oriented method only	9	6.1%
(6) Object-oriented method only	7	4.7%
(7) Others	2	1.4%
(6) Both (4) and (5)	19	12.8%
(7) Both (4) and (6)	7	4.7%
(8) Both (5) and (6)	2	1.4%
(9) Follow both (4), (5) and (6)	11	7.4%
Sub-total	148	100%
Wrong answer	23	
Not disclosed	4	
Total	175	
Perceived CASE tools success		
Very unsuccessful	4	8%
Unsuccessful	15	30%
So-so (no opinion)	14	28%
Successful	14	28%
Very successful	3	6%
Sub-total	50	100%
Wrong answer or not disclosed	125	
Total	175	

Note 1: Time of respondents involved in IS jobs: average=12.1, median=11, maximum=35.
Note 2: Total number of employees in organization: average=1748, median=600, maximum=25 000.
Note 3: Number of employees in IS department: average=44.2, median=17, maximum=900.
Note 4: Number of IS employees who were responsible for system development & maintenance: average=24, median=10, maximum=800.
Note 5: Number of IS employees who were skilled at CASE: average=10.2, median=2, maximum=700. Note 6: The degree (1 to 7) of commercial CASE influencing their IS outsourcing decisions: 62.5% have never been influenced (choosing degree 1 to 3); 25.6% have been somewhat influenced (choosing degree 5 to 7).

To maximize information quality and response rate, Dillman's 'total design method' [8] was employed in designing both the content and the administrative procedures for the questionnaire. On December 4, 1996, 786 questionnaires were mailed to: Top 100 business, and government agency officials, people in the financing industry, members of the Information Manager Association and of the Society of Information Management, and teachers of system analysis/design or software engineering in MIS departments of universities,[2] plus CASE agencies and their user

[2]The teacher listing was collected from categories of universities.

groups. Two follow-up letters were mailed on December 27 and the following January 14. If respondents provided their phone numbers, telephone interviews were later performed to clarify any unclear answers.

4. Analysis and findings

Two hundred and twenty six valid questionnaires were eventually obtained from the original mailing, providing a net response rate of 29%.

4.1. Sample characteristics

We asked teachers and CASE agents less demographic data. Table 1 provides the profile of all respondents, Tables 2 and 3 provide a profile of the general respondents. One question is not listed in the tables. General respondents were asked to pick one of four descriptions that best characterized the overall stage of development of IS in their organizations. The result is reported in Table 2. However, in another question, respondents gave their degree (1 to 7) of assessment of the degree of implementation of IS in their organizations; this was used to provide a measure of reliability for the 'perceived IS growth stage'. Analysis of variance (*ANOVA*) showed that there were significant differences among the scores of the four stages ($F=17.082$, $p<0.001$). The Pearson coefficient of correlation between the two questions was 0.454 at the significant level less than 0.001. Therefore, there was high reliability in measuring respondents' perceived IS growth stages.

4.2. IS development and CASE usage

Tables 4–10 give the results of perceived severity of critical problems in system development, perceived improvable degree by CASE to system development critical problems, perceived severity of problems in CASE tools, attitude toward CASE impacts, evaluated

Table 4
Severity of critical problems in system development

Critical problems in system development	All respondents	General respondents	Teachers & CASE-agent respondents
Poor system analysis quality	(1) 4.06	(1) 4	(1) 4.24
Poor user-analyst communication	(2) 3.96	(3) 3.88	(1) 4.24
Heavy system maintenance workloads	(3) 3.95	(2) 3.96	(7) 3.92
Poor system design quality	(4) 3.88	(4) 3.85	(5) 3.98
Low system developer productivity	(5) 3.80	(5) 3.78	(9) 3.88
Poor software quality	(6) 3.76	(8) 3.72	(3) 4.06
Poor project management	(7) 3.79	(7) 3.75	(7) 3.92
Poor document quality	(8) 3.76	(6) 3.75	(10) 3.78
Insufficient top management support and commitment	(8) 3.76	(9) 3.68	(4) 4.04
Lack of methodology to integrate various techniques and tools	(10) 3.69	(10) 3.61	(6) 3.94
Lack of techniques to shorten system development life cycle	(11) 3.63	(12) 3.59	(11) 3.76
Programming design and testing time span too long	(12) 3.61	(11) 3.59	(13) 3.68
System analysis and design time span too long	(13) 3.58	(13) 3.59	(15) 3.56
Insufficient end-user training	(14) 3.58	(14) 3.54	(12) 3.7
Poor programmer-analyst communication	(15) 3.53	(15) 3.52	(16) 3.53
Insufficient cost-effectiveness analysis	(16) 3.51	(16) 3.47	(14) 3.66
Many current software and hardware limitations	(17) 3.22	(17) 3.29	(17) 3
Total rating (range between 17 and 85)	62.94	62.42	64.69

Note 1: The Cronbach α of all respondents is 0.888.
Note 2: Each cell has a pair of numbers – i.e., (ranking #) rating #, the numbers of the parentheses in the table were the severity rankings according to their rating scores in each group (The highest score has the rank# 1).
Note 3: The t test between the total rating differences between 'general respondents' and 'teachers & CASE-agent respondents': and $t=-1.618$, significant level $\alpha=0.109$.
Note 4: The Spearman ranking correlation of rankings between 'general respondents' and 'teachers & CASE-agent respondents': $r_s=0.816$, significant level $\alpha<0.001$.

Table 5
Perceived improvable degree by CASE for system development critical problems

Critical problems in system development	All respondents	General respondents	Teachers & CASE-agent respondents
Poor document quality	(1) 3.93 (8)	(1) 3.89 (6)	(1) 4.06 (10)
Poor system design quality	(2) 3.61 (4)	(2) 3.56 (4)	(3) 3.77 (5)
Low system developer productivity	(3) 3.58 (5)	(5) 3.52 (5)	(2) 3.78 (9)
Heavy system maintenance workloads	(4) 3.54 (3)	(3) 3.52 (2)	(5) 3.59 (7)
System analysis and design time span too long	(5) 3.53 (13)	(7) 3.45 (13)	(4) 3.76 (15)
Programming design and testing time span too long	(6) 3.52 (12)	(4) 3.52 (11)	(7) 3.53 (13)
Poor software quality	(7) 3.5 (6)	(6) 3.49 (8)	(6) 3.54 (3)
Lack of techniques to shorten system development life cycle	(8) 3.44 (11)	(8) 3.45 (12)	(10) 3.44 (11)
Poor project management	(9) 3.42 (7)	(12) 3.38 (7)	(7) 3.53 (7)
Poor system analysis quality	(10) 3.41 (1)	(11) 3.38 (1)	(9) 3.51 (1)
Lack of methodology to integrate various techniques and tools	(11) 3.40 (10)	(9) 3.39 (10)	(11) 3.43 (6)
Poor programmer-analyst communication	(12) 3.40 (15)	(9) 3.39 (15)	(12) 3.42 (16)
Poor user-analyst communication	(13) 3.27 (2)	(13) 3.28 (3)	(13) 3.25 (1)
Insufficient cost-effectiveness analysis	(14) 3.08 (16)	(15) 3.14 (16)	(14) 2.90 (14)
Insufficient end-user training	(15) 3.05 (14)	(14) 3.14 (14)	(15) 2.78 (12)
Insufficient top management support and commitment	(16) 2.97 (8)	(16) 3.06 (9)	(17) 2.65 (4)
Many current software and hardware limitations	(17) 2.88 (17)	(17) 2.93 (17)	(16) 2.75 (17)
Total rating (range between 15 and 85)	57.57	57.45	57.96

Note 1: Each cell has a triple of numbers – i.e., (ranking#) rating# (ranking#), the numbers of the first parentheses were the improvement rankings according to their improvement rating scores in each group (the highest score has the rank# 1); the numbers of the second parentheses were the severity rankings according to their severity rating scores in each group (also appeared in Table 4).
Note 2: The t test between the total improvement rating differences between 'general respondents' and 'teachers & CASE-agent respondents': $t=-0.305$, significant level $\alpha=0.761$.
Note 3: The Spearman ranking correlation of improvement rankings between 'general respondents' and 'teachers & CASE-agent respondents': $r_s=0.907$, significant level $\alpha<0.001$.
Note 4: The Spearman ranking correlation of between 'improvement rankings' and 'severity rankings' in the 'general respondents' group: $r_s=0.46$, significant level $\alpha=0.063$.
Note 5: The Spearman ranking correlation of between 'improvement rankings' and 'severity rankings' in the 'teachers & CASE-agent respondents' group: $r_s=0.128$, significant level $\alpha=0.624$.
Note 6: The Spearman ranking correlation of between 'improvement rankings' and 'severity rankings' in the 'all respondents': $r_s=0.445$, significant level $\alpha=0.073$.

importance and achievement degree of implementation success determinants, reasons of not adopting CASE, and perceived future for CASE. Except for Table 9, the total rating between 'general respondents' and 'teachers and CASE-agent respondents' were not significantly different (by t tests); and their question rankings were significantly related (by Spearman ranking correlations). For general respondents, the rankings between 'perceived severity of critical problems in system development' and their 'perceived improvable degree by CASE' were marginally (at $\alpha=0.063$) significantly related. Generally speaking, all respondents considered that there were critical problems in system development and had a favorable attitude toward CASE impacts, though they also perceived some problems in CASE tools. In addition, all of them had great beliefs in CASE future improvement and user acceptance (only 2.3% perceived CASE 'no future' and 16.6% perceived 'little improvement on current tools'; these ratios were much smaller than the results of [26]). However, about the reasons of not adopting CASE, teachers and CASE-agents perceived 'organization structures and culture', 'top management support' more important, but underestimated the knowledge of general respondents about CASE and methodology. For general respondents not adopting CASE, the more important reasons were price, Chinese compatibility, and CASE quality.

Table 6
Perceived severity of problems in CASE tools

Perceived problems in CASE tools	All respondents	General respondents	Teachers & CASE-agent respondents
High price	(1) 4.14	(1) 4.10	(1) 4.26
Poor supplier support	(2) 3.81	(2) 3.81	(4) 3.84
Lack of intelligent capabilities	(3) 3.75	(3) 3.70	(2) 3.92
Poor tool integration	(4) 3.66	(4) 3.62	(5) 3.78
Poor code generation	(5) 3.58	(5) 3.53	(6) 3.74
Poor Chinese compatibility	(6) 3.57	(6) 3.53	(7) 3.72
Poor user or reference manual	(7) 3.49	(7) 3.48	(8) 3.52
Longer learning time comparing to traditional method	(8) 3.46	(8) 3.44	(9) 3.5
Poor tool efficiency	(9) 3.37	(9) 3.4	(10) 3.28
Poor multi-user facilities	(10) 3.46	(10) 3.34	(3) 3.88
Poor user interface	(11) 3.26	(11) 3.26	(11) 3.26
Poor methodology	(12) 3.16	(13) 3.14	(12) 3.2
Poor generated documents	(13) 3.14	(12) 3.19	(13) 2.98
Total rating (range between 13 and 65)	45.93	45.63	45.88

Note 1: The Cronbach α of all respondents is 0.811.
Note 2: Each cell has a pair of numbers – i.e., (ranking#) rating#, the numbers of the parentheses in the table were the severity rankings according to their rating scores in each group (The highest score has the rank# 1).
Note 3: The t test between total rating differences between and 'teachers & respondents': $t=-1.271$, significant level $\alpha=0.207$.
Note 4: The Spearman ranking correlation of rankings between 'general respondents' and 'teachers & CASE-agent respondents': $r_s=0.830$, significant level $\alpha<0.001$.

4.3. Factor analyses

We conducted four factor analyses to determine which variables were major factors predicting critical problems in system development, severe problems of CASE tools, attitude toward CASE impacts, and key implementation success determinants.

The lower bound of factors was determined by counting the eigen-values greater than 1. In order to find the upper bound, the maximum likelihood method was used to test the hypothesis: n factors are sufficient (vs. the alternative hypothesis: more factors are needed). Within the upper and lower bounds, considering the criteria of variances explained by each factor greater than 'average variable' (1/number of questions) and scree test criterion; we used the Principal Component method for extracting factors, and tried both the Orthogonal Varimax and Oblique Oblimin (in SPSS package) as the rotation methods. The final factor structures are shown in Tables 11–14.

Critical problems in system development

There were six factors in Table 11 explaining 71.6% of the total variance. However, the

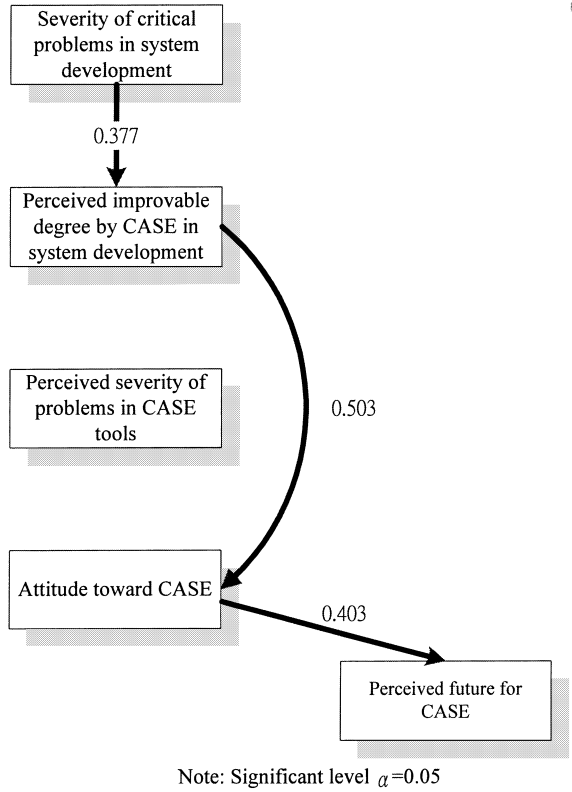


Fig. 3. Model of attitude toward CASE (all respondents $N=174$).

Table 7
Attitude toward CASE impacts

Attitude toward CASE impact	All respondents	General respondents	Teachers and CASE-agent respondents
The developed system documents would closely follow project documentation standards and formats	(1) 4.10	(1) 4.08	(4) 4.14
The outputs of all system development stages would be more consistent each other, and be also consistent with final documentation	(2) 4.07	(2) 4.04	(2) 4.18
Easier to develop prototypes	(3) 4.06	(3) 4.04	(3) 4.16
Easier to draw graphs for documentation	(4) 4.02	(4) 3.95	(1) 4.26
Increase system development productivity – reduce time, personnel, and cost	(5) 3.95	(5) 3.92	(6) 4.04
The developed system documents is easier to understand and help communication	(6) 3.86	(6) 3.80	(5) 4.08
The developed system is easier to maintain	(7) 3.79	(7) 3.77	(9) 3.84
Would not threaten job security of IS developers	(8) 3.79	(9) 3.71	(7) 4.02
Give IS developers valuable skills of using CASE	(9) 3.73	(11)3.69	(8) 3.86
Improve system development methodology	(10) 3.72	(10) 3.71	(10) 3.74
The developed system would increase software reuse	(11) 3.71	(8) 3.73	(13) 3.64
More likely to perform design alternatives before programming	(12) 3.69	(12) 3.69	(12) 3.68
The developed system is more reliable	(13) 3.56	(13) 3.56	(15) 3.57
Would not induce resistance of IS developers	(14) 3.56	(14) 3.51	(11) 3.71
Automate the tedious work in system development	(15) 3.53	(15) 3.49	(14) 3.64
Process of system development is more enjoyable to IS developers	(16) 3.37	(17) 3.34	(18) 3.48
Make top managers more satisfactory and improve awareness of the efforts of developing new systems	(17)3.43	(20) 3.29	(16) 3.53
The developed system would more meet user requirements	(18) 3.34	(16) 3.35	(20) 3.28
The developed system would make IS developers more satisfactory	(19) 3.28	(19) 3.31	(21) 3.2
Make organizational outside customers more satisfactory	(20) 3.27	(21) 3.26	(19) 3.33
Obviate the need of rigorous project management	(21) 3.27	(18) 3.31	(23) 3.1
Make IS user departments (e.g., finance, marketing) more satisfactory	(22) 3.19	(22) 3.19	(22) 3.18
Would not limit the creativity of IS developers to find solutions	(23) 3.14	(23) 3.04	(17) 3.49
Reduce the dependence on system designers	(24) 2.96	(24) 3.02	(24) 2.74
Reduce the dependence on system analysts	(25) 2.84	(25) 2.91	(25) 2.62
Total rating (range between 25 and 125)	89.06	88.71	90.28

Note 1: The Cronbach α of all respondents is 0.866
Note 2: Each cell has a pair of numbers – i.e., (ranking #) rating#, the numbers of the parentheses in the table were the rankings according to their rating scores in each group (The highest score has the rank# 1).
Note 3: The t test between the total rating differences between 'general respondents' and 'teachers & CASE-agent respondents': $t=-0.938$, significant level $\alpha=0.35$.
Note 4: The Spearman ranking correlation of impact rankings between 'general respondents' and 'teachers & CASE-agent respondents': $r_s=0.929$, significant level $\alpha<0.001$.

Table 8
Evaluated importance and achievement degree of implementation success determinants

CASE Implementation success determinants	Importance scores of all respondents	Importance scores of general respondents (N=174)	Importance scores of teachers and CASE-agent respondents	Achievement scores of general respondents who have used CASE (N=43)
Provide formal training on system development techniques required to use CASE	(1) 4.35	(1) 4.34	(2) 4.4	(2) 3.55 (1)
Introduce CASE technology via at least one pilot project	(2) 4.34	(2)4.33	(1) 4.42	(3) 3.54 (6)
Facilitate knowledge sharing and open communication among project team members	(3) 4.26	(3)4.23	(4) 4.38	(1)3.62 (3)
Enforce a system development methodology before using CASE	(4) 4.17	(5) 4.16	(6) 4.22	(5) 3.41 (5)
Secure top management support and commitment on budgets and necessary organizational changes	(5) 4.15	(7) 4.08	(2) 4.4	(5) 3.41 (7)
Retain experienced consultants to guide project using CASE	(6) 4.13	(6) 4.11	(7) 4.20	(7) 3.26 (3)
Enhance system analysis and design abilities of system developers	(7) 4.13	(4) 4.17	(11) 4.02	(4) 3.5(2)
Periodically evaluate the CASE impacts on system development productivity and quality	(8) 4.06	(8) 4	(5) 4.26	(12) 2.95 (9)
Help career path planning of IS developers	(9) 3.94	(9) 3.89	(10) 4.1	(11) 3.02 (7)
Demonstrate and promote the benefits of using CASE	(10) 3.9	(11)3.82	(8) 4.16	(9) 3.10 (13)
Periodically evaluate the CASE impacts on organizational culture and structure, and make adjustments if necessary	(11) 3.87	(10)3.84	(12) 3.98	(13) 2.79 (12)
Use the same system development methodology before and after implementing CASE	(12) 3.83	(13) 3.75	(9) 4.12	(8) 3.12 (11)
Use standard software metrics to measure the effectiveness of system development	(13) 3.76	(12) 3.77	(13) 3.72	(14) 2.45 (10)
Guarantee job security of IS developers to lower the potential resistance	(14) 3.36	(14) 3.27	(14) 3.66	(10) 3.05 (14)
Apply power-coercive strategy to enforce CASE	(15) 2.92	(15) 2.94	(15) 2.86	(15) 2.28 (15)
Total rating (range between 15 and 75)	59.23	58.71	60.9	47.54

Note 1: The Cronbach α of importance scores of all respondents is 0.846.
Note 2: Each cell of the 2nd–4th columns has a pair of numbers – i.e., (ranking#) rating#, the numbers of the parentheses in the table were the importance rankings according to their importance rating scores in each group (the highest score has the rank# 1).
Note 3: Each cell of the 5th column has a triple of numbers – i.e., (ranking#) rating# (ranking#), the numbers of the first parentheses were the achievement rankings according to the actual achievement rating scores of those 'general respondents' who had used CASE; the numbers of the second parentheses were their corresponding importance rankings (N=43).
Note 4: The t test between the total importance rating differences between 'general respondents' and 'teachers & CASE-agent respondents': t=−1.9705, significant level α=0.052.
Note 5: The Spearman ranking correlation of importance rankings between 'general respondents' and 'teachers & CASE-agent respondents': r_s=0.794, significant level α<0.001.
Note 6: The Spearman ranking correlation of importance rankings between 'general respondents' and 'general respondents who have used CASE': r_s=0.844, significant level α<0.001.
Note 7: The Spearman ranking correlation between 'evaluated importance rankings' and 'actual achievement rankings' in the group of 'general respondents who have used CASE' (N=43): r_s=0.792, significant level α<0.001.

Table 9
Reasons of not adopting CASE tools

Reasons of not adopting CASE	All respondents	General respondents	Teachers & CASE-agent respondents
High tool price	1 (4.75)	1 (4.4)	3 (5.26)
Do not understand the methodology supported by CASE	2 (5.0)	5 (5.63)	1 (4.09)
Organizational culture or structure does not fit with CASE tool	3 (5.46)	6 (5.76	2 (5.02)
Poor CASE quality	4 (5.56)	3 (5.4)	6 (5.8)
Poor Chinese compatibility	5 (5.63)	2 (5.21)	8 (6.22)
Not aware of CASE	6 (5.95)	7 (6.11)	5 (5.71)
Cannot help system development productivity	7 (5.98)	4 (5.41)	9 (6.78)
Satisfied with current system development methodology	8 (6.19)	8 (6.24)	7 (6.02)
Top management do not support	9 (6.53)	10 (7.10)	4 (5.70)
Poor quality of generated systems	10 (6.92)	9 (6.91)	11 (6.92)
Persistent resistance from IS developers	11 (7.10)	11 (7.32)	10 (6.79)

Note 1: Each cell has a pair of numbers – i.e., ranking #(scores #), the numbers of the parentheses in the table were the scores corresponding to their average rankings; the top #1 reason giving score 1, #2 score 2, etc. If a respondent only gave several top reasons (e.g., giving top 3 reasons), other reasons would be treated the average score of his (her) unanswered reasons (e.g., 4 and 11 giving the average of 7.5).
Note 2: The Spearman ranking correlation of rankings between 'general respondents' and 'teachers & CASE-agent respondents': r_s=0.418, significant level α=0.201.
Note 3: In the free space provided in the questionnaire, only two respondents gave two reasons which were not related to the above, but related to the external environments of an organization: 'IT changed too fast' and 'CASE marketing prevalence rate was low'. An anonymous reviewer mentioned a reason 'worrying that the developed system would be dependent on the CASE tool and trained users' could be classifed into 'orgainzational culture or structure does not fit the CASE tool' as above.
Note 4: The Spearman ranking correlation of rankings between 'IS developed in-house' and 'purchasing packages or outsourcing IS' respondents: r_s=0.864, significant level α=0.001. So, the opinions of both groups of respondents are similar.

Table 10
Perceived future for CASE tools

Future for CASE tools	All respondents		General respondents		Teachers & CASE-agent respondents	
	Number	*Ratio*	*Number*	*Ratio*	*Number*	*Ratio*
(1) No future	2	1.2%	3	6%	5	2.3%
(2) Little improvement on current tools	27	16.2%	9	18%	36	16.6%
(3) Improve substantially and the market acceptance of tools increases	88	52.7%	19	38%	107	49.3%
(4) Become accepted by many system developers as preferred methods of system development	31	18.6%	14	28%	45	20.7%
(5) Totally alters the way that all software is developed and maintained	19	11.4%	5	10%	24	11.1%
Sub-total	167	100%	50	100%	217	100%
Average	3.23		3.18		3.22	
Not answered	8		51		9	
Total	175		51		226	

Note: If giving the five categories the rating of 1 to 5, the *t* test of future scores between 'general respondents' and 'teachers & CASE-agent respondents' would be: t=0.292, significant level α=0.772.

Cronbach α of the sixth factor[3] was found to be too low. Therefore, we could only obtain five factors plus two variables: *poor system quality and top management support* (factor 1), *long development time and heavy maintenance* (factor 2), *lack of techniques and methodologies* (factor 3), *poor communication* (factor 4), *poor management* (factor 5),

[3]This sixth factor already existed even if we tried 5-factor structure.

Table 11
Factor matrix (varimax-rotated) of critical problems in system development

Critical problems in system development (their rankings in the parenthesis)	Communalities	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
Poor system analysis quality (1)	0.770	0.798					
Poor system design quality (4)	0.793	0.834					
Poor software quality (6)	0.720	0.793					
Insufficient top management support and commitment (8)	0.506	0.526					
System analysis and design time span too long (13)	0.724		0.8				
Programming design and testing time span too long (12)	0.746		0.824				
Heavy system maintenance workloads (3)	0.714		0.634				
Lack of techniques to shorten system development life cycle (11)	0.747			0.794			
Lack of methodology to integrate various techniques and tools (10)	0.709			0.808			
Poor user-analyst communication (2)	0.798				0.776		
Poor programmer-analyst communication (15)	0.716				0.603		
Insufficient end-user training (14)	0.694				0.622		
Low system developer productivity (5)	0.604					0.643	
Poor project management (7)	0.718					0.581	
Insufficient cost-effectiveness analysis (16)	0.698					0.691	
Poor document quality (8)	0.815						−0.493
Many current software and hardware limitations (17)	0.703						0.752
Eigen-value		6.188	1.860	1.410	1.002	0.899	0.816
Variance explained by each factor		36.4	10.9	8.3	5.9	5.3	4.8
Cronbach α of each factor		0.823	0.733	0.748	0.768	0.684	0.145
Average rating of the severity in each factor		3.87	3.72	3.66	3.69	3.7	3.49

poor documents, and *current software and hardware limits*.

Severe problems of CASE tools

Five factors in Table 12 explaining 66.1% of the total variances: *poor CASE quality and support* (factor 1), *poor interface* (factor 2), *poor technical characteristics* (factor 3), *cost problems* (factor 4, including tangible monetary expenditures and intangible learning investment), and *poor advanced capacity* (factor 5).

Attitude toward CASE impacts

Eight factors in Table 13 explaining 67.2% of the total variances: *increase satisfaction* (factor 1), *enhance quality* (factor 2), *reduce dependence and rigor* (factor 3), *increase productivity* (factor 4), *facilitate documentation* (factor 5), *assist design* (factor 6), *not inducing unemployment and resistance* (factor 7), and *skill impacts* (factor 8).

Key implementation success determinants

Five factors in Table 14 explaining 64.3% of the total variances: *communication and training* (factor 1), *evaluation and job security* (factor 2), *methodology use* (factor 3), *power-coercive strategy* (factor 4), and *software metrics* (factor 5).

4.4. Features of organizations that used CASE successfully

As an exploratory study, we also investigated the organizational characteristics of CASE adopters and successful users. Tables 15 and 16 list the variables marginally significant on χ^2 tests. Although satisfying the Morrison's [14] criteria, [4] their classification rates are not high. Among them, the variable having the highest classification power is 'number of IS

[4]Morrison suggests to compute a ratio as a criterion of the chance proportion correctly classified. For example, in Table 15, the proportional chance of adopting CASE owing to the long history of IS department is $(57/131)^2+(1-(57/131))^2=0.508$.

Table 12
Factor matrix (varimax-rotated) of perceived problems in CASE tools

Perceived problems in CASE tools (their rankings in the parenthesis)	Communalities	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Poor generated documents (13)	0.566	0.640				
Poor user or reference manual (7)	0.693	0.781				
Poor supplier support (2)	0.452	0.484				
Poor methodology (12)	0.586	0.557				
Poor user interface (11)	0.759		0.801			
Poor Chinese compatibility (6)	0.708		0.785			
Poor tool integration (4)	0.683			0.737		
Poor code generation (5)	0.768			0.810		
Poor tool efficiency (9)	0.641			0.609		
Longer learning time comparing to traditional method (8)	0.685				0.762	
High price (1)	0.625				0.735	
Poor multi-user facilities (10)	0.642					0.590
Lack of intelligent capabilities (3)	0.779					0.856
Eigen-value		4.032	1.278	1.166	1.105	1.007
Variance explained by each factor		31.0	9.8	9.0	8.5	7.7
Cronbach α of each factor		0.632	0.689	0.673	0.508	0.573
Average rating of the severity in each factor		3.40	3.42	3.54	3.8	3.61

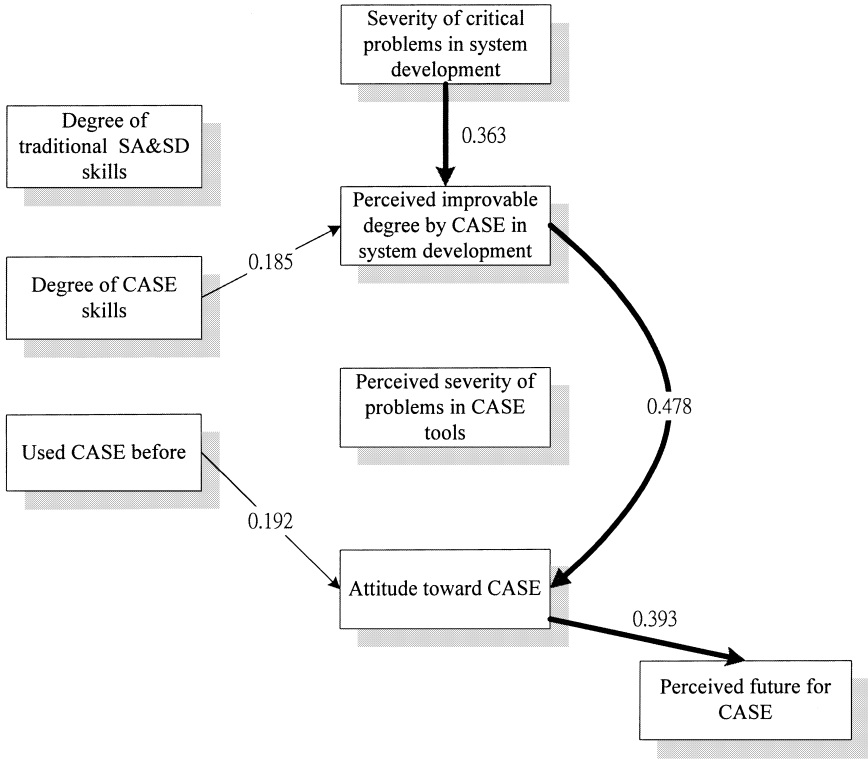


Fig. 4. Model of attitude toward CASE (all respondents N=135).

Table 13
Factor matrix (varimax-rotated) of attitude toward CASE impact

Attitude toward CASE Impact (their rankings in the parenthesis)	Communalities	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8
The developed system would more meet user requirements (18)	0.515	0.411							
The developed system would make IS developers more satisfactory (19)	0.594	0.511							
Make IS user departments (e.g., finance, marketing) more satisfactory (22)	0.797	0.840							
Make organizational outside customers more satisfactory (20)	0.806	0.877							
Make top managers more satisfactory and improve awareness of the efforts of developing new systems (17)	0.667	0.756							
The developed system is more reliable (13)	0.693		0.661						
The developed system is easier to maintain (7)	0.733		0.801						
The developed system would increase software reuse (11)	0.534		0.525						
The outputs of all system development stages would be more consistent each other, and be also consistent with final documentation (2)	0.514		0.585						
Reduce the dependence on system analysts (25)	0.876			0.913					
Reduce the dependence on system designers (24)	0.886			0.913					
Obviate the need of rigorous project management (21)	0.602			0.476					
Automate the tedious work in system development (15)	0.671				0.764				
Increase system development productivity – reduce time, personnel, and cost (5)	0.635				0.631				
Process of system development is more enjoyable to IS developers (16)	0.665				0.725				
Easier to draw graphs for documentation (4)	0.672					0.738			
The developed system documents is easier to understand and help communication (6)	0.623					0.621			
The developed system documents would closely follow project documentation standards and formats (1)	0.682					0.722			
Easier to develop prototypes (3)	0.654						0.627		
More likely to perform design alternatives before programming (12)	0.729						0.765		
Would not threaten job security of IS developers (8)	0.719							0.734	
Would not induce resistance of IS developers (14)	0.788							0.854	
Would not limit the creativity of IS developers to find solutions (23)	0.711								0.681
Give IS developers valuable skills of using CASE (9)	0.543								0.543
Improve system development methodology (10)	0.480								0.483
Eigen-value		6.968	2.385	1.606	1.470	1.218	1.170	1.066	0.906
Variance explained by each factor		27.9	9.5	6.4	5.9	4.9	4.7	4.3	3.6
Cronbach α of each factor		0.846	0.776	0.763	0.701	0.686	0.530	0.587	0.435
Average rating of the impacts in each factor		3.30	3.78	3.02	3.62	3.99	3.87	3.67	3.53

Table 14
Structure matrix (oblimin-rotated) of CASE key implementation success determinants

CASE implementation success determinants (their rankings in the parenthesis)	Communalities	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Provide formal training on system development techniques required to use CASE (1)	0.628	0.770				
Retain experienced consultants to guide project using CASE (6)	0.691	0.810				
Introduce CASE technology via at least one pilot project (2)	0.457	0.468				
Secure top management support and commitment on budgets and necessary organizational changes (5)	0.616	0.614				
Facilitate knowledge sharing and open communication among project team members (3)	0.684	0.790				
Enhance system analysis and design abilities of system developers (7)	0.440	0.580				
Demonstrate and promote the benefits of using CASE (10)	0.429		0.455			
Guarantee job security of IS developers to lower the potential resistance (14)	0.680		0.637			
Help career path planning of IS developers (9)	0.591		0.701			
Periodically evaluate the CASE impacts on organizational culture and structure, and make adjustments if necessary (11)	0.723		0.843			
Periodically evaluate the CASE impacts on system development productivity and quality (8)	0.793		0.808			
Enforce a system development methodology before using CASE (4)	0.740			0.795		
Use the same system development methodology before and after implementing CASE (12)	0.763			0.833		
Apply power-coercive strategy to enforce CASE (15)	0.735				0.846	
Use standard software metrics to measure the effectiveness of system development (13)	0.678					0.746
Eigen-value		5.072	1.405	1.166	1.074	0.936
Variance explained by each factor		33.8	9.4	7.8	7.2	6.2
Cronbach α of each factor		0.789	0.761	0.615	N/A	N/A
Average rating of the importance in each factor		4.23	3.83	4.00	2.92	3.76

employees skilled at CASE'; this distinguishes adopters from non-adopters. However, this might be the *result* of adopting CASE, not its *cause*. This variable and 'use integratedly' could also distinguish successful CASE users from unsuccessful with the higher classification power.

4.5. Analysis of CASE attitude model

By applying total scores of internal variables and not considering the external variables in our model of CASE attitude, we obtained Fig. 3. In the path analyses, we only considered the multiple (or simple) regression equations that were significant at α=0.05 (by *ANOVA F* tests), and also only drew their standardized regression coefficient (i.e., β) links that were significant at 0.05 (by *t* tests).

The 'perceived severity of problems in CASE tools' had no statistically significant influence on 'attitude toward CASE'. Though the attitude variable of our model was different from Davis' technology acceptance model (he considered the influence of 'perceived usefulness' and 'perceived ease of use' on 'attitude *towards use*'), this result was still surprising.

Next, we considered external variables. Originally, there were 23 in the model. In order to understand their possible influence on internal variables and the underlying factors, we conducted hundreds of *ANOVA F* tests. Owing to space limitation, we will not report the detailed results here. Also, we were only interested in those external variables influencing final attitude. There were three external variables significantly influencing attitude of *all* respondents: 'degree of tradi-

Table 15
Features of organizations that have adopted CASE

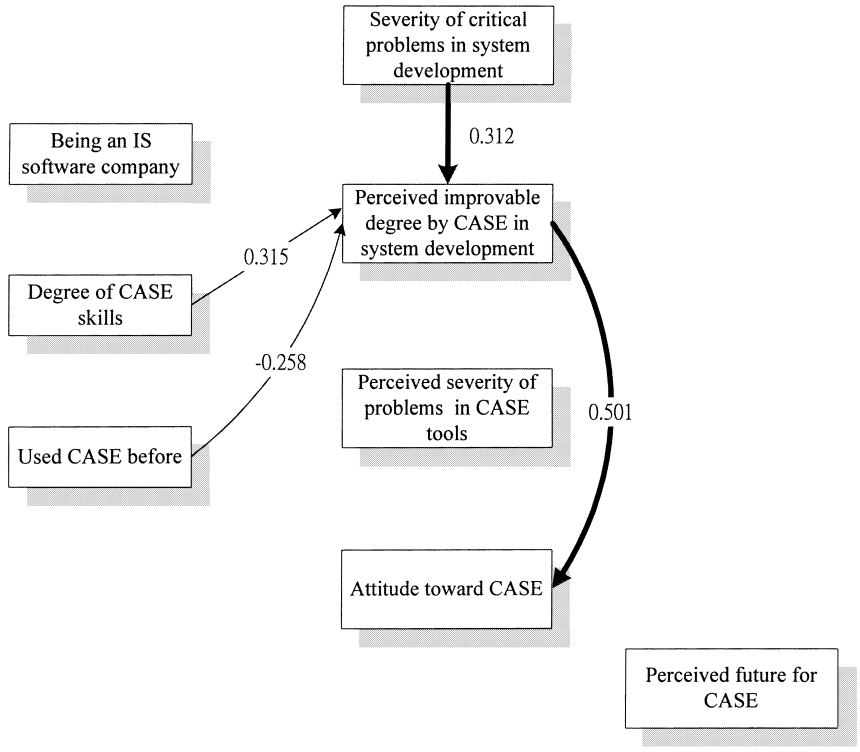
Features of organization	Currently use or used before	Have not adopted CASE	*Subtotal*
IS department has established within 10 years	16 (12.2%)	37 (28.2%)	53 (40.5%)
IS department has established more than 10 years	41 (31.3%)	37 (28.2%)	78 (59.5%)
Subtotal[1]	57 (43.5%)	74 (56.5%)	131 (100%)
Many IS employees (> median 18)	20 (16.3%)	31 (25.2%)	51 (41.5%)
Few IS employees (≤median 18)	42 (34.1%)	30 (24.4%)	72 (58.5%)
Subtotal[2]	62 (50.4%)	61 (49.6%)	123 (100%)
Many IS employees skilled at CASE (> median 2)	14 (12.7%)	51 (46.4%)	65 (59.1%)
Few IS employees skilled at CASE (≤median 2)	36 (32.7%)	9 (8.2%)	45 (40.9%)
Subtotal[3]	50 (45.5%)	60 (54.5%)	110 (100%)

Note 1: Pearson χ^2=6.428, df=1, α=0.011 (Classification correct rate=59.5%> Morrison's (1969) proportional chance criterion 50.8%). Continuity correction=5.55, df=1, α=0.018. No cell had expected count less than 5.
Note 2: Pearson χ^2=4.365, df=1, α=0.037 (Classification correct rate=59.4%> Morrison's proportional chance criterion 50%). Continuity correction=3.633, df=1, α=0.057. No cell had expected count less than 5.
Note 3: Pearson χ^2=36.655, df=1, α<0.001 (Classification correct rate=79.1%> Morrison's proportional chance criterion 51.7%). Continuity Correction=34.335, df=1, α<0.001. No cell had expected count less than 5.

Table 16
Features of organizations that used CASE successfully

Features of organization	More successfully use CASE	Less successfully use CASE	*Subtotal*
Immature IS development stage	13 (36.1%)	7 (19.4%)	20 (55.8%)
Mature IS development stage	6 (16.7%)	10 (27.8%)	16 (47.2%)
Subtotal[1]	19 (52.8%)	17 (47.2%)	36 (100%)
Many IS employees are skilled at CASE (> median 5)	12 (40%)	6 (20%)	18 (60%)
Few IS employees are skilled at CASE (≤ median 5)	4 (13.3%)	8 (26.7%)	12 (40%)
Subtotal[2]	16 (53.3%)	14 (46.7%)	30 (100%)
Most of IS applications was developed in house	14 (40%)	16 (45.7%)	30 (85.7%)
Most of IS applications was outsourced or purchased	5 (14.3%)	0 (0%)	5 (14.3%)
Subtotal[3]	19 (54.3%)	16 (45.7%)	35 (100%)
No methodology or only knows to draw system flow chart or data flow diagram	6 (18.8%)	1 (3.1%)	7 (21.9%)
Follows process, data or object-oriented methodology	11 (34.4%)	14 (43.8%)	25 (78.1%)
Subtotal[4]	17 (53.1%)	15 (46.9%)	32 (100%)
Has used CASE integratedly	4 (11.1%)	9 (25.0%)	13 (36.1%)
Doesn't use CASE integratedly	15 (41.7%)	8 (22.2%)	23 (63.9%)
Subtotal[5]	19 (52.8%)	17 (47.2%)	36 (100%)

Note 1: Pearson χ^2=2.697, df=1, α=0.101 (classification correct rate=63.9%> Morrison's proportional chance criterion 50.2%). No cell had expected count less than 5.
Note 2: Pearson χ^2=3.214, df=1, α=0.073 (classification correct rate=66.7%> Morrison's proportional chance criterion 50.2%). No cell had expected count less than 5.
Note 3: Pearson χ^2=4.912, df=1, α=0.027 (classification correct rate=60%> Morrison's proportional chance criterion 50.4%). Two cells had expected count less than 5. So, ran Fisher's exact test: exact probability=0.049 (two-tailed), 0.036 (one-tailed)
Note 4: Pearson χ^2=3.821, df=1, α=0.051 (classification correct rate=62.5%> Morrison's proportional chance criterion 50.2%). Two cells had expected count less than 5. So, ran Fisher's exact test: exact probability=0.088 (two-tailed), 0.061 (one-tailed).
Note 5: Pearson χ^2=3.955, df=1, α=0.047 (classification correct rate=66.7%> Morrison's proportional chance criterion 50.2%). No cell had expected count less than 5. 'Use CASE integrated' means that the respondent used an integrated CASE (i.e., the CASE covering upper and lower CASE capability); or used at least two CASES – one upper CASE and another lower CASE



Note: 1. Significant level α =0.05

2. The regression equation "Perceived future for CASE" is significant at 0.056, but its standardized coefficient of "Attitude toward CASE" is 0.28 (at significant level of 0.009)

Fig. 5. Model of attitude toward CASE (general respondents N=100).

tional SA (system analysis) and SD (system design) skills', 'degree of CASE skills', and 'used CASE before'. Among these three, 'degree of traditional SA and SD skills' had no significant influence on attitude of *general* respondents, however, 'being an IS software company' had. The attitude of teachers and CASE agent respondents showed four external variables: 'degree of traditional SA and SD skills', 'being a MIS department teacher', 'the number of CASE used', and 'integratedly used CASE'.

Considering external variables, 'Perceived severity of problems in CASE tools' had still no significant influence on 'attitude toward CASE'. In Fig. 4, 'degree of CASE skills' had positive influence on all respondents' 'perceived improvable degree by CASE in system development', and 'used CASE before' had on their attitude.

In Fig. 5, 'degree of CASE skills' had similar positive influence on general respondent's 'perceived improvable degree by CASE', but 'used CASE before' had negative influence. It seems that the experience might disappoint users. To teachers and CASE agent respondents, it is not valuable to include all of the four external variables in the regression equation of their attitude. After trying several combinations, we found that the only significant combination of two external variables was 'degree of traditional SA and SD skills', and 'being MIS department teacher'. In Fig. 6, it was

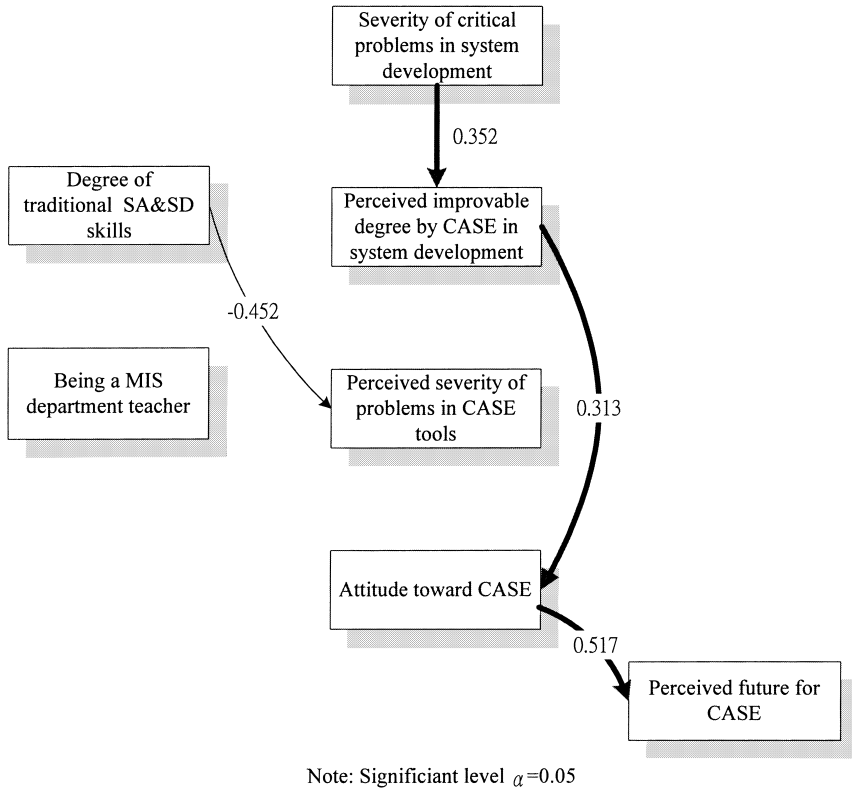


Fig. 6. Model of attitude toward CASE (teachers & CASE agent respondents N=44).

found that respondents who were less skilled in traditional SA and SD perceived more severity of problems in CASE tools.

Furthermore, we considered the underlying factors of all respondents: no any factor of 'perceived severity of problems in CASE tools' had significant influence on 'attitude toward CASE', as shown in Fig. 7. However, three factors had significant influence on some factors of 'perceived improvable degree by CASE in system development'. Possibly perceived 'cost problem' had negative influence on degree of CASE 'improving current software and hardware limits'; and 'poor CASE quality support' had negative effect on 'improving development time and heavy maintenance'. However, it might be hard to explain that the more that respondents perceived 'poor CASE quality and support', the more they believed that CASE tools were 'improving current software and hardware limits'. We assumed that respondents might have so much expectation of the value of CASE usage that the more problems they found in the use, the more improvement they wanted. In addition, respondents who were less skilled in traditional SA and SD felt more 'lack of system development techniques and methodologies'.

The results should not be considered universal because the coefficients of determination (R^2) of the regression equations were not high (about 0.3) though significant. We felt that the external variable 'used CASE before' might have little effect. Since there were five states of this variable, we split the respondents into five groups for further analysis. Because of the small size of the split samples, there were more insignificant regression equations. However, two points were worth noting. First, 'perceived severity of problems in CASE tools' still had no significant influence on 'attitude toward CASE' in any split group. Second, some equations had much higher R^2; for example, to the attitude of all respondents who used CASE before, but abandoned, R^2 of the regression coefficient was 0.6. In addition, its stan-

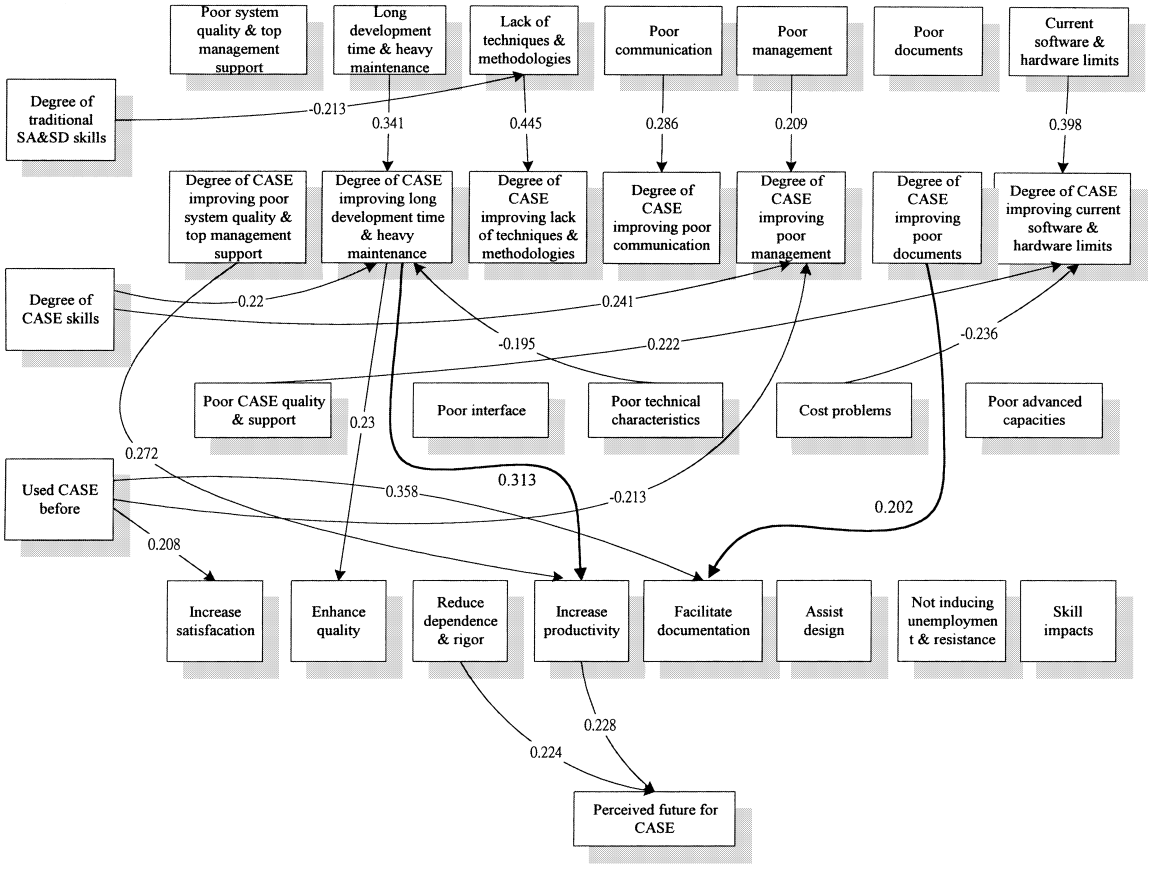


Fig. 7. Detailed model of attitude toward CASE (all respondents N=135).

dardized coefficient of 'perceived improvable degree by CASE in system development' was high (0.74). These confirmed our conjecture of CASE usage effect.

4.6. Analysis of CASE success model

Fig. 8 shows that the respondent's evaluated importance of CASE key implementation success factors could influence his (her) degree of organizational achievement; this would further influence the level of CASE success and perceived CASE impacts. It seems that, in general, the perceived CASE impacts might be good surrogates of success level. The detailed model is shown in Fig. 9. Only three determinants were evaluated to be of sufficient importance to carry into their effect. Though the remaining two determinants – 'methodology use' and 'software metrics' were not significantly important, the implementation of the first could influence 'increasing satisfaction' (user, IS developers, customer, and top manager's satisfaction); and the second could influence 'reducing dependence (on analysts and designers) and project management rigor'. But only methodology use would influence success level. In such a situation, the only good surrogate of success level might be 'increasing satisfaction'. The R^2 of these multiple regression equations were between 0.4 and 0.5.

Next, we considered five external variables as shown in Fig. 10. 'Evaluated importance of methodology use' influenced its achievement, and 'methodology use' became the only significant determinant of either success level or its surrogates – CASE

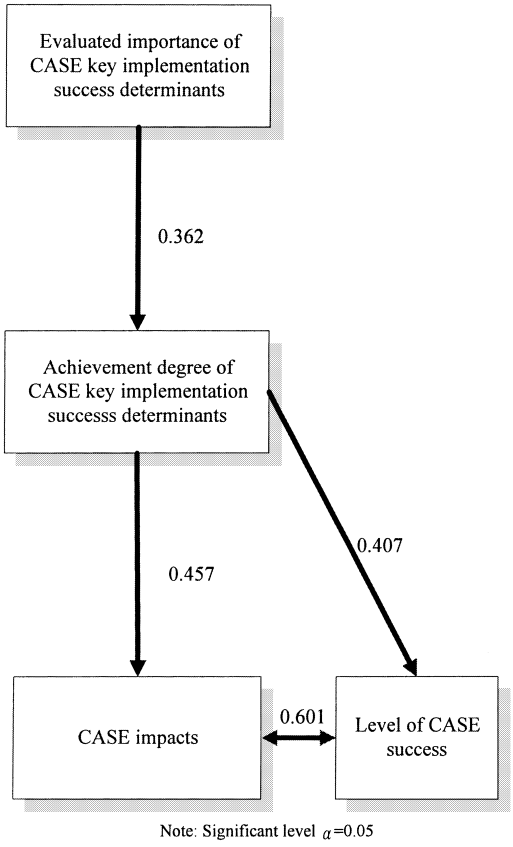


Fig. 8. Model of CASE success (excluding external variables N=35).

impacts. Interestingly, both 'following formal methodology' and 'methodology use' were important to success level. We should notice from Table 14 that there were two sub-determinants of 'methodology use' – 'enforcing methodology before CASE' and 'using the same methodology after implementation'. The variable 'following formal methodology' in the questionnaire only captured the current situation (i.e., after implementing CASE) of the respondent's associated organization. Certainly there was some correlation (Pearson coefficient=0.396) between this variable and methodology use. However, both significance to success level might imply that even if an organization had no methodology before CASE, it could succeed after introducing CASE. It was also apparent that both general respondents and teachers and CASE agent respondents evaluated the importance of 'enforcing methodology before CASE' relatively highly, and so were the corresponding achievement of the general respondents who have used CASE. However, 'using the same methodology after implementation' was not. In addition, though the significance (0.119) of the standardized coefficient (β=0.52) of 'communication and training' in the regression equation for success level was still not high, its significance was only next to 'methodology use' among the five determinants. On the other hand, the evaluated importance of 'communication and training' was the highest in Table 14. These might imply that using a *new* methodology after implementation must accompany with communication and training. Compared to the study of Urwiler et al., this research considered more variables and found 'methodology use' to be the only important one. 'Communication and training' (including consultation) was marginal and complementary to 'methodology use'.

As an exploratory study, we tried to use discriminant analysis to classify CASE success. We classified five categories of success from the corresponding success levels (1 to 5), and also two categories of success by grouping 1 and 2 into 'unsuccessful' and 4 and 5 into 'successful'. Without considering external variables, only 'methodology use' could classify five categories with correct rate 42.9%, and classify two categories with correct rate 75%. Using 'methodology use' with 'following formal methodology', the classification correct rate would be 53.3% for five categories and 81% for two categories. If we considered all five determinants and all five external variables, the correct rate was 76% for five categories and 100% for two categories.

5. Conclusions

This study, based on previous work in CASE adoption and implementation, examined CASE tool usage in Taiwan. The results of data analyses revealed that generally speaking, all respondents perceived critical problems in system development and had favorable attitude toward CASE impacts and CASE future though they also perceived some problems in CASE tools. The favorable bias might be so strong that 'perceived severity of problems in CASE tools' had no significant influence on 'attitude toward CASE' and very little influence on 'perceived CASE improve-

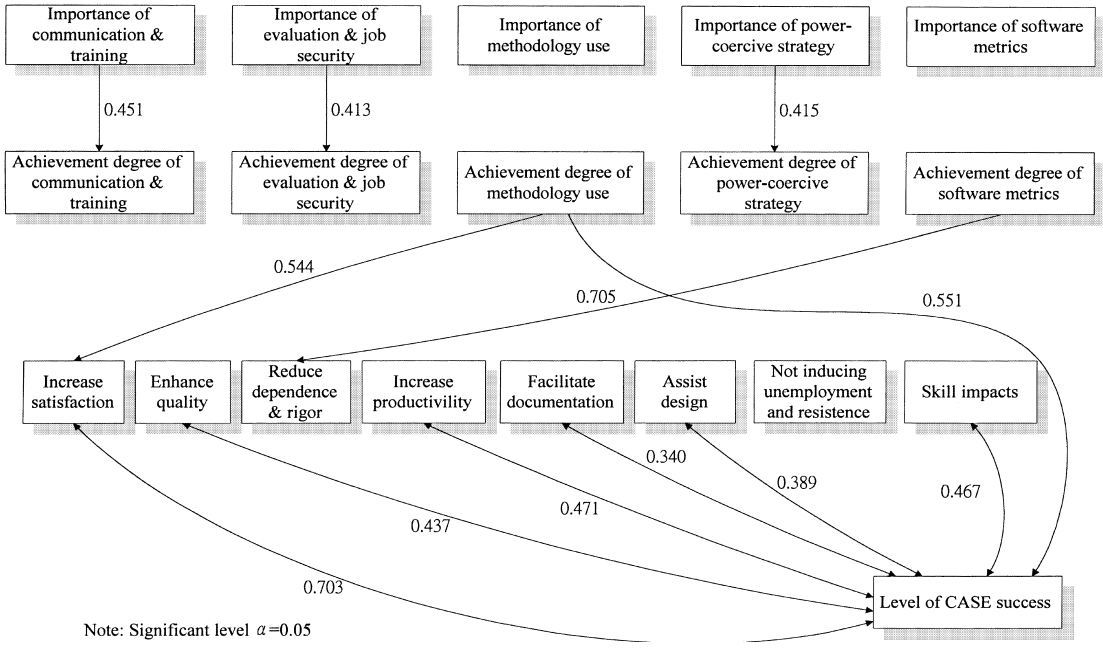


Fig. 9. Detailed model of CASE success (excluding external variables N=35).

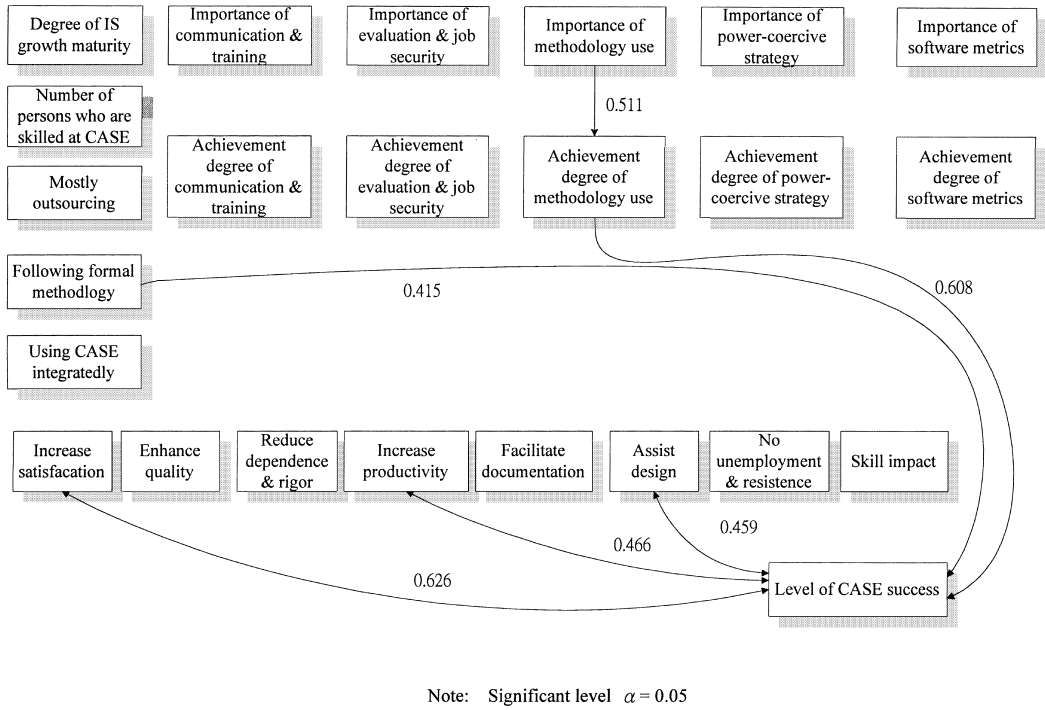


Fig. 10. Detailed model of CASE success (including external variables N=25).

ment for system development critical problems'. Successful implementation of CASE tools appeared significantly to depend only on the 'methodology usage'. In addition, using only the 'methodology use' variable could predict a relatively successful adopter from relatively unsuccessful adopter with 75% of the time. However, 'methodology use' was not the highest important factor evaluated by respondents. This research also provided some possible characteristics of organizations that used CASE successfully and some reasons for not adopting CASE.

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