CHAPTER VII

FLOW MODEL DEVELOPMENT WITH STRUCTURAL EQUATION MODELING

This chapter covers the process of structural equation modeling with the data collected from the survey. The model development process proved to be lengthy and laborious, because the flow model is very complicated. It involves eleven construct and twenty-two measurement variables. A review of the literature on structural equation modeling did not reveal any models that were as complicated as this flow model. In order to get adequate evidences to support the overall fit of the model and individual hypothesized relationships that are represented as paths in the model, a rigorous evaluation was conducted. Although every attempt is made to keep mathematical details to a minimum, it is necessarily to examine a key set fit of measures and the measurement and structural parameters for each model.

In order to minimize the length of this dissertation, this chapter only presents selected key outputs from the model-fitting program. Eight models, including three measurement models and five structural models, that were tested in this process are discussed in this chapter. The SAS program and the output pages are critical parts of understanding the model development process. However, to provide a flow to the discussion the SAS programs are listed in Appendix E. The selected program output pages that are discussed in this chapter are included in Appendix F. For more detailed information about the final structural model, readers can consult Appendix G where the complete version of the output is provided. The information listed in Appendix G should provide adequate information for testing or remodeling the conceptual model with any SEM programs.

The flow model was tested with a two-step modeling method. With two-step modeling, a structural equation model is first specified as a confirmatory factor analysis (CFA) measurement model. The CFA measurement model is tested first to determine if the measurement part of the model fits the data. If the measurement model is accepted, the structural model is then analyzed. The advantage of this two-step modeling method is that it can localize potential unfit relations (Kline 1994). Thus, generally, there were two major components in the process of testing the flow model. First, the confirmatory factor analysis was conducted to test the measurement part of the flow model. Then, using the final CFA measurement model, the path analysis was conducted to test the fit of the structural equation part of the flow model.

The sequence of testing and modifying the flow model was as follows:

1. Model specification. In this step, the flow model was expressed in the form of a structural equation model. The model was represented in two forms: (1) a drawing diagram, and (2) equations defining the model's parameters, which correspond to presumed relations among observed or latent variables. The equation form of the model was used for the SAS program to estimate model parameters using the sample data.
2. Data preparation and screening.

3. Examination on the model’s identification characteristics.

4. Confirmatory factor analysis.

   (a) Evaluate the fit of the measurement model.

   (b) Re-specify the measurement model when the original model failed to fit the data well, and repeat step 4(a).

5. Conduct path analysis to test the structural equation model.

   (a) Evaluate the fit of the structural model.

   (b) Re-specify the structural model when the original failed to provide an acceptable fit, and repeat step 5(a).

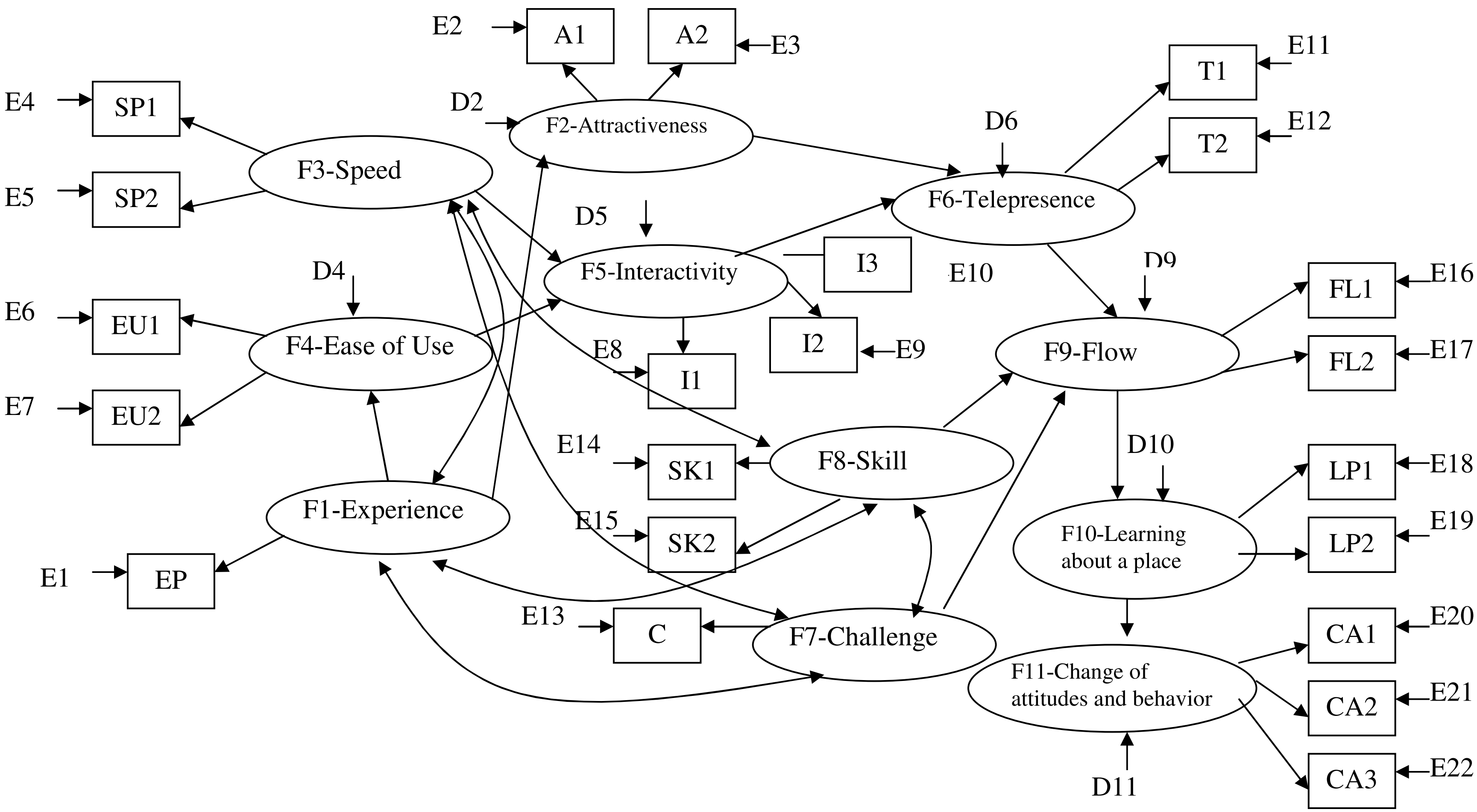
Original Flow Model Specification

Figure 3.1 in chapter III specifies the theoretical flow model. The paths in the model link eleven theoretical factors, such as challenge, skill, interactivity, flow and positive effects. Each path represents a hypothesis that was tested. Table 4.1 in Chapter IV lists the measurement variables for each latent factor. Figure 7.1 is the diagram expression of the full structural equation model. Equation forms of the flow model appear on the SAS program (Appendix E) for confirmative analysis and path analysis.

Data Screening and Preparation

Of the 281 responses, twenty-three cases were dropped from modeling because of missing values. The actual number of cases used was 258. An initial examination of the

Figure 7.1. Original flow model specified as structural equation model to be estimated



responses revealed that there was confusion for respondents about questions 21 and 22. Respondents were supposed to answer only one of the questions, but many of them answered both. This destroyed the utility of the survey responses for analysis. However, after scrutinizing the questions more closely it was determined that they added no useful information to the flow model and only added to the complexity for analysis. As a result, these questions were eliminated from the model analysis.

Univariate Normality

Although parameter estimates derived with methods that assume normality, such as maximum likelihood, are fairly accurate with large samples, when the data are severely non-normal, true models tend to be rejected too often (Kline 1998). Skew and kurtosis are two ways to describe the normality of a data set.

The sign of the univariate skew index indicates the direction of the skew, positive or negative. If most cases are below the mean, it is a positive skew. Otherwise, it is a negative skew. Zero indicates a symmetrical distribution. The index of kurtosis provides similar information.

Table 7.1 lists the descriptive statistics for the sample data including both univariate skew and kurtosis indices for each variable. It appears that the variables are somewhat skewed, most of them negatively. This means that the values of most cases are above the means. Although there is no consensus about how much non-normality is problematic, univariate skew indexes greater than 3.0 tend to be considered extremely skewed. An absolute value of the kurtosis index greater than 10.0 may suggest a problem and values greater than 20.0 may indicate a serious one by most SEM studies (Kline

TABLE 7.1

Univariate normality of the measurement variables

Variable	Mean	Std Dev	N	Minimum	Maximum	Skewness	Kurtosis
EP	1.6589147	0.8732615	258	1	5	1.3589771	1.6806739
A1	4.2906977	0.9443621	258	1	5	-1.4770356	1.9415060
A2	4.2713178	0.9521791	258	1	5	-1.5481163	2.3797050
SP1	4.1085271	0.9642667	258	1	5	-1.1902366	1.2547446
SP2	4.0271318	1.0265163	258	1	5	-1.0769002	0.7599546
EU1	3.8643411	1.1232456	258	1	5	-0.8754859	0.0608338
EU2	4.0426357	1.0259872	258	1	5	-1.0443451	0.6062484
I1	4.1046512	0.9905672	258	1	5	-1.1799708	1.0387444
I2	4.0736434	0.9815432	258	1	5	-1.1188430	0.9657359
I3	4.2286822	0.8942265	258	1	5	-1.2891615	1.7288224
T1	3.1317829	1.1115233	258	1	5	-0.1259912	-0.5927444
T2	3.0968992	1.0993056	258	1	5	-0.0871348	-0.6273503

Table 7.1 -- *continued*

Variable	Mean	Std Dev	N	Minimum	Maximum	Skewness	Kurtosis
C	4.3875969	0.9193982	258	1	5	-1.8146353	3.3189473
SK1	2.8100775	1.0205930	258	1	5	0.0121387	-0.3289010
SK2	2.5271318	1.1023676	258	1	5	0.3346615	-0.4505860
FL1	3.9457364	0.9193982	258	1	5	-0.7396940	0.3891903
FL2	4.1201550	0.9689241	258	1	5	-0.9933340	0.4840509
LP1	4.1317829	0.9892799	258	1	5	-1.2638141	1.3484526
LP2	4.0968992	1.0336320	258	1	5	-1.2394847	1.1546539
CA1	4.0775194	0.9752773	258	1	5	-1.0440099	0.7232740
CA2	4.1705426	0.9833163	258	1	5	-1.2390584	1.1965730
CA3	4.0193798	1.0528876	258	1	5	-1.0870848	0.7677727

1998). The absolute values of the skew indices listed in Table 7.1 are all well below 3.0; and absolute values of the kurtosis index are well below 10.0. In other words, the non-normality of the data is not large enough to affect the model-fitting result. Therefore, no transformation of the data is necessary.

Matrix Summary of the Raw Data

The raw survey data of the 258 cases was submitted to the SAS program. It produced two types of summaries for these data—a correlation matrix and a covariance matrix. Table 7.2 and 7.3 present these two matrices for these measurement variables in the flow model with means and standard deviations.

Identification Property of the Structural Equation Model

The structural equation model consists of two parts: a measurement model and a structural model. The original full structural equation model (Figure 7.1) was re-specified as a CFA measurement model with all possible unanalyzed associations among the factors (Figure 7.2) and a structural model (Figure 7.3).

In order for the structural portion of a structural equation model to be identified, its measurement model must be identified. The basic requirement for identification of a measurement model is that there must be at least as many observations as model parameters. Models that do not meet this requirement are under-identified. It is mathematically impossible to derive unique estimates for the parameters of an under-identified model. The number of observations is the number of variances and covariances

TABLE 7.2

Matrix summaries of the raw data -- covariance matrix

	EP	A1	A2	SP1	SP2	EU1
EP	0.763					
A1	0.072	0.892				
A2	0.031	0.738	0.907			
SP1	-0.091	0.459	0.433	0.930		
SP2	-0.010	0.455	0.413	0.744	1.054	
EU1	0.020	0.724	0.768	0.462	0.498	1.262
EU2	-0.036	0.665	0.697	0.552	0.501	0.936
I1	0.005	0.576	0.563	0.471	0.441	0.726
I2	0.025	0.617	0.641	0.541	0.480	0.808
I3	0.008	0.509	0.463	0.672	0.562	0.490
T1	-0.052	0.343	0.291	0.332	0.312	0.333
T2	-0.049	0.458	0.437	0.238	0.250	0.581
C	0.059	0.556	0.505	0.366	0.394	0.582
SK1	0.161	0.102	0.063	-0.003	0.025	-0.003
SK2	0.165	0.010	0.067	-0.026	-0.018	0.103
FL1	0.005	0.541	0.493	0.469	0.429	0.600
FL2	0.053	0.716	0.738	0.442	0.433	0.798
LP1	-0.033	0.588	0.544	0.390	0.382	0.672
LP2	-0.029	0.625	0.557	0.355	0.390	0.667
CA1	-0.047	0.518	0.504	0.342	0.297	0.520
CA2	0.093	0.619	0.561	0.390	0.400	0.626
CA3	0.053	0.570	0.528	0.297	0.268	0.505

Table 7.2 -- *continued*

	EU2	I1	I2	I3	T1	T2
EU2	1.053					
I1	0.704	0.981				
I2	0.830	0.813	0.963			
I3	0.547	0.591	0.645	0.800		
T1	0.321	0.270	0.282	0.273	1.235	
T2	0.517	0.356	0.433	0.262	0.863	1.208
C	0.528	0.481	0.501	0.390	0.190	0.355
SK1	-0.019	0.055	0.030	0.059	0.142	0.104
SK2	0.079	0.069	0.101	0.023	0.086	0.135
FL1	0.582	0.547	0.599	0.507	0.544	0.550
FL2	0.699	0.641	0.664	0.463	0.284	0.463
LP1	0.594	0.570	0.554	0.441	0.224	0.423
LP2	0.564	0.542	0.553	0.406	0.271	0.493
CA1	0.510	0.502	0.531	0.395	0.344	0.475
CA2	0.607	0.535	0.563	0.432	0.343	0.446
CA3	0.486	0.457	0.489	0.377	0.363	0.484

Table 7.2 -- *continued*

	C	SK1	SK2	FL1	FL2	LP1
C	0.845					
SK1	-0.113	1.042				
SK2	-0.158	0.521	1.215			
FL1	0.402	0.064	0.087	0.845		
FL2	0.537	0.042	0.034	0.563	0.939	
LP1	0.610	-0.022	-0.074	0.509	0.599	0.979
LP2	0.635	-0.009	-0.117	0.484	0.630	0.878
CA1	0.507	0.096	0.045	0.448	0.559	0.671
CA2	0.513	0.134	0.132	0.515	0.614	0.627
CA3	0.518	0.241	0.099	0.437	0.577	0.624

	LP2	CA1	CA2	CA3
LP2	1.068			
CA1	0.642	0.951		
CA2	0.606	0.648	0.967	
CA3	0.625	0.804	0.705	1.109

Number of cases in data file are........... 258
Number of cases used in this analysis are .. 258

TABLE 7.3

Summary of the raw data – correlation matrix

	EP	A1	A2	SP1	SP2	EU1
EP	1.000					
A1	0.088	1.000				
A2	0.037	0.821	1.000			
SP1	-0.108	0.504	0.472	1.000		
SP2	-0.011	0.469	0.422	0.752	1.000	
EU1	0.020	0.683	0.719	0.427	0.432	1.000
EU2	-0.040	0.686	0.713	0.558	0.475	0.812
I1	0.005	0.616	0.597	0.493	0.433	0.653
I2	0.029	0.665	0.686	0.571	0.477	0.733
I3	0.011	0.603	0.544	0.779	0.612	0.488
T1	-0.054	0.327	0.275	0.310	0.273	0.267
T2	-0.051	0.441	0.417	0.225	0.222	0.471
C	0.073	0.641	0.577	0.413	0.418	0.564
SK1	0.180	0.106	0.065	-0.003	0.024	-0.002
SK2	0.171	0.009	0.063	-0.025	-0.016	0.083
FL1	0.006	0.623	0.564	0.529	0.455	0.581
FL2	0.062	0.782	0.800	0.473	0.435	0.734
LP1	-0.038	0.629	0.577	0.409	0.376	0.604
LP2	-0.032	0.641	0.566	0.356	0.368	0.574
CA1	-0.056	0.563	0.543	0.363	0.297	0.475
CA2	0.109	0.667	0.599	0.411	0.396	0.567
CA3	0.058	0.573	0.526	0.293	0.248	0.427

Table 7.3 -- *continued*

	EU2	I1	I2	I3	T1	T2
EU2	1.000					
I1	0.692	1.000				
I2	0.824	0.836	1.000			
I3	0.596	0.667	0.734	1.000		
T1	0.282	0.245	0.259	0.275	1.000	
T2	0.459	0.327	0.401	0.266	0.706	1.000
C	0.560	0.528	0.555	0.474	0.186	0.352
SK1	-0.018	0.054	0.030	0.065	0.125	0.093
SK2	0.069	0.063	0.093	0.023	0.070	0.112
FL1	0.617	0.600	0.664	0.616	0.532	0.544
FL2	0.703	0.668	0.698	0.534	0.263	0.435
LP1	0.585	0.581	0.571	0.498	0.204	0.389
LP2	0.532	0.530	0.545	0.439	0.236	0.433
CA1	0.510	0.519	0.555	0.453	0.317	0.443
CA2	0.602	0.549	0.584	0.491	0.314	0.413
CA3	0.449	0.438	0.473	0.400	0.310	0.419

Table 7.3 -- *continued*

	C	SK1	SK2	FL1	FL2	LP1
C	1.000					
SK1	-0.120	1.000				
SK2	-0.156	0.463	1.000			
FL1	0.476	0.068	0.086	1.000		
FL2	0.603	0.043	0.032	0.632	1.000	
LP1	0.671	-0.021	-0.068	0.560	0.625	1.000
LP2	0.669	-0.008	-0.103	0.509	0.629	0.859
CA1	0.565	0.097	0.041	0.499	0.591	0.695
CA2	0.568	0.133	0.121	0.570	0.644	0.645
CA3	0.535	0.224	0.085	0.451	0.566	0.599

Table 7.3 -- *continued*

	LP2	CA1	CA2	CA3
LP2	1.000			
CA1	0.637	1.000		
CA2	0.596	0.676	1.000	
CA3	0.574	0.783	0.681	1.000

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Number of cases in data file are ...........     258
Number of cases used in this analysis are ..     258
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among the observed variables. If an identified model has fewer parameters than observations, it is over-identified. An over-identified model is the one that is of special interest in a model testing process.

The number of observations of the measurement model was calculated as follows:

Number of observations = v(v+1)/2 = 22*23/2 = 253

where v is the number of observed measurement variables

The number of parameters that need to be estimated was 99, including 22 factor loadings from latent factors to their measurement variables, 54 covariances among latent factors, and 13 measurement errors. The degrees of freedom were 253 – 99 = 154. Thus, this model was over-identified. With the measurement model being identified, if the structural portion of the model is recursive (e.g. no feedback loops), then the full structural equation model is identified. The structural model of the flow model was indeed recursive, thus the full model was identified and could be tested.

Confirmatory Factor Analysis of the Measurement Model

This step tests if the measurement variables measure the correspondent latent variables. If the measurement model is correct, the result of CFA should meet the following requirements:

(1) indicators specified to measure a common factor all have relatively high loadings on that factor,

(2) chi-square test should be relatively small,

Figure 7.2. Initial measurement model for confirmative factor analysis

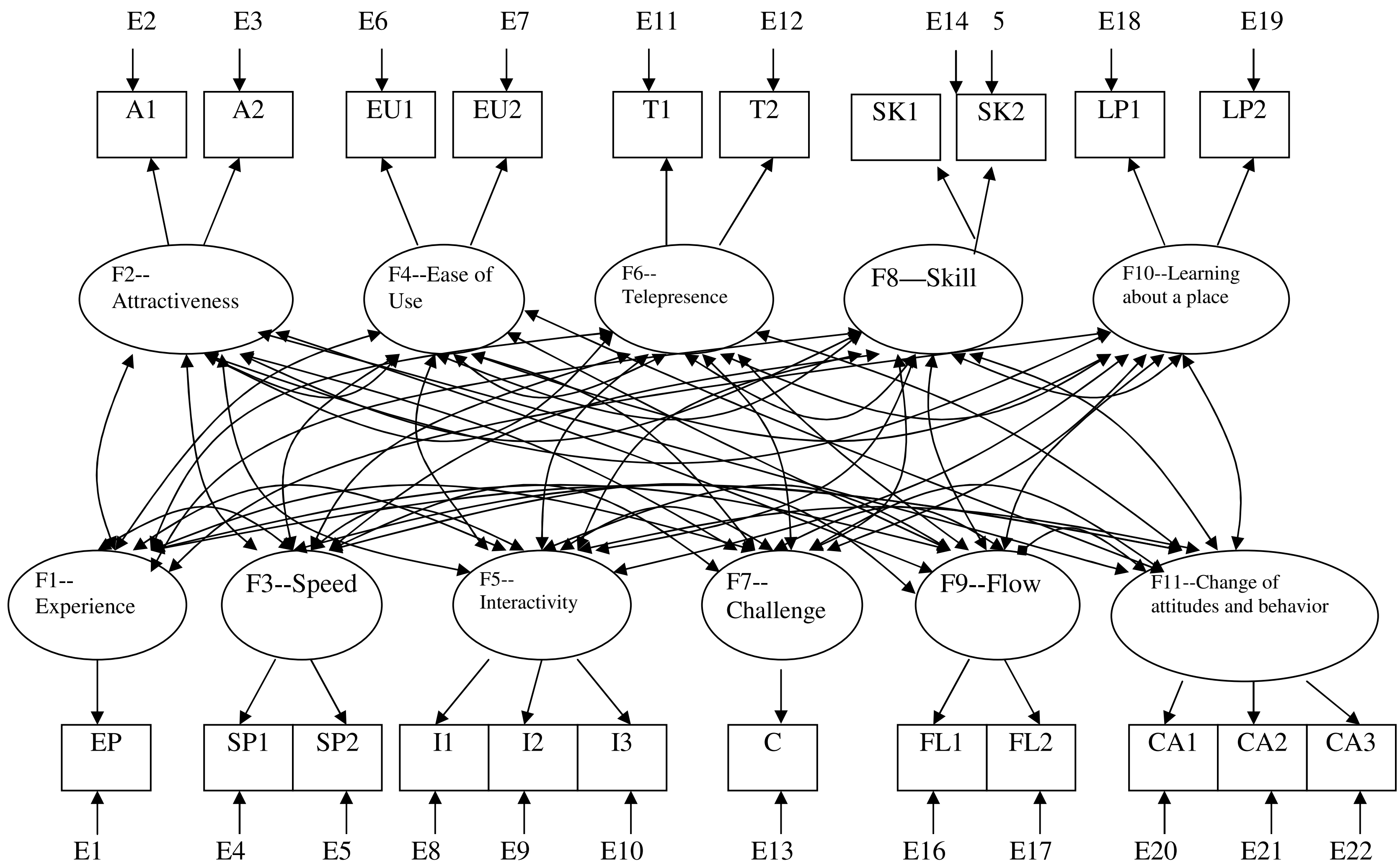
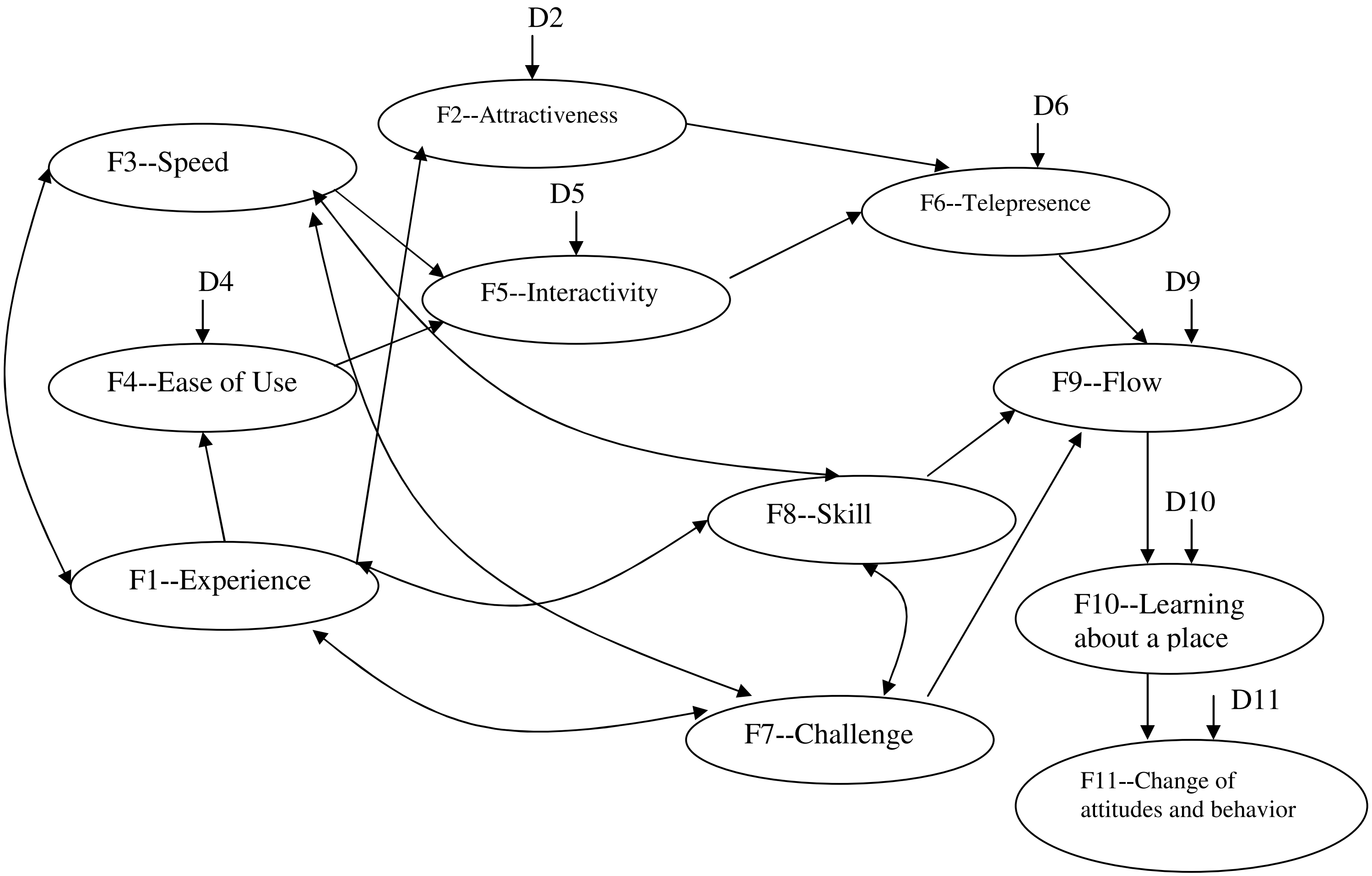


Figure 7.3. Structural model part of the flow model



(3) other fit indices should meet the minimum level of being acceptable, and

(4) normalized residuals should be small and centered around zero.

These requirements were recommended by Hatcher (1994). This research used the combination of these requirements to evaluate whether a CFA model fit the data. A CFA model was considered to fit only if all these conditions were met.

Evaluate the Fit of the Original Measurement Model

A SAS program was submitted to the model-fitting procedure Proc CALIS. This research used the maximum likelihood estimation method to test the flow model. It asked the model-fitting program to use a covariance matrix to evaluate the measurement model. Latent variables must have scales (metrics) in order for a computer to calculate estimates. The variance of each latent variable was fixed to be 1.0 to reduce the number of parameters to estimate.

A common practice with structural equation modeling is to use a diagram to illustrate the estimation of all the parameters for confirmative factor analysis and path analysis. However, because of the complexity of this model (see Figure 7.2) it is impossible to diagram the CFA analysis results in a readable way. The selected output for the CFA analysis for the original measurement is listed as Output pages 1 – 9 (Appendix F). Output page 1 reports fit indexes. The results of the model fitting program suggest an acceptable initial fit in many ways (chi-square /df = 3.4, RMSEA = 0.0976, CFI = 0.9173). The general sequence of assessing the fit between the model and the data in this research were: first review the selected fit measures, and then proceed to indices that provide a more detailed assessment on the fit of various parts in the model. Table 7.4 reports the selected fit measures for the initial measurement model.

Chi-square Test

The chi-square test for the initial CFA model is 531.2720.The degrees of freedom are 154. The chi-square/df ratio is 3.4. Kline's suggests that the ratio of chi-square/df should be less than 3.0 for an acceptable fit. The value of chi-square/df ratio for the initial measurement model falls short of Kline's criterion.

Other Fit Indices

The values of CFI, NFI and NNFI for the initial CFA model were relatively high. The value of CFI was 0.9173 indicating an acceptable fit. However, values of NFI and NNFI for the model are 0.8891 and 0.8759, which are less than the suggested level of an acceptable fit of 0.9.

Another fairly widely used index is the root mean square error of approximation (RMSEA). Models that have a RMSEA of 0.10 or more have a poor fit. A confidence interval can be computed for the index. Ideally the lower value of the confidence interval is very near zero and the upper value is "not very large."

TABLE 7.4

Selected fit measures of the initial measurement model

Fit measures	Values
Chi-square	531.270
Degrees of freedom	154
Chi-square/df	3.4
Bentler's Comparative Fit Index (CFI)	0.9173
Bentler & Bonett's (1980) NFI	0.8891
Bentler & Bonett's Non-normed Index (NNFI)	0.8759
RMSEA	0.976

The values related to RMSEA for the CFA model are reproduced here:

RMSEA Estimate	0.0976
RMSEA 90% Lower Confidence Limit	0.0886
RMSEA 90% Upper Confidence Limit	0.1068

The result of RMSEA also suggests a moderate fit of the model.

Significance of Factor Loadings, Standardized Path Coefficients and R-square Values

Factor loadings are listed in Output page 2 and 3. A factor loading is an un-standardized path coefficient from a latent variable to a measurement variable. If a factor loading is non-significant, it means that the measurement variable does not measure the underlying factor well. The non-standardized loadings along with the correspondent standard errors and *t* values are listed on Output page 2.

It was especially pertinent to determine if there was a near zero standard error. A near zero standard error usually indicates an estimation problem. Reviewing the output, there was no such problematic standard error.

t values represent the *t* tests of the null hypothesis that the factor loading is equal to zero. The *t* values in the output show that all factor loadings were larger than 3.291. This means that all the factor loadings were significant at $p < 0.001$ level.

Standardized path coefficients appear on Output page 4. The output shows that the standardized loadings were reasonably large, ranging from 0.6615 – 0.9987. This indicates that these measurement variables did measure the correspondent latent factors.

The values of R-square are listed in Output page 5. The interpretation of R-square is the percentage of the variance of the dependent variable explained or accounted for by the explanatory variables. In this situation, the dependent variables are the measurement variables, and the explanatory variables are the latent factors. In other words, because each indicator is specified to measure a single factor, the standardized loadings are interpreted as correlations and their squared values as proportions of explained variance. The squared multiple correlation (R^2) calculated for each indicator larger than 0.5 means that more than half of an indicator's variance is explained by the factor it measures. For instance, the standard loading of T1 on factor T (telepresence) was 0.8664, indicating factor T accounts for 0.8664^2, or 0.7506 of indicator T1's variance. Measurement errors reported depict proportions of unexplained variance. The R-square values were all above 0.4, indicating the fit of the measurement model was good.

Correlations among Latent Factors

Output page 6 reports correlations among latent factors. Most of the correlations were within an acceptable range. However, there were four pairs of factors that demonstrated high levels of correlation. They were F2:F4, F4:F5, F2:F9 and F4:F9.

Normalized Residuals

The distribution of normalized residuals and the ten Largest Normalized Residuals are listed in Output page 7. If a model fit the data well, the distribution of the normalized residuals should be centered around zero, be symmetrical, and contain no or few large residuals (Hatcher 1994). The output shows that the distribution of the normalized residual satisfies the requirements of being centered around zero, and appears symmetrical. However, there are five residuals that are larger than 2.0. Residual larger than 2.0 normally indicate estimation problems (Hatcher 1994), for example, the model overestimates or underestimates the strength of relationships between the variables.

In summary, the evidence for the adequacy was mixed. Various parts of the output of the model-fitting program support that overall the original CFA model fit the data reasonably well. However the value of chi-square/df, fit index NNFI and the five large normalized residuals also indicate that some part of the model fit does not fit the data very well. Revisions to the model are discussed below.

Identify Ways to Improve the Initial Measurement Model

Although values of fitness indices indicate the overall fitness of the model was favorable, it is possible that some parts of the model may poorly fit the data. Therefore, it was necessary to make a closer examination of other parts of program's output.

As mentioned above, normalized residuals larger than 2.0 indicate estimation problems. The first five largest residuals listed in Output page 7 are reproduced here in Table 7.5.

The output shows that T1 is involved in three of the top five residuals. The normalized residual of SP1:I3 ranks the second. To determine why these residuals are large, it was necessary to examine the matrix of actual covariance and the predicted covariance matrix. The actual covariance matrix is listed in Output page 8 and the

TABLE 7.5

Largest normalized residuals for the initial measurement model

Row	Column	Residual
FL1	T1	4.30175
I3	SP1	4.22465
I3	SP2	3.03264
T1	SP1	2.92608
T1	SP2	2.67105

predicted covariance matrix is listed in Output page 9. Table 7.6 provides a comparison of the actual covariance and the predicted covariance.

It appears that the predicted covariance is somewhat smaller than the actual covariance. This means that the CFA model underestimates the strength of the relationship between FL1 and T1, the relationship between I3 and SP1, and the relationship between I3 and SP2. The fact that the discrepancy between the sample covariance matrix and the predicted matrix is not very large agrees with the previous conclusion that the model appears to have a moderate fit. The reason for this underestimation may be complicated. A possible cause was that these measurement variables were measuring more than one latent factor. A safe way to proceed is to drop off the three variables involved, T1, I3, and SP1, from the measurement model. T1 is one of the measurement variables for telepresence; I3 is one of the measurement variables for interactivity; and SP1 is one of the measurement variables for speed. Deleting these variables could improve the performance of the measurement part of the flow model. It would not have an impact on the original conceptual flow model because the structural equation part of the flow model was not affected.

Evaluating the Fit of Revised Measurement Model A

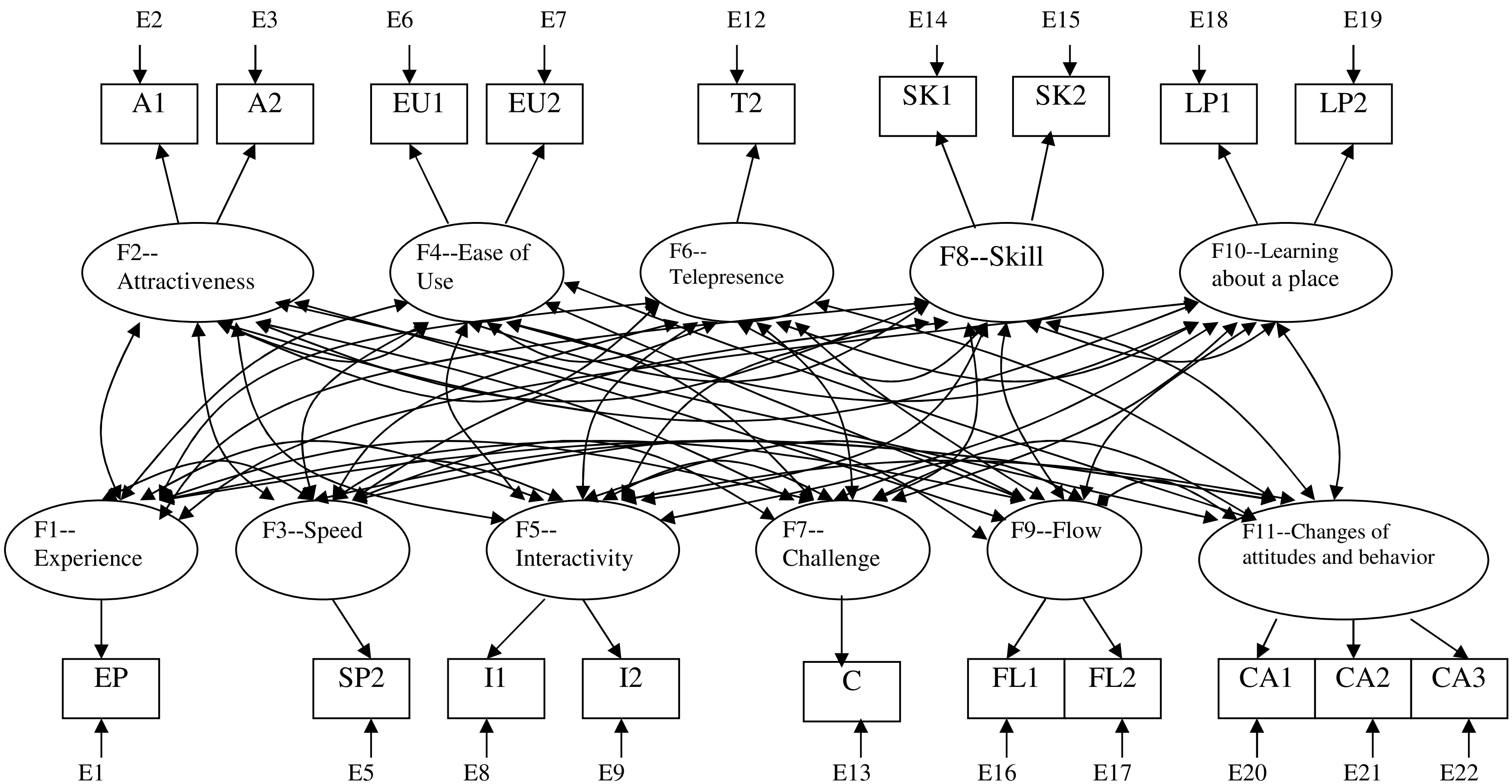
Figure 7.4 shows the revised CFA model. Three measurement variables, T1, I3 and SP1, were dropped from the model. The SAS program reflecting this change is listed in Appendix E.

TABLE 7.6

Comparison of the actual covariance and predicted covariance of the initial CFA model

Variable pair	Actual Covariance	Predicted Covariance
FL1:T1	0.5441	0.2611
SP1:I3	0.6716	0.4190
I3:SP2	0.5618	0.3743

Figure 7.4. Revised measurement model A for confirmative factor analysis



The selected output for the revised measurement model A is listed as Output page 10 – 16 (Appendix F). The results show that the modified model provides a satisfactory fit to the data. Table 7.7 shows the comparison of the major fit measures.

Chi-sqaure Value and Goodness of Fit Indexes

As shown in Table 7.7, the value of chi-square has improved from 531.2720 to 255.2268. Although the degrees of freedom reduced from 154 to 97 because of the drop of three variables from the model, the ratio of chi-square/df for the revised model is only 2.629. This value meets the requirement of less than 3.0 as suggested by Kline (1998). The RMSEA value for the revised model is also smaller. The major fit indices, CFI, NNFI and NFI are not only higher than those of the original model, they are also above 0.9, all indicating a good fit.

Factor Loadings and Path Coefficients

The t tests for the factor loadings of the revised model are listed in Output page 10. They are all much larger than 3.291. This means that all the factor loadings are significant at $p < 0.001$ level. The standardized factor loadings appear in Output page 11. They are all above 0.6.

Normalized Residuals

Output page 16 lists the top ten largest normalized residuals. They are all below 2.0, much smaller than the original model. This indicates that all the estimations of the relations between indicators and their correspondent latent factors are acceptable.

TABLE 7.7

Comparison of fit measures for the initial measurement model and revised measurement model A

Fit measures	Original Measurement Model	Revised Measurement Model A
Chi-Square	531.2720 (df = 154)	255.2268 (df = 97)
Chi-Square/df	3.448	2.629
RMSEA Estimate	0.0976	0.0797
Bentler's Comparative Fit Index (CFI)	0.9173	0.9572
Bentler & Bonett's Non-normed Index (NNFI)	0.8759	0.9246
Bentler & Bonett's (1980) NFI	0.8891	0.9341

R-Square and Composite Reliability

Although the output for the revised model indicates a good-fit CFA model, it is prudent to evaluate the measurement reliability for each latent factor before the modified CFA model is used for the second step's structural equation modeling process. Composite reliability is computed through R-square values and standardized factor loadings. It is not always necessary to compute composite reliability. However, because R-square implies measurement reliability (Hatcher 1994), it is necessary to evaluate the composite reliability for factors with all their indicators displaying low R-square values. Output page 15 shows that R-square values for each indicator ranges from 0.44 to 0.99. Only indicators for factor F8 (SK) display relatively low R-square values with R-square for SK1 0.4905 and SK2 0.4368. A factors composite reliability is calculated as:

$$\text{Composite reliability} = \frac{\left(\sum L_i\right)^2}{\left(\sum L_i\right)^2 + \sum Var\left(E_i\right)}$$

where L_i = the standardized factor loadings

$Var(E_i)$ = the error variance, or $1-R^2$.

(Hatcher 1994, 326)

Table 7.8 provides the information needed for the above equation. With the information on Table 7.8 and the equation for composite reliability, the composite reliability for F8 was calculated as 0.633. This value is above the minimum acceptable

TABLE 7.8

Information needed to compute composite reliability
for F8 (skill) in revised measurement model A

Measurement Variables	Standardized Loading	R^2	$1-R^2$
SK1	0.7003	0.4905	0.5095
SK2	0.6609	0.4368	0.5632

level of 0.6 as suggested by Hatcher (1994). Therefore, the measurement reliability for latent variable F8 was acceptable. This CFA model was used in the next step's path analysis. Note that, whereas the resulting model was based on an extensive data-fitting process, this did not cause any changes of the original conceptual flow model. This is because the CFA process only affects the measurement part of the model. The purpose of this process was to find problematic indicators that failed to satisfactorily measure the correspondent latent factors. The structure of the original flow model was intact so far.

Path Analysis of the Structural Equation Model

This step tested the theoretical suppositions proposed in Chapter III based on the result of the confirmative factor analysis. The CFA analysis resulted in an acceptable measurement model – the revised measurement model A that fits the data (Figure 7.4). The measurement model was converted to a structural equation model that presents the relationships specified in the flow model. Figure 7.5 shows the conceptual structural equation model representing these relations.

Evaluating the Fit of the Initial Structural Model

Output pages 17 - 29 (Appendix F) display the selected results of the model-fitting program. Table 7.9 reports the selected fit measures as reported in Output page 17.

As with CFA, assessing the fit of a structural equation model involves inspecting various aspects of the statistical characteristics of that model. Hatcher (1994, 197) suggests that if a path model demonstrates an ideal fit to the data, it should meet the following requirements:

Figure 7.5. The initial flow model with modifications on the measurement variables

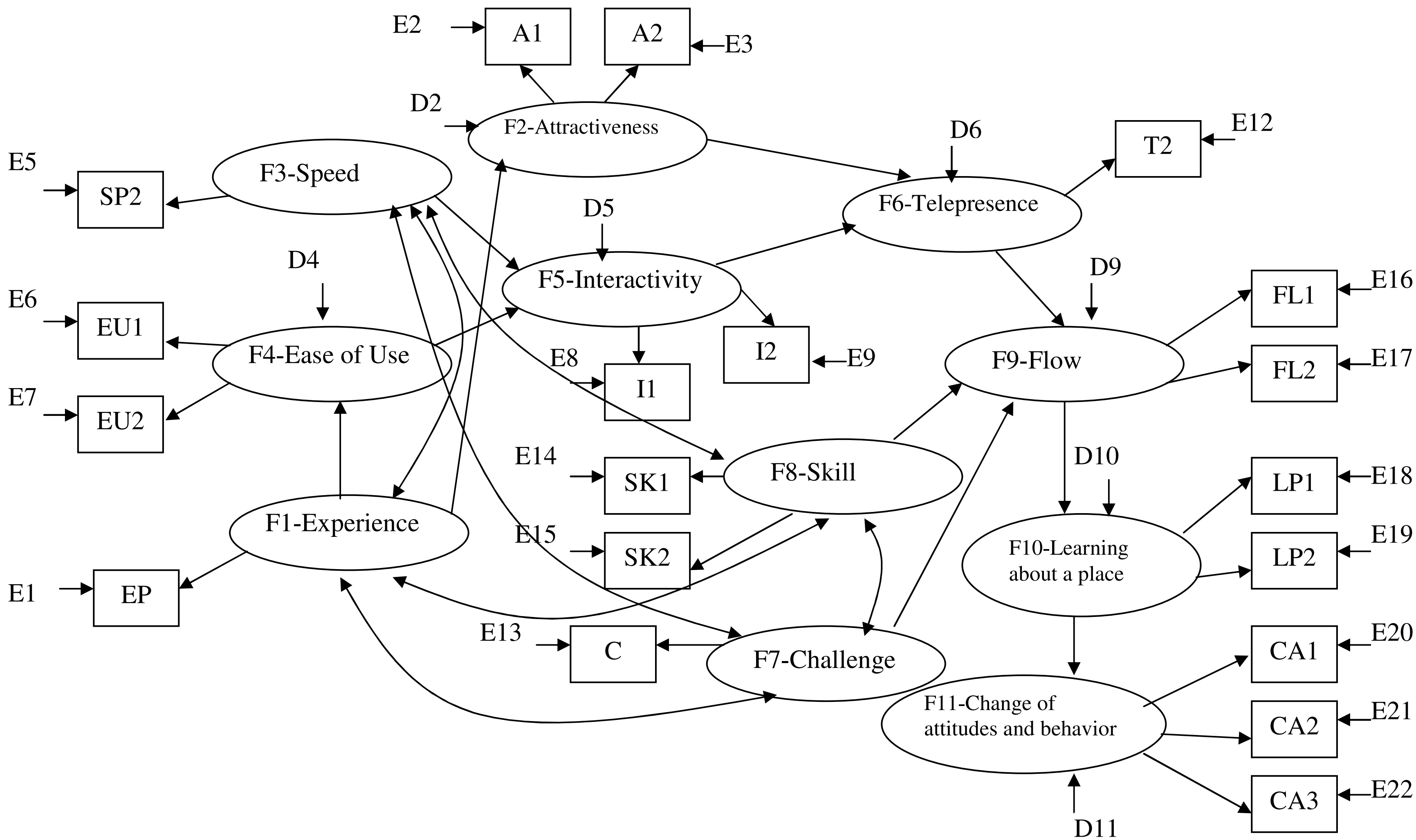


TABLE 7.9

Selected fit measures for the initial structural model

Fit Measures	Values
Chi-square	393.9842
Degrees of freedom	133
Chi-square/df	2.96
Bentler's Comparative Fit Index (CFI)	0.9295
Bentler & Bonett's (1980) NFI	0.8982
Bentler's Comparative Fit Index (NNFI)	0.9093
RMSEA	0.0874

1. The absolute values of entries in the normalized residual matrix should not exceed 2.00.
2. The *p* value associated with the model chi-square test should exceed 0.05; the closer to 1.00, the better.
3. The comparative fit index (CFI) and the non-normed fit index (NNFI) should both exceed 0.9; the closer to 1.00, the better.
4. The R^2 value for each endogenous variable should be relatively large.
5. The absolute value of the *t* statistics for each path coefficient should exceed 1.96, and the standardized path coefficients should be nontrivial in magnitude.

He also pointed out that a model does not have to demonstrate all of these characteristics in order to be acceptable. In fact, many research articles only use the chi-square test and major goodness of fit indices to evaluate the fitness of a theoretical model. Nonetheless, this research compared the output against the requirements 1, 3, 4, and 5 in order to have the confidence to accept or reject the model being tested. Requirement 2 was not used in evaluating the fit of the model. As stated earlier, the chi-square value is very sensitive to sample sizes. A chi-square test could easily be significant with the large sample size used in this research. Thus, the ratio of chi-square/df was used instead.

Assessing the overall fit of the path model based on the above recommendations, the original structural model provides an excellent initial fit. The following sections examine these statistical characteristics in detail.

Chi-square

As with CFA, the first step was to examine the value of chi-square and other goodness of fit indices listed in Output page 17. The value of chi-square is 393.9843 with degrees of freedom of 133. The ratio of chi-square/df is 2.96, satisfying the recommended level of less than 3.0 for a sample size over 200 (Kline 1998).

Goodness of fit indices

Values of the comparative fit index (CFI), Bentler and Bonett's (NFI) and the non-normed fit index (NNFI) range from 0.8982 to 0.9296. These fit indices are also called comparative fit indices because they are measures based on comparative fit to a baseline model. The baseline model usually assumes complete independence among the observed variables (Kaplan 2000). Therefore, indices ranging from 0.8982 to 0.9296 indicate that the initial flow model is 89.8% - 92.96% of an improvement over the baseline model. CFI for the original theoretical model is 0.9296. NFI for the theoretical model is 0.9033. Both of these exceed the acceptable level of 0.9 as an acceptable fit. NNFI is 0.8982, very close to the recommended acceptable level. In fact, most research would consider, this index level to indicate an acceptable fit. The values of these measures are adequate enough to conclude that the model fits the data moderately.

Significance test for factor loadings and standardized path coefficients

As with CFA, the selected output includes the significant test for factor loadings and standardized path coefficients. They appear in Output pages 18 – 22. The result shows that not all *t* tests for factor loadings are greater than 1.96, which means that some of the factor loadings are not significantly different from zero. Of special interest for the second step's modeling are the path coefficients that constitute the structural portion of the model. Five paths in the model demonstrate non-significant *t* test values. Output page 19 is reproduced here to show the problematic paths.

The paths with low *t*-test values are from F1 (experience) to F2 (attrctiveness), from F1 (experience) to F4 (ease of use), from F3 (speed) to F5 (interactivity), from F7 (challenge) to F9 (flow) and from F8 (skill) to F9 (flow). These results suggest that the causal relationships represented by these paths are not significant at the $p < 0.05$ level. These findings are important because they suggest that these paths could be deleted from the model in the modification process without significant impact on the structural model.

R^2 Values for Latent Endogenous Variables

R^2 values for the model's endogenous variables are presented in Output page 24. The results show that all the R^2 values for the endogenous variables are relatively large, except the one for EP, with R^2 value of 0.00188. The extremely small value of 0.00188 indicates a problem with the path from F1 to its indicator EP that failed to show in previous confirmative factor analysis. Consistent with the R^2 value, the standardized estimation for the path from F1 to EP presented on Output page 21 shows that the path coefficient is only 0.0434. As discovered previously, the *t* test values for the paths from F1 to F2 and from F1 to F4 are insignificant. All these findings indicate that deleting F1 (experience with virtual tour Web sites) would not affect the model's performance.

Output page 19

```
                         The CALIS Procedure
      Covariance Structure Analysis: Maximum Likelihood Estimation

                Latent Variable Equations with Estimates


      F2       =  21.7218*F1       +  1.0000 D2
      Std Err     32.8290 PF1F2
      t Value      0.6617

      F4       =  23.2376*F1       +  1.0000 D4
      Std Err     35.1265 PF1F4
      t Value      0.6615

      F5       =   0.7434*F4       +  0.0491*F3       +  1.0000 D5
      Std Err      0.1085 PF4F5       0.0898 PF3F5
      t Value      6.8536             0.5471

      F6       =   2.2709*F2       +  0.8229*F5       +  1.0000 D6
      Std Err      0.3515 PF2F6       0.2115 PF5F6
      t Value      6.4605             3.8916

      F9       =   0.2575*F6   +  0.0165*F7   +  -0.0610*F8 + 1.0000 D9
      Std Err      0.0680 PF6F9   0.3181 PF7F9    0.1326 PF8F9
      t Value      3.7892         0.0517         -0.4603

      F10      =   1.1071*F9       +  1.0000 D10
      Std Err      0.0893 PF9F10
      t Value     12.3914

      F11      =   0.7772*F10      +  1.0000 D11
      Std Err      0.0504 PF10F11
      t Value     15.4237
```

Normalized Residuals and Their Distribution

Output page 25 displays the distribution of the normalized residuals together with the top ten largest residuals. Considering that this is the first round of the model fitting process, the results of the residuals are very encouraging. They are relatively small and centered around zero with only a few outliers that are greater than 2.0.

Model Modification

To this point, it was clear that the initial specification of the model fit the data modestly well, yet there were still some parts that needed to be modified. This section covers the model modification process. Generally, there are two model modification strategies: model trimming and model building. Model trimming involves dropping paths from a model. Model building is about adding paths (Kline 1998). The goal of model trimming or building is to find a model that fits the data well without violating field knowledge or theoretical feasibility. The hoped-for result of these processes is to find a final model that represents the nature of the relationships that exist in the population. Therefore, whether the modification is interpretable according to theory should determine if a modification is acceptable. The modification process begins with examining the normalized residual matrix, the significance of the causal paths, and the modification indices to find clues for model improvement.

Output page 25

```
                                The CALIS Procedure
                  Covariance Structure Analysis: Maximum Likelihood Estimation

                              Distribution of Normalized Residuals

                                 Each * Represents 2 Residuals

----------Range---------    Freq    Percent

-2.00000      -1.75000       1       0.53
-1.75000      -1.50000       0       0.00
-1.50000      -1.25000       2       1.05    *
-1.25000      -1.00000       5       2.63    **
-1.00000      -0.75000      11       5.79    *****
-0.75000      -0.50000       9       4.74    ****
-0.50000      -0.25000      19      10.00    *********
-0.25000             0      28      14.74    **************
       0       0.25000      43      22.63    *********************
 0.25000       0.50000      19      10.00    *********
 0.50000       0.75000      10       5.26    *****
 0.75000       1.00000       8       4.21    ****
 1.00000       1.25000       9       4.74    ****
 1.25000       1.50000       4       2.11    **
 1.50000       1.75000       3       1.58    *
 1.75000       2.00000       6       3.16    ***
 2.00000       2.25000       3       1.58    *
 2.25000       2.50000       2       1.05    *
 2.75000       3.00000       4       2.11    **
 3.00000       3.25000       0       0.00
 3.25000       3.50000       1       0.53


                                      The CALIS Procedure
                  Covariance Structure Analysis: Maximum Likelihood Estimation

                    Average Normalized Residual                      0.650362
                    Average Off-diagonal Normalized Residual         0.721724


                        Rank Order of the 10 Largest Normalized Residuals

                               Row         Column        Residual

                               CA3         SK1            3.45466
                               CA2         A1             2.98407
                               SK1         EP             2.85090
                               CA2         FL2            2.78747
                               CA2         FL1            2.78470
                               SK2         EP             2.69822
                               CA2         C              2.69750
                               CA2         EU2            2.52363
                               CA2         I1             2.43117
                               CA2         EU1            2.37230
```

Largest normalized residuals

Output page 25 reports the top ten largest normalized residuals. The largest one is 3.45466 related to CA3:SK1. Residuals represent the difference between the actual covariance among measurement variables and the predicted covariance. Therefore, it is necessary to examine the two covariance matrices to identify causes of this discrepancy.

Reported in Output page 26 are the values of the actual covariance matrix. Output page 27 displays the predicted covariances. The actual covariance between CA3 and SK1 is 0.241049075; whereas the predicted covariance is only 0.009547512. The predicted covariance is much smaller than the actual covariance, indicating the theoretical model had underestimated the relationship between these two variables. In other words, the actual relationship between the underlying latent factors of F11 (changes of attitude and behavior) and F8 (knowledge of the place) is much stronger than the original theoretical model implies. This result suggests that a path could be added from F8 to F11. However, it is safer to consult modification indices before making such changes.

Modification indices

The program generated the result of the Lagrange multiplier test. The ten largest Lagrange multipliers in phi matrix are reported in Output page 28. Output page 29 displays the ten largest Lagrange multipliers in gamma. The ten largest Lagrange multipliers in beta are reported in Output page 30. Output page 29 and 30 are reproduced here.

The purpose of the Lagrange multiplier test is to estimate the improvement of the chi-square value by adding a new path or a new covariance to the theoretical model. In

Output page 29

Rank Order of the 10 Largest Lagrange Multipliers in _GAMMA_

Row	Column	Chi-Square	Pr > ChiSq
C	F1	340.55404	<.0001
CA2	F1	36.94140	<.0001
F10	F7	31.62210	<.0001
F11	F1	23.15882	<.0001
CA2	F3	17.01156	<.0001
F11	F8	15.48708	<.0001
FL2	F1	13.52772	0.0002
FL2	F7	11.03317	0.0009
EU2	F1	9.57598	0.0020
F10	F8	8.83329	0.0030

Output page 30

Rank Order of the 10 Largest Lagrange Multipliers in _BETA_

Row	Column	Chi-Square	Pr > ChiSq
F4	F2	67.37661	<.0001
CA2	F2	34.96148	<.0001
F10	C	34.36517	<.0001
CA2	F4	32.08169	<.0001
C	F10	31.74465	<.0001
CA2	F9	30.91481	<.0001
F10	CA2	30.24840	<.0001
CA2	A1	30.23228	<.0001

the phi matrix, the rows and columns consist of the model's exogenous variables. The two largest Lagrange multipliers in phi matrix are all related to the relationships among disturbance and error terms. The program estimated that the chi-square statistics could be improved if covariances were added between the disturbance and error terms. However, adding these relationships can complicate the model, which, according to the SEM literature, should be avoided if possible (Hatcher 1994). Therefore, the results of the phi matrix are disregarded at this point.

In a gamma matrix, the columns consist of the model's exogenous F variables, and the rows consist of the model's endogenous variables. Pairs concerning latent variables are of special interest because they provide hints of adding causal paths to improve the model. Output page 29 shows that one of the largest Lagrange multipliers in the gamma matrix is related to F10 (learning about a place) and F7 (challenge). The program estimated that adding a path from F7 to F10 could significantly reduce the value of the chi-square statistics by 31.6221(p <0.0001). The other pair is associated with the latent variables is F8 (skill) and F11 (challenges of attitude and behavior). The program estimated that if a path were added from F8 to F11, the chi-square value would decrease by 15.48708. This result explains the findings from the values of the normalized residuals in Output page 25 where the largest normalized residual pair is CA3 and SK1. CA3 is one of the indicators of F11, and SK1 is one of the indicators of F8.

The modification indices estimated in the beta matrix also suggested adding relations that may improve the fit statistics of the model. The program estimated that if a path was added from F2 (attractiveness) to F4 (ease of use), the chi-square value would be significantly improved by 67.37661.

The significance of the causal paths and R-square

Of the two model modification approaches, it is generally safer to drop a path than to add one (Bentler and Chou 1987; Kline 1998). Several parts of the output file suggest the need to drop the latent variable F1 (experience with virtual tour Web sites) from the model. First, as discovered earlier, the near-zero level of R-square for EP indicates that the latent factor F1 does not explain the variance of EP adequately. Second, results of factor loadings show that the direct effects of F1 (users' experience with virtual tour Web sites) on F2 (users' evaluation of the attractiveness of the Web site), and the direct effect of the F1 on F4 (users' feeling of the ease of use) are non-significant at 0.05 level (Output page 19). Thus, dropping the paths representing these relations from the model would not affect its performance significantly.

In addition, there are three paths with factor loadings non-significant at the level of 0.05. They are the paths from F3 (speed) to F5 (interactivity), from F7 (challenge) to F9 (flow), and from F8 (skill) to F9 (flow). These paths can be dropped from the model as well (Output page 19).

As a result of this analysis of the output file, the first round of modifications of the initial theoretical model included:

(1). dropping the path linking users' experience with virtual tour Web site (F1) and users' evaluation of the attractiveness of the Web site (F2),

(2). dropping the path connecting users' experience with virtual tour Web site (F1) and users' experience of ease of use (F4),

(3). dropping the latent variable *experience* (F1) from the model,

(4). dropping the path connecting challenge (F7) to flow (F9), (5). dropping the path connecting skill (F8) to flow (F9),

(6). adding one path connecting F11 (changes of attitude and behavior) and F8 (knowledge about the place),

(7). adding one path connecting *attractiveness* (F2) and *ease of use* (F4), and

(8). adding a path connecting F7 (the Web site reviews something new) and F10 (*learning about a place)*

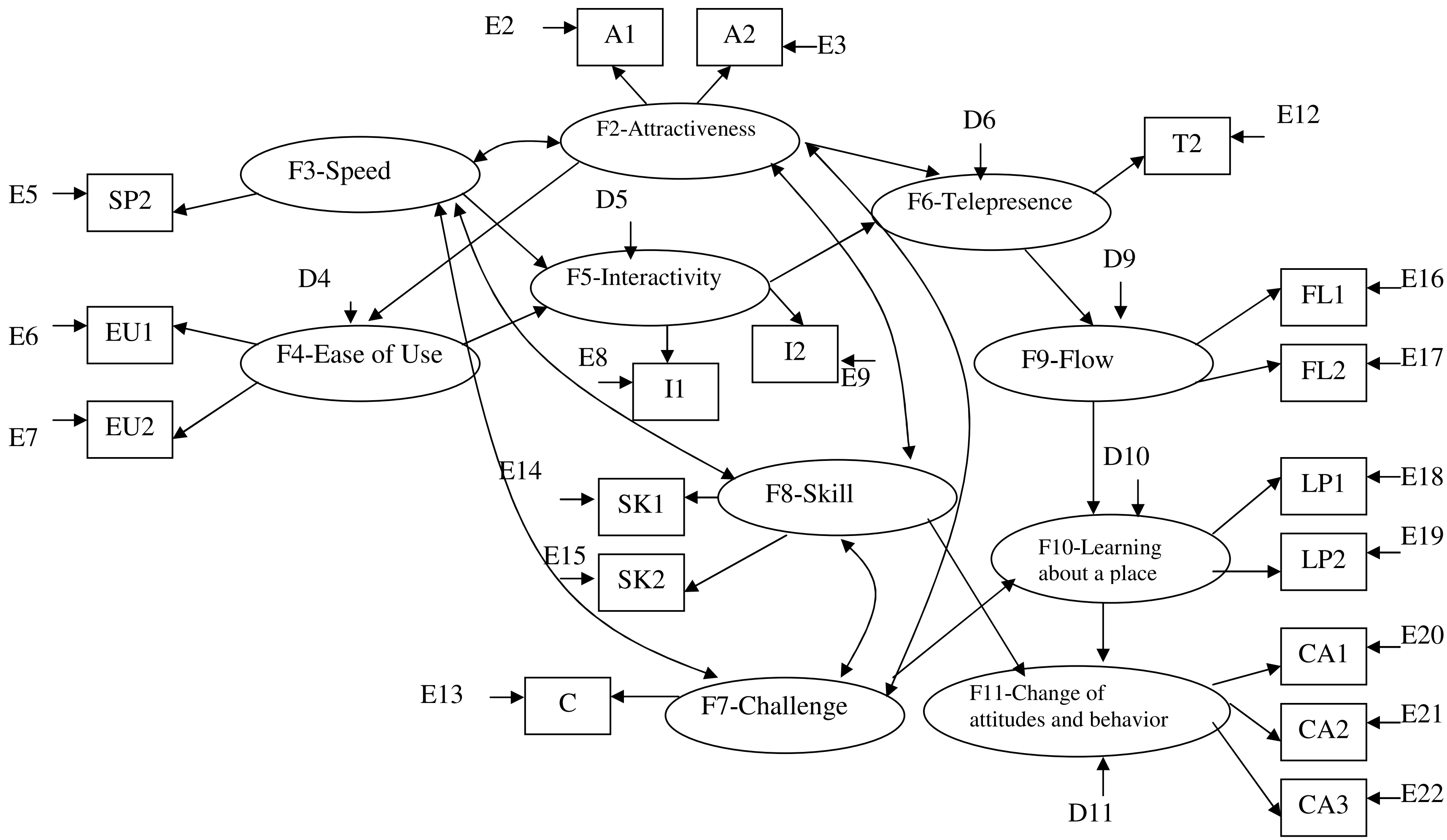
The three new paths added are all theoretically defensible. They represent important relationships between these factors in the context of browsing an interpretive Web site. The path connecting F7 and F10 reveals that if a Web site's contents provide something new that challenges visitors' knowledge base, they tend to have positive feelings toward learning more about the place after visiting the Web site.

The new path connecting F2 and F4 indicates that the more attracted a user is to a Web site, the more he can tolerate the Web site's usability when he is browsing the Web site. The path connecting F8 and F11 implies that domain knowledge, in this case, knowledge about birding, has a positive influence on taking positive actions after getting information from the Web site.

Evaluating the Fit of Revised Structural Model A

Figure 7.6 shows the revised structural equation model – revised model A. The latent variable F1 was deleted from the model together with the two paths linking it with F2 and F4. Two other paths, F7 $\rightarrow$ F9, and F $\rightarrow$ F9 were deleted from the original model. Three paths were added: F2 $\rightarrow$ F4, F8 $\rightarrow$ F11, F7 $\rightarrow$ F10.

Figure 7.6. Revised structural model A



Chi-square and Other Selected Fit Measures

Table 7.10 reports the differences of the major fit measures between the original structural model and the revised structural model A. It is clear that the revised model fits the data significantly better than the original model. The dramatic improvement is seen from the changes of the chi-square statistics. The chi-square value decreased from 393.9842 to 303.8852. The ratio of chi-square/df changed from 2.9623 to 2.5753. All the goodness of fit indices indicate a better fit. Bentler's Comparative Fit Index (CFI) has reached 0.9494. Bentler and Bonett's NFI and NNFI are all over 0.9.

It seems that a decision could be made to select the revised structural model A as the final theoretical model. However, fit indexes indicate only the overall or average fit of a model. It is possible some part of the model fits the data poorly even if the values of fit indexes appear to be favorable. Therefore, it is necessary to inspect other parts of the output file before accepting the model. As usual, the distribution of normalized residuals should be consulted first.

Normalized Residuals and Their Distribution

Shown below is Output page 39. It reports the distribution of normalized residuals for the revised model A. It is apparent that there is improvement in the values of the normalized residuals and their distribution. The majority of the values are very small with only a few slightly over 2.0. Compared to the distribution of the normalized residuals for the original model reported in Output page 25, the distribution of the normalized residuals of revised structural model A is much closer to zero. Due to a few outlying residuals at the bottom of the table, the distribution is somewhat asymmetrical.

TABLE 7.10

Comparison of the selected fit measures between the original structural model and revised structural model A

Fit Measures	Original Structural Model	Revised Structural Model A
Chi-Square	393.9842 (df = 133)	303.8852 (df = 118)
Chi-Square/df	2.9623	2.5753
RMSEA Estimate	0.0874	0.0783
RMR	0.0635	0.0540
Bentler's Comparative Fit Index (CFI)	0.9295	0.9494
Bentler & Bonett's Non-normed Index (NNFI)	0.9093	0.9344
Bentler & Bonett's (1980) NFI	0.8982	0.9206

Output page 39

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Distribution of Normalized Residuals

Each * Represents 2 Residuals

----------Range---------		Freq	Percent	
-1.50000	-1.25000	2	1.17	*
-1.25000	-1.00000	4	2.34	**
-1.00000	-0.75000	6	3.51	***
-0.75000	-0.50000	10	5.85	*****
-0.50000	-0.25000	21	12.28	**********
-0.25000	0	29	16.96	**************
0	0.25000	40	23.39	********************
0.25000	0.50000	16	9.36	********
0.50000	0.75000	11	6.43	*****
0.75000	1.00000	9	5.26	****
1.00000	1.25000	5	2.92	**
1.25000	1.50000	4	2.34	**
1.50000	1.75000	4	2.34	**
1.75000	2.00000	3	1.75	*
2.00000	2.25000	2	1.17	*
2.25000	2.50000	4	2.34	**
2.50000	2.75000	1	0.58	

Average Normalized Residual 0.536222
Average Off-diagonal Normalized Residual 0.597837

Rank Order of the 10 Largest Normalized Residuals

Row	Column	Residual
CA2	A1	2.52983
CA2	FL1	2.49754
CA2	FL2	2.48359
CA2	I1	2.45583
CA2	EU2	2.25553
CA2	I2	2.19219
CA2	EU1	2.11341
CA2	T2	1.87783
CA1	T2	1.83603
FL1	T2	1.77644

Output page 39 also provides the rank order of the ten largest normalized residuals. It shows that all the large residuals that are over 2.0 are related to the measurement variable CA2, which is one of the measures of latent variable F11. Does the model underestimate the impact of other latent variables on F11 directly or indirectly? This is possible, but the modification indices needed to be reviewed first.

Modification Indexes

Only results of Output page 41 and 42 are listed here. Output page 40 displays the ten largest Lagrange multipliers in the phi matrix. They all suggest adding paths to connect error terms or disturbances. In order to keep the model simpler, these changes were not considered.

Output page 41 reports the ten largest Lagrange multipliers in the gamma matrix. Two large multipliers are F11:F2 and F11:F7. The test suggests that if paths were added from F2 (attractiveness of the Web site) to F11 (changes of attitudes and behavior), and from F7 (the Web site reviews something new) to F11 (changes of attitudes and behavior), the chi-square would improve significantly. The path from F2 to F11 indicates that the attractiveness of a Web site depicting a geographical place could have direct impact on visitors' willingness to seek more information about the place, or to visit that place. The path from F7 to F11 suggests that challenge (the Web site reviewing something new about a place) also exhibits impacts on people's changes of attitude and behavior.

Output page 41

The CALIS Procedure

Covariance Structure Analysis: Maximum Likelihood Estimation

Rank Order of the 10 Largest Lagrange Multipliers in _GAMMA_

Row	Column	Chi-Square	Pr > ChiSq
CA2	F2	33.34003	<.0001
FL1	F2	25.45789	<.0001
FL2	F2	22.53041	<.0001
F11	F2	16.15274	<.0001
F11	F7	14.94507	0.0001
CA2	F3	13.34413	0.0003
CA2	F7	9.77751	0.0018
EU2	F2	9.27393	0.0023
CA1	F8	7.08763	0.0078
A2	F7	6.47679	0.0109

Output page 42

Rank Order of the 10 Largest Lagrange Multipliers in _BETA_

Row	Column	Chi-Square	Pr > ChiSq
F6	FL2	34.92801	<.0001
CA2	F9	30.64527	<.0001
CA2	F4	29.48325	<.0001
CA2	A1	27.85745	<.0001
F10	CA2	27.10155	<.0001
CA2	F6	26.50900	<.0001
CA2	EU2	26.35751	<.0001
F10	F11	26.03986	<.0001
LP2	LP1	24.07883	<.0001
LP1	LP2	24.06260	<.0001

Output page 42 displays the ten largest Lagrange multipliers in the beta matrix. One of the large multipliers is associated with the latent variables F10 (learning of a place) and F11 (changes of attitude and behavior). However, their relationship has been defined in the theoretical model, thus, the results in the beta matrix are disregarded.

After consulting the modification indices, revised structural model A was modified as revised structural model B by

(1). adding a path from F2 (attractiveness) to F11 (change of attitudes and behavior), and

(2). adding a path from F7 (challenge) to F11 (change of attitudes and behavior).

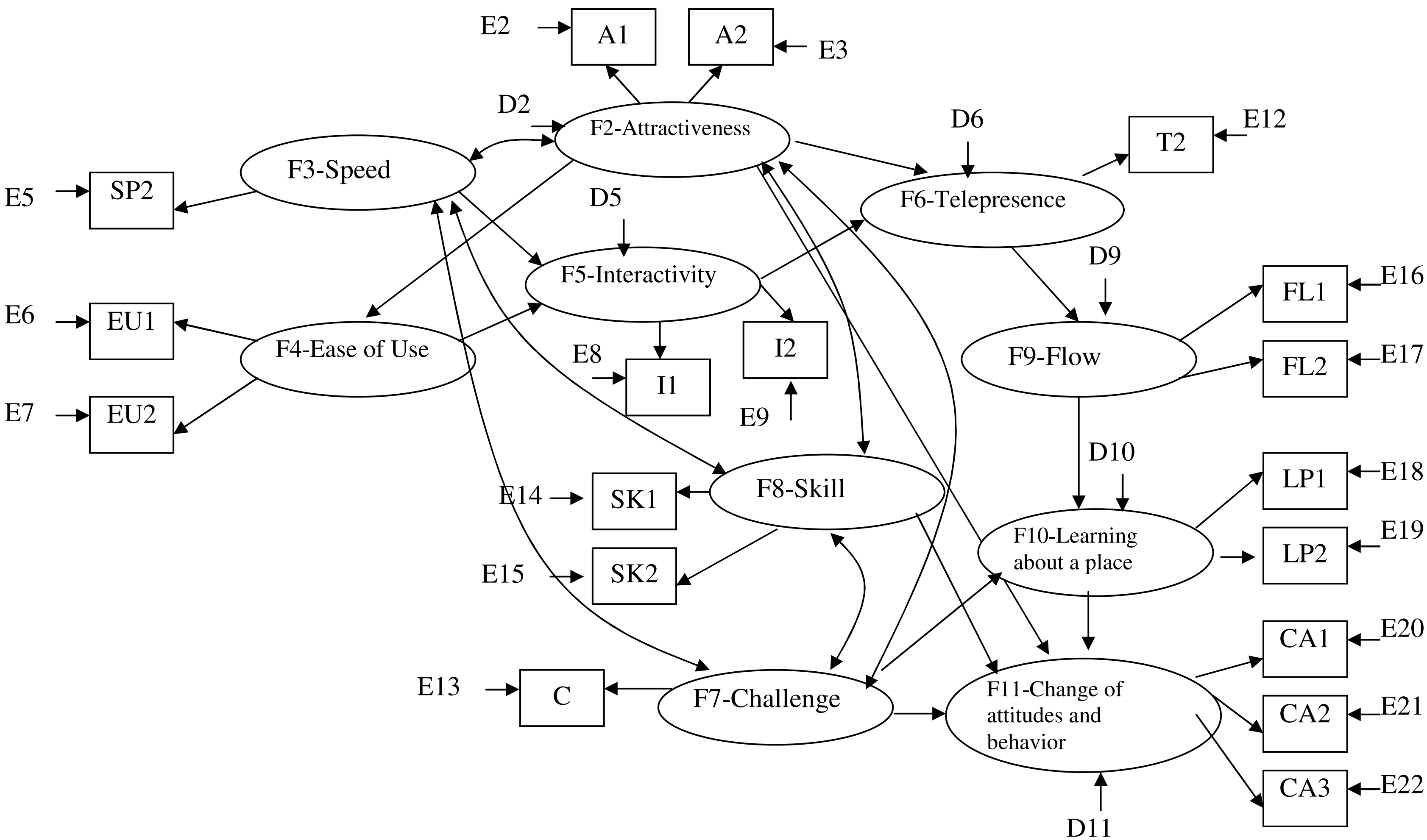
Evaluating the Fit of Revised Structural Model B

Figure 7.7 presents revised structural model B. Output pages 43 - 54 (Appendix F) report the testing results for revised structural model B. As usual, considering the multifaceted nature of the model fitting process, various aspects of the results need to be examined. All the major fit indexes indicate a better fit than revised structural model A.

Chi-square and Other Selected Goodness of Fit Indexes

The value of chi-square statistics for the revised model B is 282.7732. With the degrees of freedom of 116, the ratio of chi-square/df is 2.4377. This value satisfies the recommended chi-square/df ratio of less than 3.0.

Figure 7.7. Revised structural model B



The values of goodness of fit indexes, CFI, NFI and NNFI are not only above 0.9, they are also higher than those displayed in revised model A. Table 7.11 compares the major fit indexes of the three structural models developed so far.

Chi-square Difference Test

Two models are considered to be hierarchically related if changes are made only by adding or deleting paths. A chi-square difference test can be used to test the difference of the fit between hierarchically related models. Because revised model structural A and revised structural model B are hierarchically related, a chi-square difference test was used to compare the two models' fit. The results of the chi-square test between the two models are as follows:

Revised Model A without paths F2-F11 and F7-F11:

chi-square (118) = 303.8852;

Revised Model B with paths F2-F11 and F7-F11:

chi-square (116) = 282.7732;

Chi-square difference (df = 118 – 116 = 2) = 303.8852 - 278.2499 = 25.6352 (p<0.001).

The Chi-square difference test that compares structural model A and structural model B reveals a significant difference value of chi-square difference (df = 2, p < 0.001). This finding shows that revised structural model B provides a fit to the data that is significantly better than the fit provided by revised structural model A.

TABLE 7.11

Comparison of the selected fit measures for the original structural model, revised structural model A and revised structural model B

Fit Measures	Original Model	Revised Model A	Revised Model B
Chi-Square	393.9842	303.8852	282.7732
	(df=133)	(df = 118)	(df=116)
Chi-Square/df	2.96	2.5753	2.46
RMSEA Estimate	0.0874	0.0783	0.0748
RMR	0.0635	0.0540	0.0460
Bentler's Comparative Fit Index (CFI)	0.9295	0.9494	0.9546
Bentler & Bonett's Non-normed Index (NNFI)	0.9093	0.9344	0.9402
Bentler & Bonett's (1980) NFI	0.8982	0.9206	0.9261

Normalized Residuals and Their Distribution

The major improvement of structural model B over structural model A is shown on the values of normalized residuals. Output page 51 shows that all the normalized residuals are below 2.0. Their distributions are all closer to zero and fairly symmetrical. This result indicates that the discrepancy between the actual covariance of variables and the predicted covariance of the variables is very small.

R-Square Values for Endogenous Variables and Significance of Path Coefficients

Output page 50 presents R-square values for all the endogenous variables. Of special interest are the values for the structural model's endogenous latent variables. The results show that they are all over 0.6. This value indicates that their predictors explain over 60% of their variances.

Of special interest is the significance of factor loadings and path coefficients for the portion of the structural equation model. Output page 45 shows that the t-tests for factor loadings connecting latent variables all exceed 1.96, except for the path from F7 to F11. This indicates that all factor loadings are significant at the 0.05 level except for the path from F7 to F11. Although the standardized path coefficient for the path from F7 to F11 is 0.1549, exceeding the level of 0.05 as being trivial (Hatcher 1994). The t-test value for the factor loading is only 1.3530. This value falls just short of the value required for significance at the 0.05 level. Therefore, despite all the other favorable results that suggest revised structural model B is satisfactory, it would be interesting to see if deleting the path from F7 (challenge) to F11 (changes of attitude and behavior) would affect the fit of the model.

```
Output page 48

                            The CALIS Procedure
                  Covariance Structure Analysis: Maximum Likelihood Estimation

                            Latent Variable Equations with Estimates

    F4       =    0.9946*F2       +  1.0000 D4
      Std Err      0.0620 PF2F4
      t Value     16.0392


      F5       =    0.7779*F4       +  1.0000 D5
      Std Err      0.0506 PF4F5
      t Value     15.3696


      F6       =    0.2392*F5       +  0.8178*F2       +  1.0000 D6
      Std Err      0.0697 PF5F6        0.0560 PF2F6
      t Value      3.4297             14.6077

      F9       =    0.7717*F6       +  1.0000 D9
      Std Err      0.0393 PF6F9
      t Value     19.6579

      F10      =    0.6826*F9       +  0.3798*F7       +  1.0000 D10
      Std Err      0.1717 PF9F10       0.1718 PF7F10
      t Value      3.9748              2.2105


      F11      =    0.4746*F10  +  0.2453*F2   +  0.1425*F7   +  0.2848*F8    +  1.0000 D11
      Std Err      0.0765 PF10F11  0.0890 PF2F11   0.1054 PF7F11  0.0821 PF8F11
      t Value      6.2045          2.7555          1.3530         3.4690
```

Evaluating the Fit of Revised Structural Model C

Figure 7.8 shows revised structural model C. The path connecting F7 (challenge) and F11 (changes of attitude and behavior) was deleted.

Chi-square Value and Other Selected Fit Measures

Output pages 55 – 63 (Appendix F) report the selected output for revised structural model C. Table7.12 compares the results of the four structural models tested

Results reported in Table 7.12 shows that the major fit measures of revised structural model C are very close to those of revised structural model B. In fact, they are almost identical except for the chi-square statistics. The value of chi-square shows that the results for revised structural model C is slightly less favorable than structural model B. Is this difference in chi-square value significant enough to say that structural model B provides a better fit than structural model C? Results of the chi-square test between the two models are as follows:

Revised structural model B with F7 – F11: chi-square (113) = 282.7732;

Revised structural model C without F7 – F11: chi-square (117) = 287.8970;

Chi-square difference (df = 117 – 113 = 4) = 287.8970 - 282.7732 = 5.1238.

The chi-square difference is 5.1238 with degrees of freedom of 4. This statistic falls just short of the value required for significance at the level of 0.25 (5.38527). Apparently deleting the path of F11:F7 did not hurt the overall model's fit. Thus, a conclusion can be drawn that from the statistics of chi-square test and other goodness of.

Figure 7.8. Revised structural model C

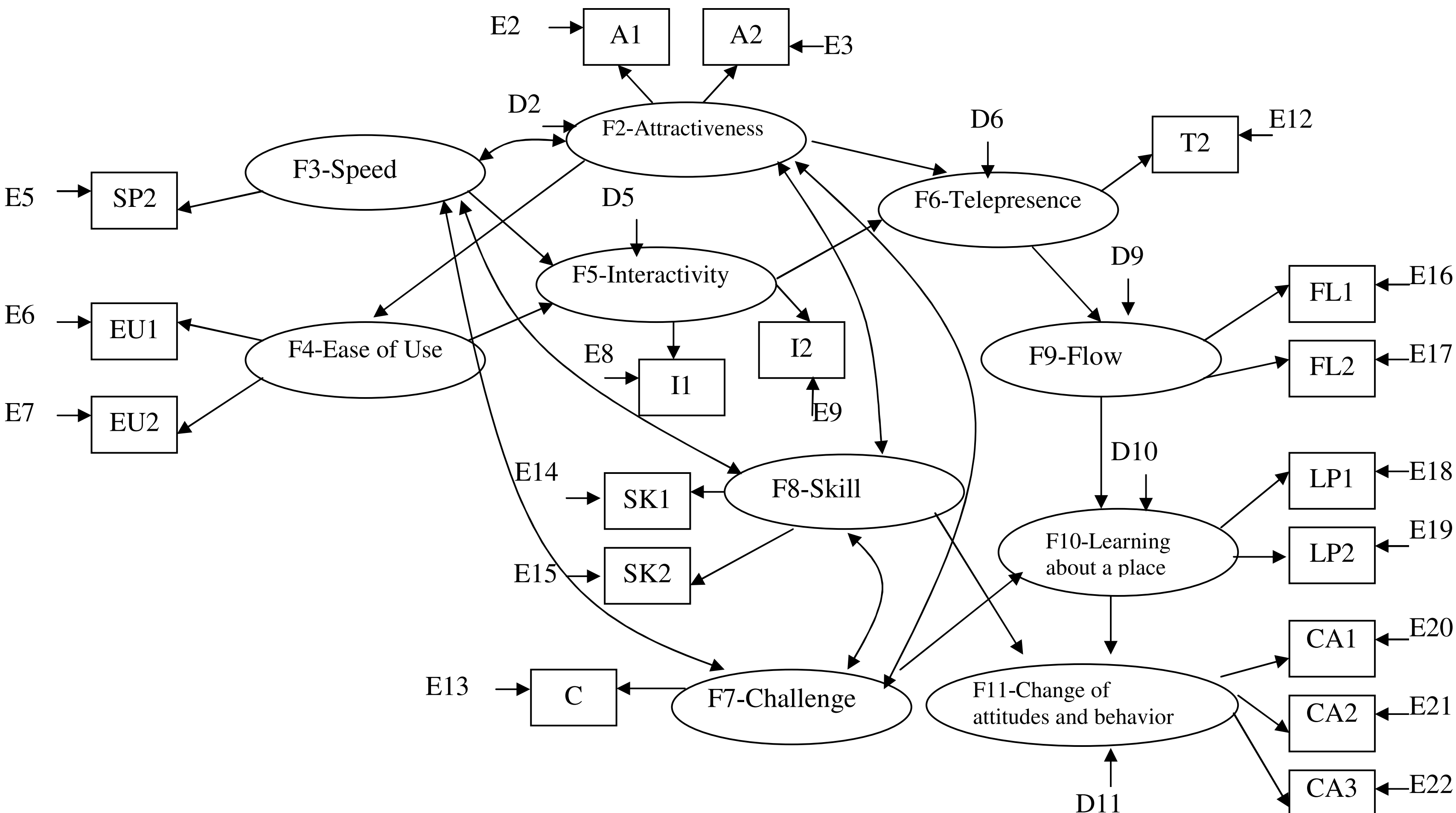


TABLE 7.12

Comparison of the selected fit measures for the four structural models: the original structural model, revised structural model A, revised structural model B and revised structural model C

Fit Measures	Original Model	Revised Structural Model A	Revised Structural Model B	Revised Structural Model C
Chi-Square	393.9842	303.8852	282.7732	287.8907
	(df = 133)	(df = 118)	(df =116)	(df = 117)
Chi-square/df	2.96	2.5753	2.460	2.4606
RMSEA Estimate	0.0874	0.0783	0.0748	0.0754
RMR	0.0635	0.0540	0.0460	0.0459
Bentler's Comparative Fit Index (CFI)	0.9295	0.9494	0.9546	0.9535
Bentler & Bonett's Non-normed Index (NNFI)	0.9093	0.9344	0.9402	0.9392
Bentler & Bonett's (1980) NFI	0.8982	0.9206	0.9261	0.9248

fit indexes, revised structural model B and revised structural model C are equivalent in their fit to the data.

Up to this point, the models tested are all hierarchically related, which means that changes were made by adding or deleting paths. The intention of this means of model modification is to find the minimum changes of the original model as suggested by the literature (Kline 1998). The chi-square test and fit indexes all suggest a good fit. However, there is one problem that had remained through adding or deleting paths. Reviewing Output page 62 for values of R-square shows that the R-square value for flow construct (F9) exceeds 1.00. This value indicates multicollinearity. Multicolinearity occurs when inter-correlations among variables are so high that these two variables measure the same thing. Output page 60 reports the standardized estimate of the path from F6 to F9:

$$F9 = 1.0588*F6 + 1.0000\ D9$$

This seems to suggest that F6 (telepresence) measures some of the characteristics of F9 (flow). In other words, instead of contributing to the occurrence of flow as suggested in the original flow model, the state of telepresence might in fact be a manifestation of flow experience. Could telepresence be one of the characteristics of flow experience in the context of human-computer interaction on the Web? Telepresence occurs when Internet users perceive themselves as being in a remote environment while interacting with the computer. When people experience telepresence they forget their immediate surroundings. According to optimal experience theory, there were nine characteristics associated with the flow experience, such as the loss of self-consciousness, and the sense of time distortion. However, this theory was proposed before the Internet had become a popular place for activity and experience. Previous research on flow experience focused mainly on traditional activities. If telepresence turns out to be one of the characteristics of flow, this finding would be an important contribution to the optimal experience theory.

The next section investigates the possibility of using telepresence as one of the measurement variables of the flow experience.

Evaluating Revised Structural Model D

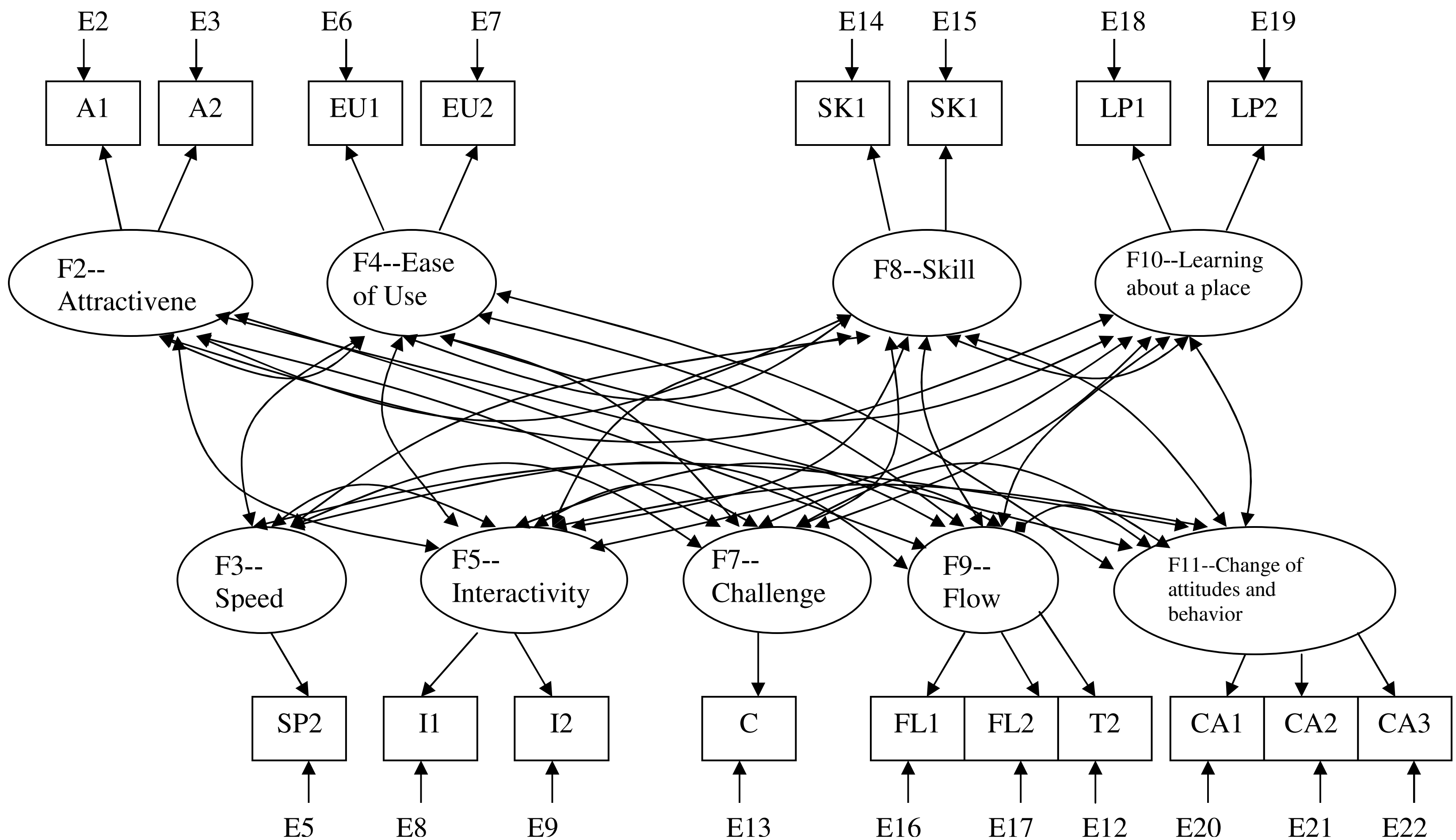
Because the changes involve the modification of the measurement part of the model, it was necessary to conduct CFA analysis for the new revised measurement model before the structural model D could be tested. The final measurement model derived from previous CFA analyses was revised measurement A. This measurement model needed to be revised as measurement model B.

Confirmative Analysis for Revised Measurement Model B

Figure 7.9 presents revised measurement model B for confirmative analysis. In this model the indicator of telepresence (T), T2, was defined as one of the measurement variables of flow.

Output pages 64 – 70 (Appendix F) reports the results from the program. Various parts of the output suggest a satisfactory fit of the CFA model. Thus, the hypothesis that telepresence is a manifestation of flow experience is supported by the results. The

Figure 7.9. Revised measurement model B for confirmative factor analysis



major statistical characteristics are summarized as follows:

(1) Chi-square value is 259.3671 with degrees of freedom of 99.

(2) Chi-square/df ratio is 2.62, satisfying the recommended level of less than 3.0.

(3) Values of CFI, NNFI and NFI are 0.9564, 0.9326, and 0.9323 respectively, well above the recommended level of 0.9 as an acceptable fit.

(4) The *t* value for all factor loadings are all above 1.96 (Output page 65), and are statistically significant.

(5) All the standardized factor loadings and path coefficients are non-trivial in absolute magnitude

(6) The distribution of the normalized residual is centered around zero with only one of the normalized residuals being slightly larger than 2.0 (Output page 70).

The variables with normalized residuals slightly over 2.0 are associated with FL1 and T2. The absolute value is 2.29. This indicates that there were some common unknown causes for the variation of the two variables. Thus, it is worthwhile to modify the measurement model B. The revised measure model C added the estimation of the covariance of the error terms of these two variables (Figure 7.10).

Output page 70

The CALIS Procedure

Covariance Structure Analysis: Maximum Likelihood Estimation

Distribution of Normalized Residuals

Each * Represents 2 Residuals

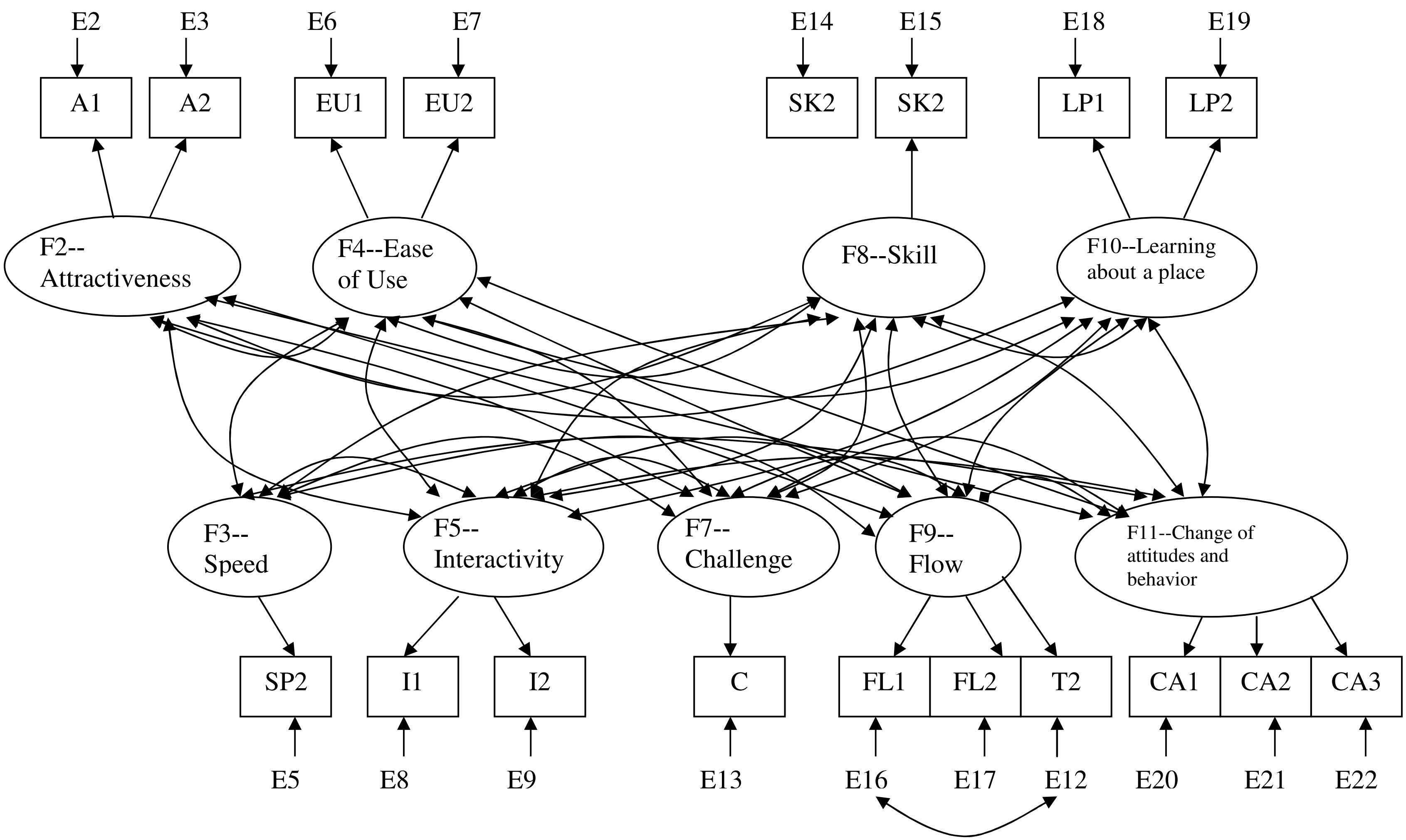
----------Range---------		Freq	Percent	
-1.25000	-1.00000	2	1.17	*
-1.00000	-0.75000	9	5.26	****
-0.75000	-0.50000	11	6.43	*****
-0.50000	-0.25000	29	16.96	**************
-0.25000	0	28	16.37	**************
0	0.25000	40	23.39	********************
0.25000	0.50000	17	9.94	********
0.50000	0.75000	14	8.19	*******
0.75000	1.00000	10	5.85	*****
1.00000	1.25000	3	1.75	*
1.25000	1.50000	2	1.17	*
1.50000	1.75000	5	2.92	**
1.75000	2.00000	0	0.00	
2.00000	2.25000	0	0.00	
2.25000	2.50000	1	0.58	

Average Normalized Residual	0.429810
Average Off-diagonal Normalized Residual	0.480359

Rank Order of the 10 Largest Normalized Residuals

Row	Column	Residual
FL1	T2	2.29193
CA2	EU2	1.73350
CA2	A1	1.69058
CA2	SP2	1.66243
CA3	SK1	1.57335
CA2	EU1	1.57061
CA2	I1	1.45537
CA2	FL1	1.35212
SK2	T2	1.24436
CA1	SK2	-1.15696

Figure 7.10. Revised measurement model C for confirmative factor analysis



Evaluating the Fit of Revised Measurement Model C

Output pages 71 - 77 (Appendix F) present the results of the confirmatory factor analysis for the revised measurement model C. Table 7.13 compares some of the fit measures of revised measurement B and revised measurement model C.

The results from the comparison of the two measurement models favor the revised measurement model C. For revised model C, values of chi-square and the ratio of chi-square/df are smaller. RMSEA and RMR are slightly smaller. The values of CFI, NNFI and NFI are all above 0.9 and larger. Other results also demonstrate a good fit for measurement model C as summarized here:

(1) The *t* values for all factor loadings are all above 1.96 (Output page 62) and are statistically significant.

(2) All the standardized factor loadings and path coefficients are non-trivial in absolute magnitude.

(3) The distribution of the normalized residual is fairly symmetrical and centered around zero, none of the absolute values of the normalized residuals is larger than 2.00.

(4) Factor loadings of indicators on their respective factors are relatively high.

Composite Reliability of Flow Construct

Of special interest is the measurement of the flow construct. With the adding of telepresence as another indicator, it is necessary to calculate the composite measurement reliability for the latent variable flow. With the following equation, the composite reliability of flow was calculated as:

TABLE 7.13

Comparison of the selected fit measures for measurement model B and measurement model C

Fit Measures	Revised Measurement Model B	Revised Measurement Model C
Chi-Square	259.3671	238.3964
	(df = 99)	(df = 98)
Chi-square/df	2.62	2.43
RMSEA Estimate	0.0794	0.0747
RMR	0.0418	0.0405
Bentler's Comparative Fit Index (CFI)	0.9564	0.9618
Bentler & Bonett's Non-normed Index (NNFI)	0.9326	0.9404
Bentler & Bonett's (1980) NFI	0.9323	0.9377

Composite reliability of flow = $\frac{\left(\sum L_i\right)^2}{\left(\sum L_i\right)^2 + \sum Var(E_i)}$ = 0.693

where L_i = the standardized factor loadings

$Var(E_i)$ = the error variance, or $1\text{-}R^2$.

The value of the composite reliability of flow meets the recommended level of no less than 0.6 (Hatch 1994). Thus the measurement for flow was considered as valid.

The above analysis provides an adequate confidence for the fit of measurement model C. The findings generally support the reliability and validity of the constructs and their indicators. Therefore, the measurement model C was accepted as this research's final measurement model. This measurement model was ready to be used as the measurement part of the revised structural equation model B. The next section covers the process of path analysis for revised structural model D (Figure 7.11).

Evaluating the Fit of Revised Structural Model D

Revised structural model D should reflect the combination of measurement model C (Figure 7.10) and the structural model C (Figure 7.8). Output page 61 shows that there was a high correlation between F2 (attractiveness) and F3 (speed) as a result of estimating structural model C. It is worthwhile to test if speed has any effect on the Web site's attractiveness to people. Therefore, a path linking F2 and F3 was added to the model. Figure 7.11 presents revised structural model D.

Output page 61

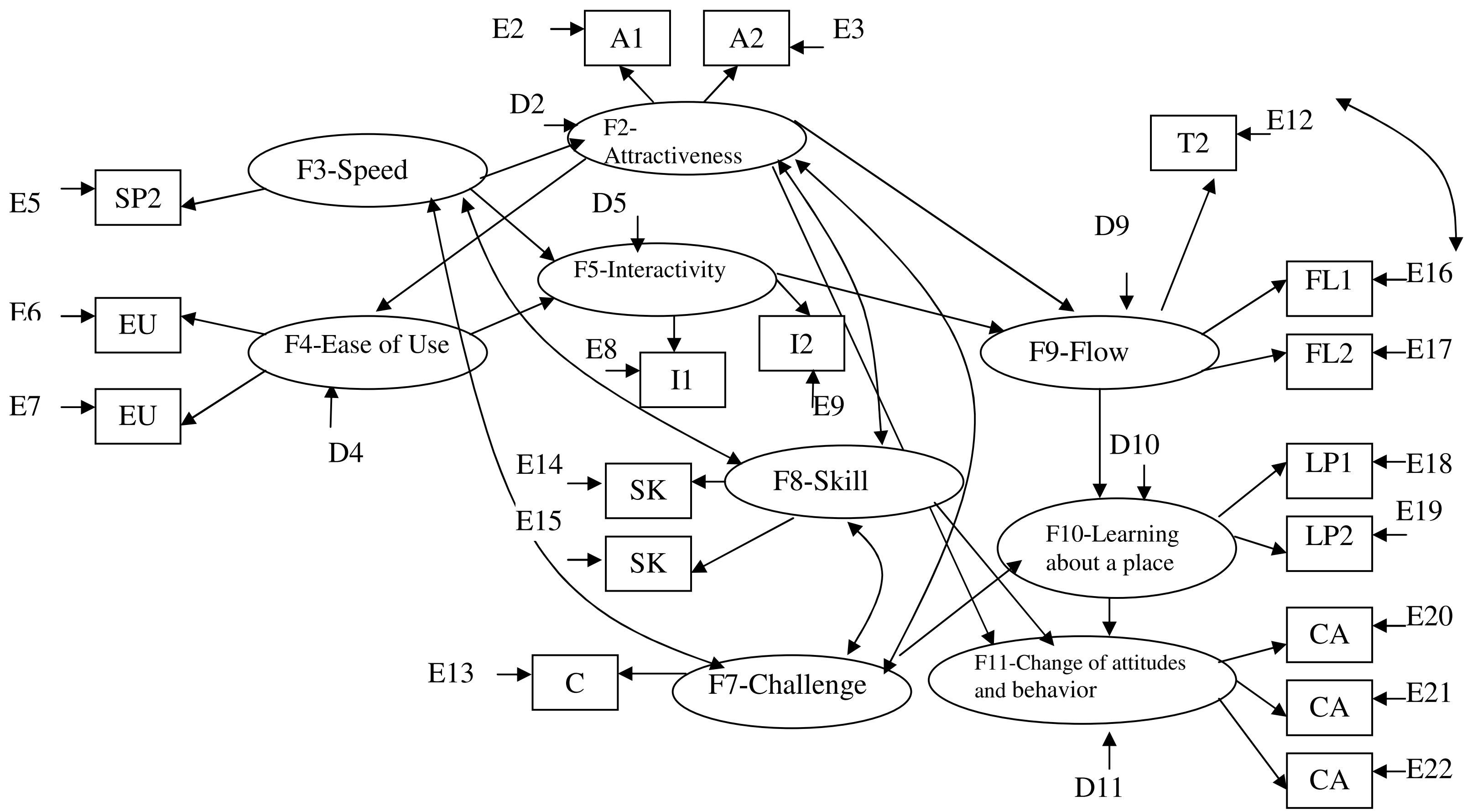
The CALIS Procedure

Covariance Structure Analysis: Maximum Likelihood Estimation

Correlations Among Exogenous Variables

Var1	Var2	Parameter	Estimate
F2	F3	CF2F3	0.51845
F2	F7	CF2F7	0.70333
F3	F7	CF3F7	0.42636
F2	F8	CF2F8	0.09269
F3	F8	CF3F8	-0.00107
F7	F8	CF7F8	-0.18819

Figure 7.11. Revised structural model D



Chi-square and Other Selected Fit Measures

Output page 78 - 85 (Appendix F) report the selected results for evaluating revised structural model D. Output page 78 lists fit measures for the revised structural model D. Table 7.14 reports the selected fit measures for revised structural model D.

This table shows that the chi-square statistic is 270.3993 with degrees of freedom of 119. The ratio of chi-square/df is 2.2723. This value is much lower than the recommended level of chi-square/df ratio of less than 3.0, indicating that the revised structural model D fits the data well.

The table also shows that the model displayed values greater than 0.9 on the major fit indexes. The values of CFI, NNFI and NFI were 0.9588, 0.9470 and 0.9294 respectively. All these fit indices indicate a satisfactory fit of structural model D to the data.

Normalized Residuals and Their Distribution

Output page 85 reports the normalized residuals. None of the absolute values of the normalized residuals is larger than 2.0. The distribution of the normalized residual is fairly symmetrical and centered around zero. The values of the normalized residuals and their distribution satisfy the criteria for an acceptable fit as recommended by Hatcher (1994).

TABLE 7.14

Selected fit measures for revised structural model D

Fit Measures	Revised Structural Model D
Chi-Square	270.3993
	(df = 119)
Chi-Square/df	2.2723
RMSEA Estimate	0.0704
RMR	0.0463
Bentler's Comparative Fit Index (CFI)	0.9588
Bentler & Bonett's Non-normed Index (NNFI)	0.9470
Bentler & Bonett's (1980) NFI	0.9294
Akaike Information Criterion (AIC)	32.3993

Significant Test of Factor Loadings, Path Coefficients and R^2 Values

Factor loadings for measurement variables and latent variables are presented in Output page 79 - 80. The *t* scores for testing the null hypothesis, that the factor loadings were zero ranges from 2.2279 to 16.0438, indicated these factor loadings are all significant ($p < 0.05$). All the standardized factor loadings and path coefficients are non-trivial in absolute magnitude.

R-square values for the structural equation part of the model are all over 0.65. (Output page 84). These values are large enough to conclude that these latent variables are well explained by their predictors.

Although the output shows strong correlation between F3 (speed) and F7 (challenge as defined as the content of the Web site), adding a path connecting them did not result in a statistically significant factor loading. Thus, the path was discarded. With the possibility of accepting revised structural model D as this research's final model, the last final test was to conduct a chi-square difference test comparing the difference between chi-square values of structural model D and its measurement model C.

A Chi-Square Difference Test Comparing the Structural Equation Model D with the Measurement Model C

Kline (1998) and Hatcher (1994) recommend this test. The purpose of this chi-square difference test is to determine whether there is a significant difference between the fit provided by the structural model and the fit provided by the measurement model. A finding of non-significance satisfies the requirement for nomological validity of the structural model (Hatcher 1994). Nomological validity requires that if a structural model satisfactorily represents the relations between the latent variables, there should be no significant difference between the chi-square value for the structural model and the chi-square value for the measurement model. The results of the chi-square difference test for revised structural model D and the chi-square of revised measurement model C are as follows:

Chi-square difference = 270.3993 - 238.3964 = 32.0029;

degrees of freedom = 119 – 98 = 21;

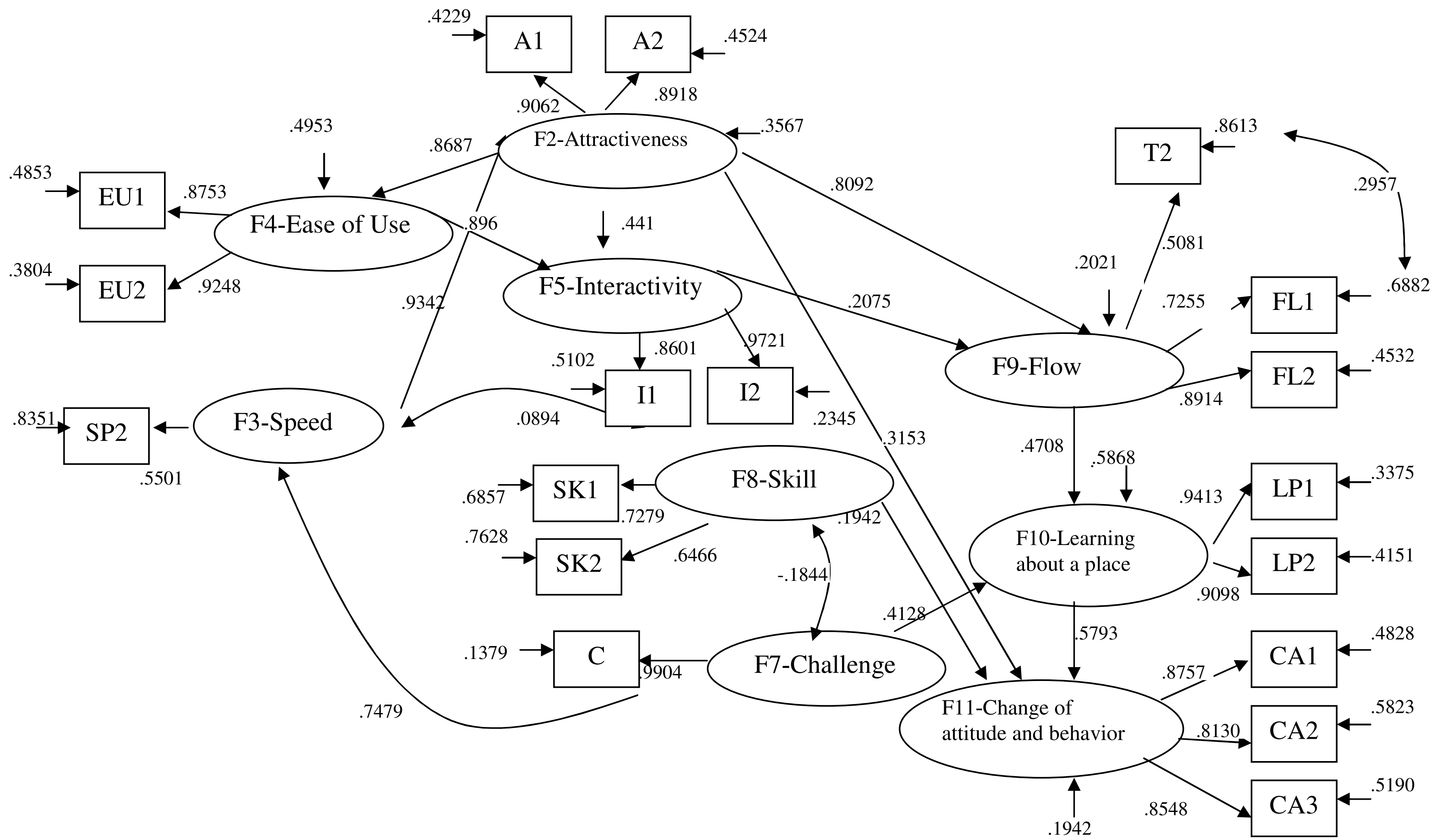
With 21 degrees of freedom, the critical value of chi-square is 32.6706 at $p < 0.05$. The obtained value of chi-square difference is smaller than this value, indicating that there is no significant difference in the fit provided by the measurement part the structural equation part of the final model. The nomological validity is satisfied. Therefore, structural model D was accepted as this research's final model. Figure 7.12 shows the final flow model with estimations of parameters.

Summary of Model Development

This research utilized the structural equation modeling method to test the proposed flow model. The data used for the test were from an online survey. The test was conducted using a two-step modeling technique. Four measurement models and five structural equation models have been specified and tested with the SAS program. The four measurement models tested were:

(1) The initial measurement model (Figure 7.2).

Figure 7.12. Revised structural model D with estimations of parameters



(2) Revised measurement model A, in which three measurement variables – I3 (a measurement variable for interactivity), SP1 (a measurement variable for speed) and T1 (a measurement variable for telepresence) were dropped from the model (Figure 7.4).

(3) Revised measurement model B (Figure 7.9), in which telepresence was specified as the measurement variable for latent variable flow.

(4) Revised measurement model C (Figure 7.10), in which two error terms, the covariance of E12 and E16 were estimated. E12 is the error term for T2, a measurement variable for telepresence. E16 is the error term for FL1, a measurement variable for flow.

The five structural equation models tested were:

(1) The initial theoretical flow model (Figure 7.5)

(2) Revised structural model A (Figure 7.6). Major modifications include:

  (a) The latent variable – F1 (experience with virtual tour Web site) and, two paths related to it were dropped from the original theoretical model. These two paths are F1 (experience with virtual tour Web site)→ F2 (attractiveness) and F1 (experience with virtual tour Web site) → F4 (ease of use).

  (b) Two other paths with trivial path coefficients – one from F7 (challenge) to F9 (flow) and the other from F8 (skill) to F9 (flow) were deleted from the original model

(c) Three paths were added to the model. One goes from F7 (challenge) to F10 (increased learning of a place); one goes from F2 (attractiveness) to F4 (ease of use); the other goes from F8 (skill) to F11 (changes of attitude and behavior).

(3) Revised structural model B, in which two paths were added to the revised structural model A. One goes from F2 (attractiveness) to F11 (changes of attitude and behavior); the other goes from F7 (challenge) to F11 (changes of attitude and behavior) (Figure 7.7).

(4) Revised structural model C, in which the path from F7 (challenge) to F11 (changes of attitude and behavior) was deleted (Figure 7.8)

(5) Revised structural model D (Figure 7.11). The model was re-specified with telepresence being specified as an indicator of flow experience (F9) instead of the cause of flow experience. This model also added a path from F3 (speed) to F2 (attractiveness).

Tables 7.15 and 7.16 compare the testing results of these models. Table 7.16 compares the differences of the major statistical characteristics among the structural models. The table includes a new fit index that had not been included previously. This new index is listed in the last row of the table, called Akaike Information Criterion (AIC). The AIC is a modification of the standard fit index that includes a "penalty" for complexity. It is suitable for comparing two models that are not hierarchically related. A model with the lowest value of AIC is preferred (Kline 1998). Revised structural model D is not hierarchically related to the original structural model, revised structural model A,

TABLE 7.15

Comparisons of the selected fit measures for the four measurement models tested

Fit Measures	Original Measurement Model	Revised Measurement Model A	Revised Measurement Model B	Revised Measurement Model C
Chi-Square	531.2720	255.2268	259.3671	238.3964
	(df = 154)	(df = 97)	(df = 99)	(df = 98)
Chi-square/df	3.448	2.629	2.62	2.43
RMSEA Estimate	0.0976	0.0797	0.0794	0.0747
Bentler's Comparative Fit Index (CFI)	0.9173	0.9572	0.9564	0.9618
Bentler & Bonett's Non-normed Index (NNFI)	0.8759	0.9246	0.9326	0.9404
Bentler & Bonett's (1980) NFI	0.8891	0.9341	0.9323	0.9377

TABLE 7.16

Comparisons of the selected fit measures for the five structural models tested

Fit Measures	Original Model	Revised Structural Model A	Revised Structural Model B	Revised Structural Model C	Revised Structural Model D
Chi-Square	393.9842 (df=133)	303.8852 (df = 118)	282.7732 (df=116)	287.8907 (df = 117)	270.3993 (df = 119)
Chi-Square/df	2.96	2.5753	2.460	2.4606	2.2723
RMSEA Estimate	0.0874	0.0783	0.0748	0.0754	0.0704
RMR	0.0635	0.0540	0.0460	0.0459	0.0463
Bentler's Comparative Fit Index (CFI)	0.9295	0.9494	0.9546	0.9535	0.9588
Bentler & Bonett's Non-normed Index (NNFI)	0.9093	0.9344	0.9402	0.9392	0.9470
Bentler & Bonett's (1980) NFI	0.8982	0.9206	0.9261	0.9248	0.9294
Akaike Information Criterion (AIC)	127.9842	67.8852	50.7732	53.8907	32.3993

B, and C, because the measurement part of revised structural model D was different from the other four models. Thus AIC indexes were used for comparing the fit of these models. Table 7.16 shows that the AIC value for revised structural model D is 32.3993, which is significantly smaller than those of the other models.

A chi-square difference test that compares structural model D to its measurement model demonstrated a non-significance difference in chi-square values. The results presented in Tables 7.15 and 7.16, and findings with other statistical characteristics, all indicate the preference for revised structural model D to be the final model of this research. Figure 7.12 illustrates the final estimation of measurement and structural parameters.