A path analysis model for web application success

Monica Lam
California State University, Sacramento

ABSTRACT

This research study investigates the concept of web application success using multiple regression analysis and path analysis based on a survey data set in US industries. The results partially confirm the hypothesized path analysis model with both exogenous and endogenous variables affecting web application success. The main findings suggest that factors affecting web application success have to be understood in an integrative manner; management and human resource are more important than development methodologies, tools, and techniques; different development supports are required for different stakeholders even for the same purpose; and ambiguous end user requirements have to be addressed in conceptual, logical, and physical design.

Keywords: web application success, path analysis model, regression analysis, development methodologies, development phases, development tools and techniques

INTRODUCTION

The recent failure of the Obama Healthcare enrollment system on the web has caused a lot of questions in the public as well as in the IT field. How could such a high profile system with tremendous resource support fail miserably? There are various suggested reasons: a compressed time frame that did not allow a complete testing, a convoluted system of multiple companies operating separately, unexpected high volume at the start of the enrollment period, an incorrect specification that required users to fully register in order to browse, the lack of synchronization between various databases and the registration system, and others. While these are not brand new problems, the financial resources in billions into the state and federal contractors to build the system seem overwhelming facing the spectacular failure. Are there factors we need to pay attention to in order to ensure web application success? This research attempts to investigate that question. The factors to be investigated include company characteristics, IT architecture, computing infrastructure, evaluation criteria by different stakeholders, system development methodologies, system development phases, system development tools and techniques, adoption factors of development resources, and failure factors. The goal is to understand the significance of factors that may affect web application success and their interaction, which hopefully will provide guidelines for effective web application development.

LITERATURE BACKGROUND

The concept of web application success is not precisely defined in the literature. In a study about government web sites, Chua and Goh (2012) investigated how web 2.0 affected government web sites' quality. The system quality has the factors of usability, responsiveness, ease of access, and privacy. The information quality has the factors of accuracy, dependability, coverage, and ease of use. The service quality has the factors of empathy, interactivity, playfulness, and aesthetic appeal. It was determined that web 2.0 techniques are particularly correlated with service quality in web application. Worwa and Stanik (2010) discussed the quality criteria for web-based information system, which consist of reliability, usability, security, availability, scalability, maintainability, and time-to-market. It suggested that the perspective of end-users as well as developers should be taken into consideration for evaluating web application quality. Chang and Chen (2008) used technical adequacy, content quality, specific content, and appearance to measure web site quality. It was found that the web site brand is more important than web site quality in customers' purchase intention. In another study about online auction and shopping web sites, Calisir et al. (2010) concluded that customers regard usability more highly than functionality. Usability includes navigation, interaction, learnability, ease of use, response time, memorability, efficiency, and satisfaction. Functionality includes security, search options, information provision, services, user support, and customizability. Among all variables of usability, navigation and interaction are more significant than others. Many studies in the literature operationalize web application success in terms of different quality measures.

Regarding development methodologies for web application, Jeary et al. (2009) did an evaluation of the utility of web development methods. The study had a group of 23 students who developed web applications using different methodologies, and provided feedback on their utilities. To classify development methodologies, their scope, approach, and focus were utilized. In terms of scope, it was found that different methodologies range from covering the full life cycle, covering some phases but not all, to only one or two aspect of a life cycle such as requirement analysis. Among the 52 web development methodologies in the study, a majority of them are incomplete dealing with only a few aspects of the entire development life cycle. In terms of approach, there are the choices of entity-relationship, object-oriented, and some hybrid techniques. The classical entity-relationship data modeling is still a major influence on the conceptual and logical analysis for system requirements. In terms of focus, there is the focus on pre-requirements for assessing the feasibility or merit of a web application, on user modeling or requirement, on conceptual or design model, or on automation techniques for different development tasks. It was concluded that the proliferation of web application development methodologies in academia is not providing support to practitioners mainly because those methodologies are incomplete or difficult to apply, and they do not meet the realistic demands of developing web application. It was suggested that large scale and industrial usage be the future research direction of this topic.

Avison and Fitzgerald (2003) classified system development methodologies into three eras: pre-methodology (no methodology), early methodology (waterfall life cycle and flowchart), and post-methodology (object-oriented, application framework, agile methods). There are different tools and techniques proposed in different eras. In post-methodology era, Web Application Extension (WAE) to Unified Modeling Language (UML) is a comprehensive methodology for documenting system requirements for web application (Conallen 2003). Web Modeling Language (WebML) uses graphic notation and textual XML syntax for complex web sites (Ceri 2000). Milanov and Njegus (2012) investigated how agile methods affect the return-on-investment (ROI) in system projects. It was concluded that the use of agile methods is not a decisive factor for ROI. Prechelt (2011) compared the performance effect of different computing platform on the quality of software. The overall results show that how a platform is used by developers is more important than the platform per se. In other words, the people who use the technology matter more than the technology. In an experiment about web application comprehension tasks, Ricca et al. (2010) found that UML stereotypes improve the performance of less experienced developers.

There are a few empirical research results regarding web application development from the literature. Based on twenty case studies in United Kingdom, Taylor et al. (2001) identified technical, business, and analytical as three required skill sets for web site development. From three different projects in a major Danish software development company, Kautz et al. (2004) identified the following four characteristics of the utilization of methodology for web application development. First, there is no universally applicable methodology. The development time pressure usually pushes developers to jump into the physical design without the conceptual analysis as advocated by many methodologies. Second, if a methodology is used, it is more likely for the sake of having a methodology for addressing politics issues than for the real functionality provided by the methodology. Third, developers prefer iterative methodologies to sequentially organized methodologies. Fourth, methodology adoption depends on management support, explicit adoption, and involved parties' cooperation agreement. In a survey of 164 companies, Lang and Fitzgerald (2006) found that the hybrid, customized, or proprietary in-house as the most popular methodology for web/hypermedia system design; and screen prototypes, flowcharts, 2D site mapping, storyboards, and entity-relationship diagram as the most popular development techniques. In a survey of 66 companies in Malaysia, Masrek et al. (2008) concluded that in-house, rapid application development, and Unified Modeling Language (UML) are the common methodology; and dataflow diagram, flowcharting, prototyping, entity-relationship diagram, and project management are the common development techniques. Base on one case study, Smolander and Rossi (2008) reported that the benefit provided by UML for enterprise-wide e-business architecture is medium for technical and language requirement, and low for organizational requirements.

Overall, the literature provides some results regarding the adoption of development methodologies and development techniques for web applications. However, the results are limited by case study, small sample size, non-USA data set, or simple ranking analysis. With regard to the concept of web application success, it was extensively investigated using different measures in the literature. However, the relationship among company characteristics, system evaluation criteria, development methodologies, development phases, development techniques, and web application success still needs to be understood using a larger sample in the USA work environment.

HYPOTHESIZED RESEARCH MODEL

In this research, we adopt a combination of regression analysis and path analysis to investigate how company characteristics, system evaluation criteria, system development methodologies, system development phases, and system development techniques affect web application success. Company characteristics as listed in Table 1 include number of employees, annual sales, annual profit, IT architecture, and system development cost. System evaluation criteria are represented by the end users' feedback, development team members' feedback, and company's overall criteria, which are listed in Tables 2-4. Table 5 has the adoption factors for methodologies, tools, and techniques. Table 6 has the failure factors for web application development. Table 7 lists the development methodologies for web application success. Table 8 lists the development phases for web application success. Table 9 lists the development tools and techniques for web application success. The variables in Tables 1-6 are the exogenous variables in the path analysis model. The variables in Tables 7-9 are endogenous variables in the path analysis model. Web application success is the latent variable determined by two indicator variables: S1 - a quantitative measure of the number of web applications that have been developed in the past three years, and S2 - a qualitative measure of the number of web applications developed by a company in the past three years that are still being used. See Table 10 for a description of the two indicator variables S1 and S2. The hypothesized path analysis model is in Figure 1. The company characteristics (C), end user evaluation factors (EU), development team member evaluation factors (TM), company evaluation factors (CC), failure factors (FF), and adoption factor (AF) are hypothesized to determine the system development methodologies (SM), system development phases (SP), and system development tools and techniques (ST), as well as to determine the latent variable of web application success. System methodologies (SM), system phases (SP), and system tools and techniques (ST) are also hypothesized to determine the latent variable of web application success.

EMPIRICAL SURVEY INFORMATION

The empirical survey started with the development of a preliminary questionnaire, which was submitted to ten web developers for pretest. The preliminary questionnaire was revised based on pretest feedback to clarify terminology, eliminate ambiguity, reorder questions, and enhance the content. Then the finalized survey was administered by an Internet research company to a sample of 1500 contacts in a period of 4 weeks. There were one initial email to invite participation in the survey, and one reminder email to contacts. The contacts have the job title of computing infrastructure manager, database administrator, editor/copywriter, graphic designer, HTML developer, information architect, IT executive, network manager, producer, project manager, project stakeholder, programmer, quality assurance engineer, and tech lead; with IT executive as the majority of all respondents (71%). Tables 11-14 have the key descriptive statistics of the data set. To encourage participation, an incentive of a donation of $10 was given to a charity organization of the respondent's choice. The initial collection of responses was filtered using a reliability test based on respondents' answers to multiple pairs of variables measuring the same concepts. Those respondents with their answers to those pairs of variables greater than 3 points in a scale of 1-7 were deleted from the survey. The reliability test generated a total of 312 valid responses. During the multiple regression analysis and path analysis, due to missing values, the sample size was further reduced to 236 as the final data set for analysis.

ANALYSIS PROCEDURE AND RESULTS

The analysis procedure consists of two parts. The first part is to identify the exogenous and endogenous variables which are significant predictors for web application success using multiple regression analysis. The second part is to determine the validity of the hypothesized path analysis model in Figure 1 using the significant predictors from first part. The first part was carried out as follows for each of the indicator variables (S1 and S2, see Table 10) for the latent variable web application success:

1. Repeat the following for each of the variable groups in Tables 1-6:
   1.1 Use all the variables in one predictor group (i.e. one table) as the independent variables, and the indicator variable as the dependent variable to perform regression analysis. The backward selection method was used during the model building process.
   1.2 Independent variables with a significant level less than or equal to 0.05 were kept for step 2.
2. All the significant predictors identified from step 1 were used together to run a new regression model for the indicator variable. The significant predictors with a significant level less than or equal to 0.05 were kept for further analysis.
3. Repeat the following for each of the variable groups in Tables 7-9:
   3.1 Use all the variables in one predictor group (i.e., one table) as the independent variables, and the indicator variable as the dependent variable to perform regression analysis. The backward selection method was used during the model building process.
   3.2 Independent variables with a significant level less than or equal to 0.05 were kept for step 4.
4. All the significant predictors identified from steps 2 and 3 were used together to run a new regression model for the indicator variable. The significant predictors with a significant level less than or equal to 0.05 were kept for further analysis.

The purpose of steps 1-2 is to identify the significant exogenous variables for the path analysis model. Steps 1-2 resulted in the significant exogenous variables of C2 - number of employees, C10 - computing infrastructure, EU2 - navigation as end user evaluation, TM10 -

system scalability as development team member evaluation factor, CC1 - cost/benefit threshold as company evaluation factor, AF3 - improve management of development process as adoption factor, FF1 - ambiguous user requirements from beginning as failure factor, FF3 - unacceptable system quality as failure factory, and FF17 - unresolved conflicts among team members as failure factor. The purpose of steps 3-4 is to identify the significant endogenous variables for the path analysis model. Steps 3-4 resulted in the significant endogenous variables of SP5 - functionality requirement, SP15 - application coding, ST12 - web application extension to unified modeling language, ST19 - periodic and standardized progress reports, and ST21- diagram generation software.

Part 2 of the analysis is to test the hypothesized path analysis model in Figure 1. AMOS was used to run the path analysis model. The model fit summary is presented in Table 15. The CMIN table reports the chi-square statistic. The P value of 0 indicates that the data does not fit well with the overall hypothesized path model. However, the literature (Meyers et al. 2006) suggests that chi-square statistics should not be used solely to judge the overall model fit because it is sensitive to sample size. Other fit indexes have to be used to avoid the rejection of a good-fitting model due to some trivial but statistically significant differences between the observed and predicted values. The absolute fit measure of goodness-of-fit (GFI) index is 0.908 (> 0.9), and the root mean square error of approximation (RMSEA) is 0.077 (< 0.1) indicate good absolute fit. The relative fit measures including comparative fit index (CFI = 0.795), normal fit index (NFI = 0.717), incremental fit index (IFI = 0.812), and relative fit index (RFI = 0.540) do not meet the 0.9 threshold with the IFI being the fairly acceptable for relative fit. The parsimonious goodness of fit (PGFI) 0.49 is very close to the threshold of 0.5. Since the hypothesized model has a lot of parameters to estimate, the PGFI is a valuable fit measure to use. The expected cross-validation index (ECVI) of 1.286 for the default model being less than 2.813 of the independent model indicates a good fit of the model.

The regression weights in the final path analysis model are given in Table 16. The R^2 for web application success as a latent variable in the model is 0.719, which indicates that the hypothesized model accounts for a significant portion of the variance of web application success. Using the significance level of less than or equal to 0.05, the significant coefficients for paths are given in the final model as shown in Figure 2. The paths which are at least 3.0 from exogenous variables to endogenous variables include FF17 - unresolved conflicts among team members a failure factor affecting ST12 - web application extension to unified modeling language (0.494), AF3 - improve management of development process as adoption factor affecting ST19 - periodic and standardized progress reports (0.488), AF3 - improve management of development process as adoption factor affecting SP15 - application coding (0.47), FF17 - unresolved conflicts among team members as failure factor affecting ST21 - diagram generation software (0.341), AF3 - improve management of development process as adoption factor affecting ST21 - diagram generation software (0.336), and FF3 - unacceptable system quality as failure factor affecting ST21 - diagram generation software (0.319).

The following results from the path analysis model are noteworthy (see Figure 2). First, the exogenous variable of C10 - computing infrastructure, EU2 - navigation as end user evaluation, TM10 - system scalability as development team member evaluation factor, and CC1 - cost/benefit threshold as company evaluation factor are not significant predictors in this model. While the above variables are significant in the regression analyses from the first part of the analysis procedure, in the comprehensive model with all other variables, they are not influential enough to maintain their significance. This finding reminds us about the importance of the synergic effect from all factors in the overall organizational environment. Some factors by themselves on the local level may be very important. Who can argue that the navigation of a web application as evaluated by end users or the system scalability as evaluated by development team members is not important for the success of web application? However, when those micro factors on the local levels were considered together with all other organizational issues on the global level, they lost their lasting effect. This finding encourages us to have a macro view considering factors from all levels to increase the likelihood of web application success.

Second, C2 - number of employees affects directly the web application success (0.183) without any intermediate endogenous variables. The number of employees is a strong indicator of the resources a company has, which can directly impact web application success.

Third, the exogenous variable of AF3 - improve management of development process as adoption factor, FF1 - ambiguous user requirements from beginning as failure factor, FF3 - unacceptable system quality as failure factor, and FF17 - unresolved conflicts among team members as failure factor are strong predictors for endogenous variable and web application success.

AF3 significantly affects SP5 - functionality requirement (0.192), SP15 - application coding (0.47), ST19 - periodic and standardized progress reports (0.488), and ST21 - diagram generation software (0.336). AF3 also affects web application success through SP5 - functionality requirement (0.183), as well as through SP15 - application coding (0.114). When improving management of development process is used as an important adoption factor of system development methodology and techniques, the factors of functionality requirement, application coding, periodic and standardized progress reports, and diagram generation software are also considered as important, which eventually leads to web application success. This finding echoes Prechelt's conclusion (2011) that the management of the development process is a very important factor for success. No matter how sophisticated a development methodology is, it still relies on people to execute and manage it well for it to have positive effect. The strong and significant effect of AF3 confirms that the priority for ensuring web application success should be on management and the people who carry out the management.

FF1 - ambiguous user requirements from beginning as failure factor is another significant exogenous variable in the model. FF1 affects SP5 (0.187), SP15 (0.172), and ST12 (-0.282). The negative correlation between FF1 and ST12 - web application extension (WAE) to unified modeling language (UML) deserves some attention. This negative correlation indicates that the higher the ambiguity of user requirements, the more unlikely that UML/WAE will be used to document the user requirements. While UML/WAE proclaims its usefulness for documenting complicated requirements of web applications, it is not being used by practitioners in situations with highly ambiguous user requirements. Complicated and ambiguous requirements are two different issues to deal with in web application development. As lamented by many practitioners in system development, end users usually cannot articulate what they need from a system. Then it does not matter how comprehensive a system development technique is if end users do not even know what they need. This finding suggests that system development tools and techniques which are difficult to understand are not being used especially when end user requirements are ambiguous. To avoid failure, the recurring issue of ambiguous end user requirements must be addressed. FF1 also affects web application success indirectly through SP5 (0.183), SP15 (0.114), and ST12 (-0.068).

FF3 - unacceptable system quality as failure factor is another significant exogenous variable in the model. FF3 directly affects SP5 (0.194) and ST21 (0.319), as well as indirectly affects web application success through ST12 (-0.068). This result shows that the importance of system quality drives developers to emphasize on functionality requirements and diagram generation software. The importance of system quality is proven to be an influential factor for system development and web application success.

FF17 - unresolved conflicts among team members as failure factor is another significant exogenous variable in the model. FF17 directly affects ST12 (0.494) and ST21 (0.341), as well as indirectly affects web application success through ST12 (-0.068). The correlation of 0.494 between FF17 and ST12 is the strongest in this path analysis model. The more important the unresolved conflict among team members as a failure factor, the more likely that UML/WAE is adopted as a system development tool for web application. This positive and strong relationship may be due to the use of complicated development methodology and tool to moderate conflicts among development team members. The opposite effect of FF1 - ambiguous user requirements from beginning as failure factor (-0.282) vs. FF17 - unresolved conflicts among team members as failure factor (0.494) on ST12 - UML/WAE reveals that end users and team members may pull the system development process to different directions, which eventually causes the failure of web application development.

Fourth, among the endogenous variables in the middle tier of the path model, only SP5 functionality requirement, SP15 - application coding, and ST12 - UML/WAE significantly affect web application success. ST19 - periodic and standardized progress reports and ST21 - diagram generation software have no bearing on web application success. Note that none of the system methodologies (SM1 - SM6 in Table 7) is retained in the model. Yet UML associated with WAE as a system development technique (not a methodology) has a significant yet minimal, negative relationship to web application success.

Overall speaking, the hypothesized path analysis model is partially supported by the survey data. There are significant correlation paths from exogenous variables to endogenous variables, and also significant correlation paths from endogenous variables to the latent variable of web application success.

CONCLUSION AND FUTURE DIRECTION

This research study utilized multiple regression analysis and path analysis model to investigate the concept of web application success. The analysis results confirm that the factor of improving management of development process as adoption factor, ambiguous user requirements, unacceptable system quality as a failure factor, and unresolved conflicts among team members as a failure factor are significant predictors for the adoption of functionality requirement and application coding as development phases; as well as for the adoption of UML/WAE, periodic and standardized progress reports, and diagram generation software as development techniques.

The research results provide a few considerations for web application success in practice as follows. First, micro and macro factors on different levels should be considered in an integrative manner so as to understand their synergic effect on web application success. The effect of one factor may be cancelled out or enhanced depending on the interaction among all factors. Second, how a development methodology, phase, technique, or tool is used and managed is more important than its proclaimed sophistication. The human and management factor during the development process can be the most critical success factor for web application. Third, the conflicting requirements between end-users and development team members may need different or even opposite support from methodologies, tools, and techniques. In other words, the selection process for methodologies, tools, and techniques for developing web applications needs to be flexible according to different stakeholders' needs and cognitive abilities. Even for the same purpose, there may be the need to adopt different tools for different stakeholders. Fourth, to address the issue of ambiguous user requirements as a major failure factor for web application, the future investigation should focus on how to help end users to articulate what they need. The IT academia and industry responded with the agile development methodologies such as prototyping and extreme programming to address the ambiguity issue of user requirements. However, those agile methodologies did not emerge as a significant success factor for web application in this research. There may still be the need of closing the gap between user requirements and functional design of web application. This issue may have to be resolved in all levels including conceptual, logical, and physical.

In terms of limitations, the measures of web application success can be broadened to include different stakeholders' feedback over a period of time. The short-term and long-term effect may be different in evaluating success for web applications. Different statistical techniques such as confirmatory factor analysis and structural equation modeling can be used to validate the results in this research. As web applications will continue to be important in the future, further research in this area is necessary in order to provide guidelines for successful development.

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APPENDIX

Table 1. Company Characteristics

<table>
<tr><td>C2</td><td>Number of employees</td><td colspan="7">( ) under 500
( ) 500 – less than 1000
( ) 1,000 – less than 10,000
( ) 10,000 – less than 50,000
( ) 50,000 – less than 100,000
( ) 100,000 or more</td></tr>
<tr><td>C3</td><td>Annual sales</td><td colspan="7">( ) under 10 m
( ) 10 – less than 100 m
( ) 100 – less than 1,000 m
( ) 1,000 – less than 10,000 m
( ) 10,000 – less than 50,000 m
( ) 50,000 – less than 100,000 m
( ) 100,000 m or more</td></tr>
<tr><td>C4</td><td>Annual profit</td><td colspan="7">( ) under 5 m
( ) 5 – less than 50 m
( ) 50 – less than 500 m
( ) 500 – less than 5,000 m
( ) 5,000 – less than 25,000 m
( ) 25,000 – less than 50,000 m
( ) 50,000 m or more</td></tr>
<tr><td rowspan="3">C7</td><td rowspan="3">To what extent do you consider your current IT architecture service-oriented?</td><td colspan="7">not service-oriented -------------- very service-oriented</td></tr>
<tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td rowspan="3">C8</td><td rowspan="3">To what extent do you consider your current IT architecture component-based?</td><td colspan="7">not component-based ------------ very component-based</td></tr>
<tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td rowspan="2">C9</td><td rowspan="2">To what extent do you consider your organization's IT infrastructure in terms of operating system, network, programming language, system work flow, etc. homogeneous or heterogeneous?</td><td colspan="7">very homogeneous ----------------- very heterogeneous</td></tr>
<tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td></tr>
<tr><td rowspan="2">C10</td><td rowspan="2">How do you rate the effectiveness of your organization's computing infrastructure?</td><td colspan="7">not effective at all -------------------------- very effective</td></tr>
<tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td></tr>
<tr><td>C12</td><td>What is the average cost for your organization to develop a Web application?</td><td colspan="7">( ) Under 10,000
( ) 10,000 – less than 50,000
( ) 50,000 – less than 100,000
( ) 100,000 – less than 250,000
( ) 250,000 – less than 500,000
( ) 500,000 or more</td></tr>
</table>

Table 2. End Users' Feedback for Evaluating the Success of Web Applications (scale of 1-7 with 7 as the most important)

	How important are the following end users' feedback for evaluating the success of Web application development in your organization?
EU1	end users' feedback about functionality
EU2	end users' feedback about navigation
EU3	end users' feedback about usability/user friendliness
EU4	end users' feedback about sense of security
EU5	end users' feedback about visual/audio/aesthetic characteristics

Table 3. Development Team Members' Feedback for Evaluating the Success of Web Applications (scale of 1-7 with 7 as the most important)

	How important are the following development team members' feedback for evaluating the success of Web application development in your organization?
TM1	development team members' feedback about functionality
TM2	development team members' feedback about navigation
TM3	development team members' feedback about easiness to interact with
TM4	development team members' feedback about security features
TM5	development team members' feedback about visual/audio/aesthetic characteristics
TM6	development team members' feedback about suitability of development methodology
TM7	development team members' feedback about suitability of development tools and techniques
TM8	development team members' feedback about how well the system performs required tasks
TM9	development team members' feedback about system maintainability
TM10	development team members' feedback about system scalability

Table 4. Your Organization's Overall Criteria for Evaluating the Success of Web Applications (scale of 1-7 with 7 as the most important)

	How important are the following overall criteria for evaluating the success of Web application development in your organization?
CC1	Whether the application passes the cost/benefit threshold?
CC2	Whether the application is within the approved budget?
CC3	Whether the application can be delivered within the approved timeline?
CC4	Whether the application satisfies the business needs as expected?
CC5	Whether the application delivers the overall quality as expected?
CC6	Whether the application is maintainable?
CC7	Whether the application is scalable?
CC8	Whether different deliverables are on time?

Table 5. Factors for Choices of Methodology, Tools, and Techniques for Web Application Development (scale of 1-7 with 7 as the most important)

	How do you rate the importance of the following factors that drive the choices of methodologies, tools, and techniques for Web application development in your organization?
AF1	Improve overall quality of applications
AF2	Improve maintenance
AF3	Improve management of development process
AF4	Improve team member communication
AF5	Improve communication with end users
AF6	Reduce cost
AF7	Reduce development time

Table 6. Reasons for Project Failure (scale of 1-7 with 7 as the most important)

	How do you rate the importance of the following reasons for failure of Web application development in your organization?
FF1	Ambiguous user requirements from beginning
FF2	New/revised requirements
FF3	Unacceptable quality
FF4	Lack of clear communication among team members
FF5	Lack of clear communication with end users
FF6	Lack of proper project management control
FF7	Lack of role and responsibility
FF8	Lack of top management support
FF9	Inappropriate methodologies
FF10	Inappropriate documentation tools/techniques
FF11	Inappropriate development tools/techniques
FF12	Political reasons
FF13	Not enough manpower
FF14	Not enough expertise
FF15	Not enough time
FF16	Poor Planning
FF17	Unresolved conflicts among team members
FF18	Unresolved conflicts with end users

Table 7. Significance of Web Application Development Methodology for Project Success (scale of 1-7 with 7 as the most important)

	How do you attribute the following methodologies to the success of Web application development if they are used in your organization?
SM1	Rational Unified Process
SM2	Extreme Programming
SM3	Rapid Application Prototyping
SM4	WebML (Web Modeling Language)
SM5	Waterfall System Development Life Cycle
SM6	Compuware's UNIFACE

Table 8. Significance of Phases in Web Application Development Process (scale of 1-7 with 7 as the most important)

	How do you attribute the following development phases to the success of Web application development if they are used in your organization?
SP1	Creative Brief/Concept Creation
SP2	Functional/Technical/Operational Feasibility Studies
SP3	Cost/Benefit Analysis
SP4	Generation of Project Plan: Mission, Objectives, Targeted Users, Scope, Budget, Web Teams
SP5	Functionality Requirements
SP6	Data Storage and Access Design
SP7	Operations and Business Process Design
SP8	Navigation Design
SP9	Presentation/Page Layout Design
SP10	Web Service Design
SP11	Component Design
SP12	Infrastructure Configuration
SP13	Technical Specifications
SP14	Kickoff Meeting to Review Functional and Technical Specifications
SP15	Application Coding
SP16	Code Review
SP17	Production
SP18	Testing
SP19	Launch

Table 9. Significance of Tools and Techniques in Web Application Development (scale of 1-7 with 7 as the most important)

	How do you attribute the following tools/techniques to the success of Web application development if they are used in your organization?
ST1	Entity Relationship Diagrams (ERD)
ST2	Story Boarding
ST3	Use Case Diagrams
ST4	Class Diagrams
ST5	Object Diagrams
ST6	Sequence Diagrams
ST7	Collaboration Diagrams
ST8	Statechart Diagrams
ST9	Activity Diagrams
ST10	Component Diagrams
ST11	Deployment Diagrams
ST12	Web Application Extension to Unified Modeling Language
ST13	Program Flowcharts
ST14	Decision Tables
ST15	Hierarchy-Input-Process-Output Charts (HIPO)
ST16	Pseudocode
ST17	Workflow Analysis
ST18	Review/Staging Web Site for Communication Purposes
ST19	Periodic and standardized Progress Reports
ST20	Project Management Software
ST21	Diagram Generation Software
ST22	Code Generation/Review/Testing Software
ST23	Application Framework

Table 10. Measures for Web Application Success

S1	How many Web applications in total have been developed by your organization in the past 3 years?	( ) 0 – 1 ( ) 2 – 5 ( ) 6 – 10 ( ) 11 – 15 ( ) 16 – 20 ( ) 21 or more
S2	How many Web applications developed by your organization in the past 3 years are being used?	( ) 0 – less than 20% ( ) 20 – less than 40% ( ) 40 – less than 60% ( ) 60 – less than 80% ( ) 80 – 100%

Table 11. Respondent Company Type

Company Type	Percentage
Multi-National Company	22.43
Public Limited Company	7.22
Small/Medium Enterprise	54.75
Federal/State Government Type	2.66
Others	12.93

Table 12. Number of Employees in Respondent Company

Number of Employees	Percentage
Under 500	62.74
500 – less than 1000	10.65
1,000 – less than 10,000	17.11
10,000 – less than 50,000	6.08
50,000 – less than 100,000	1.52
100,000 or more	1.90

Table 13. Annual Sales in Respondent Company

Annual Sales	Percentage
Under 10 m	31.18
10 – less than 100 m	27.38
100 – less than 1,000 m	12.55
1,000 – less than 10,000 m	4.56
10,000 – less than 50,000 m	3.04
50,000 – less than 100,000 m	3.04
100,000 m or more	18.25

Table 14. Job Title of Respondent

Job Title	Percentage
Computing Infrastructure Manager	1.14
Database Administrator	0.38
Editor/Copywriter	0
Graphic Designer	0.76
HTML Developer	1.52
Information Architect	1.90
IT Executive (CIO, VP, Director)	71.10
Network Manager	0.38
Producer	0
Project Manager	9.13
Project Stakeholder/Client/Business Owner	3.42
Programmer/Code Writer	4.18
Quality Assurance Engineer	1.14
Tech Lead	4.94

Table 15. Model Fit Summary

CMIN

Model	NPAR	CMIN	DF	P	CMIN/DF
Default model	62	178.297	74	.000	2.409
Saturated model	136	.000	0		
Independence model	16	628.944	120	.000	5.241

RMR, GFI

Model	RMR	GFI	AGFI	PGFI
Default model	.186	.908	.832	.494
Saturated model	.000	1.000		
Independence model	.461	.672	.629	.593

Baseline Comparisons

Model	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI
Default model	.717	.540	.812	.668	.795
Saturated model	1.000		1.000		1.000
Independence model	.000	.000	.000	.000	.000

Parsimony-Adjusted Measures

Model	PRATIO	PNFI	PCFI
Default model	.617	.442	.490
Saturated model	.000	.000	.000
Independence model	1.000	.000	.000

RMSEA

Model	RMSEA	LO 90	HI 90	PCLOSE
Default model	.077	.063	.092	.001
Independence model	.134	.124	.145	.000

ECVI

Model	ECVI	LO 90	HI 90	MECVI
Default model	1.286	1.136	1.469	1.328
Saturated model	1.157	1.157	1.157	1.248
Independence model	2.813	2.494	3.163	2.823

Table 16. Regression Weights in the Final Path Analysis Model

			Estimate	S.E.	C.R.	P	Label
SP15	<---	C2	.104	.072	1.441	.150	
ST12	<---	C2	-.122	.108	-1.135	.256	
SP5	<---	TM10	.081	.059	1.389	.165	
SP5	<---	CC1	-.022	.043	-.523	.601	
SP15	<---	CC1	.065	.062	1.042	.297	
SP5	<---	AF3	.192	.055	3.463	***	
SP15	<---	AF3	.470	.076	6.157	***	
ST12	<---	AF3	.215	.114	1.886	.059	
ST19	<---	AF3	.488	.106	4.589	***	
ST21	<---	AF3	.336	.111	3.023	.002	
SP5	<---	FF3	.194	.054	3.582	***	
SP15	<---	FF3	.117	.078	1.492	.136	
ST12	<---	FF3	.105	.119	.883	.377	
ST19	<---	FF3	.173	.111	1.559	.119	
ST21	<---	FF3	.319	.116	2.755	.006	
ST12	<---	C10	.069	.113	.612	.540	
ST21	<---	C10	.016	.102	.157	.875	
ST19	<---	EU2	.030	.115	.264	.792	
ST21	<---	EU2	-.135	.117	-1.154	.248	
SP5	<---	FF1	.187	.057	3.261	.001	
SP15	<---	FF1	.172	.083	2.074	.038	
ST12	<---	FF1	-.282	.126	-2.239	.025	
ST19	<---	FF1	.086	.117	.730	.465	
ST21	<---	FF1	-.079	.122	-.645	.519	
SP5	<---	FF17	.027	.037	.737	.461	
SP15	<---	FF17	-.015	.054	-.271	.787	
ST12	<---	FF17	.494	.082	6.038	***	
ST19	<---	FF17	.147	.076	1.927	.054	
ST21	<---	FF17	.341	.080	4.280	***	
success	<---	SP5	.183	.076	2.420	.016	
success	<---	SP15	.114	.052	2.187	.029	
success	<---	ST12	-.068	.034	-1.973	.048	
success	<---	ST19	.050	.039	1.263	.206	
success	<---	ST21	-.057	.039	-1.481	.139	
success	<---	C2	.185	.064	2.879	.004	
success	<---	TM10	-.043	.066	-.648	.517	
S1	<---	success	1.000				
S2	<---	success	.451	.140	3.231	.001	

Figure 1. The Hypothesized Path Analysis Model

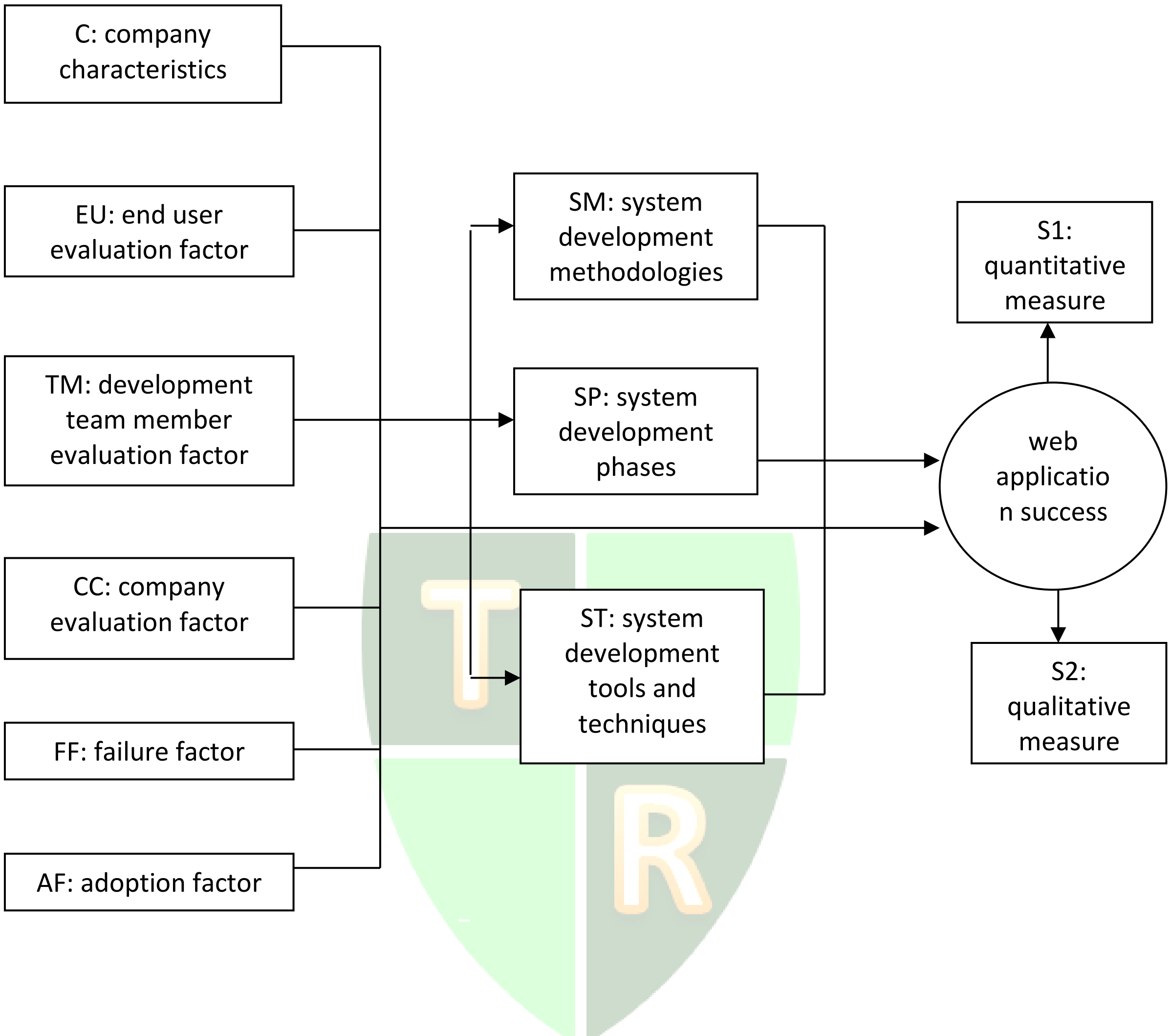

Figure 2. The Final Path Analysis Model with Significant Paths and Weights