

# Chapter 16

## An Evaluation of Virtual Teamwork Model in Online Higher Education



Akinul Islam Jony  and Enric Serradell-López 

**Abstract** Virtual teamwork is considered as one of the key skills to an employer in the recruitment process because of the globalization of business and technological advancement. The company needs employees skilled in virtual teamwork to run their globalized business process. So, it becomes important for graduates to have good skills, knowledge, and ability of virtual teamwork through their higher education before starting their professional careers. Therefore, this paper is going to evaluate a virtual teamwork model which was proposed for developing an effective virtual teamwork in the context of online higher education so that graduate can achieve a sound knowledge and skills about virtual teamwork. The model is assessed by applying the partial least squares structural equation modeling (PLS-SEM) statistical technique to validate the model's statistical significance. The evaluation of the model shows that the model has a significant positive impact on the effectiveness of virtual teamwork in online higher education. Hence, it is believed that the application of the model would be useful to enhance the knowledge, skills, and ability of future graduates in online higher education, and can foster their early success in their professional career. Also, any company which practiced virtual teamwork in their business process can be benefited from this model for the better management of their virtual teams.

**Keywords** Model evaluation · Partial least squares · PLS-SEM · Structural equation modeling · Virtual teamwork · Higher education · E-Learning

---

A. I. Jony (✉) · E. Serradell-López  
Universitat Oberta de Catalunya, Barcelona, Spain  
e-mail: [ajony@uoc.edu](mailto:ajony@uoc.edu)

E. Serradell-López  
e-mail: [eserradell@uoc.edu](mailto:eserradell@uoc.edu)

## Introduction

Technological advancement and globalization of business have made virtual teamwork as one of the key activities and skills to an employer [1, 15, 19, 21]. It also reflected in the recruitment process where employers are asking for virtual teamwork skills from jobseekers with regular importance [3]. Therefore, it becomes important for the graduates to be skilled in virtual teamwork before starting their professional career. A graduate can achieve this skill through higher education with the facility of building virtual teamwork skills. Considering the importance of developing virtual teamwork in higher education, this paper is going to evaluate a model which is particularly proposed for developing an effective virtual teamwork in online higher education so that graduate can achieve the required knowledge and skills about virtual teamwork. This model of virtual teamwork is proposed as a theoretical or conceptual model by Jony and Serradell-Lopez [18], which needs a complete evaluation for the statistical significance.

Therefore, this research work is mainly aimed to present the systematic evaluation of the model for justifying its statistical supports. The model is assessed and validated by applying the partial least squares structural equation modeling (PLS-SEM) statistical technique. The analysis shows that the model has a substantive statistical significance. Hence, it can be said that the application of the model in online higher education can be useful for developing an effective virtual teamwork. As a consequence, the students (future graduates) from higher education will be able to enhance their knowledge, skills, and ability on virtual teamwork, which eventually help them to foster their early success in their professional career. Also, any globalized company can be benefited from this model for managing and evaluating their virtual teams more effectively.

The rest of the paper is structured as follows. Section “[Methodology](#)” describes the methodology of this empirical study. The conceptual model of virtual teamwork [18], which is going to evaluate in this study using the PLS-SEM technique is presented as a PLS path model in Section “[The PLS Path Model](#)”. The assessment of the measurement model and the structural model are presented in Sections “[Evaluation of Measurement Model](#)” and “[Evaluation of Structural Model](#)” respectively to illustrate the evaluation of the conceptual model, and the quality assessment of the results. Finally, Section “[Evaluation of Structural Model](#)” concludes the paper.

## Methodology

The empirical research study of this paper aimed to evaluate the virtual teamwork model in online higher education which is proposed by Jony and Serradell-Lopez [18]. Specifically, it’s aimed to measure the relationship between Motivation, Communication, Knowledge Sharing, Trust, Cohesion, Coordination, and Performance constructs of the model, and assess the impact on the effectiveness of virtual

teamwork development in online higher education. The existing literature and theories have served as the source of identification of the contents of each of the constructs in the theoretical or conceptual model. Table 16.1 shows the complete set of the questionnaire (indicator variables) for measuring all the constructs of the model. For simplicity, only the set of indicators are listed in this paper but the detailed description of the measurement model development is not included here for limiting the length of this paper. However, the items were created and refined for ensuring their quality. The final questionnaire contained 5-point Likert scale items to record the responses.

The data collection of this empirical study was based on a survey from a virtual teamwork competition held in 2019 [7]. The questionnaire of the survey is answered by the virtual teams of undergraduate students from different countries. These virtual teams were the participants of a competition (Virtual Tournament) where they asked

**Table 16.1** Indicators for the constructs of the model

Indicator Name	Description of Indicator
Motivation_1	All the team members had the opportunity to develop knowledge and skills
Motivation_2	As team members, we were able to add value to the teamwork
Motivation_3	In our team, we found that we were challenged by the teamwork
Communication_1	Communication in our team was open and honest
Communication_2	Team members were in contact with each other on a regular basis in order to conduct the teamwork
Communication_3	Team members exchanged information clearly and accurately
Knowledge_Sharing_1	Knowledge and information sharing were understood to be the norm in our team
Knowledge_Sharing_2	Team members exchanged knowledge and information with each other to solve a problem together
Knowledge_Sharing_3	All the team members exchanged their opinion in important decision making
Trust_1	Team members consulted with each other if they needed support
Trust_2	Our team valued individual input from the team members
Trust_3	There was no mutual distrust between team members
Cohesion_1	Our team was a very cohesive unit
Cohesion_2	Our team members experienced a sense of shared goals and objectives
Cohesion_3	Team members had interpersonal connections with each other
Coordination_1	Our team coordinated tasks effectively among each other
Coordination_2	Team members in our team displayed high levels of cooperation
Coordination_3	When disagreement occurred, they were addressed promptly in order to solve them
Performance_1	Our team worked effectively
Performance_2	Our team is satisfied with the outcomes
Performance_3	Our team generally worked on time

to work virtually in their virtual teams for a month to complete the designated task. After the competition, each team has asked to answer the questionnaire voluntarily. Among all the registered virtual teams in the competition, 159 data samples (one sample per virtual team, where all the answers are based on the combined opinions of each team member of the team) are collected of which 150 samples were usable after applying missing value treatment. Data was analyzed and evaluated using the SmartPLS which is one of the widely used and popular software [24] of the PLS-SEM statistical technique.

## The PLS Path Model

As per the conceptual model [18], and the measurement items of the constructs in the conceptual model presented in Table 16.1, the following PLS path model (presented in Fig. 16.1) is developed which will be evaluated using the PLS-SEM statistical technique. Before going for the step-by-step evaluation of the model, let's check whether all the relationships of the model are supported statistically or not. Afterward, the model will be assessed with all the standard evaluation criteria of the PLS-SEM technique, separately for both measurement and structural parts of the model.

After running the PLS-SEM algorithm and bootstrapping procedure for the model estimation, there are found 3 relationships, that is *Knowledge Sharing* → *Performance* ( $t = 0.460$ ,  $p = 0.645$ ), *Trust* → *Performance* ( $t = 0.515$ ,  $p = 0.607$ ), and *Cohesion* → *Performance* ( $t = 0.089$ ,  $p = 0.929$ ) are not statistically significant because none of them has  $p$  value less than 0.05, and also none of them has  $t$  value above the threshold of 1.96 at least for the significance level of 5%. As these 3 relationships are not statistically supported according to  $t$  values, and  $p$  values, these 3 relationships can be eliminated from the model. In addition, these predecessor constructs *Knowledge Sharing*, *Cohesion*, and *Trust* have already affected positively on the *Performance* construct through the *Coordination* construct. So, it is believed that the elimination of these 3 relationships does not degrade the quality and orientation of the model.

As there are 3 relationships in the PLS path model which are not statistically significant, the following PLS path model (presented in Fig. 16.2) after eliminating those insignificant relationships will be evaluated next thoroughly in this paper to statistically validate the model.

The complete evaluation of the measurement and structural models of the PLS path model are presented in the following two subsequent Sects. 4 and 5 respectively.

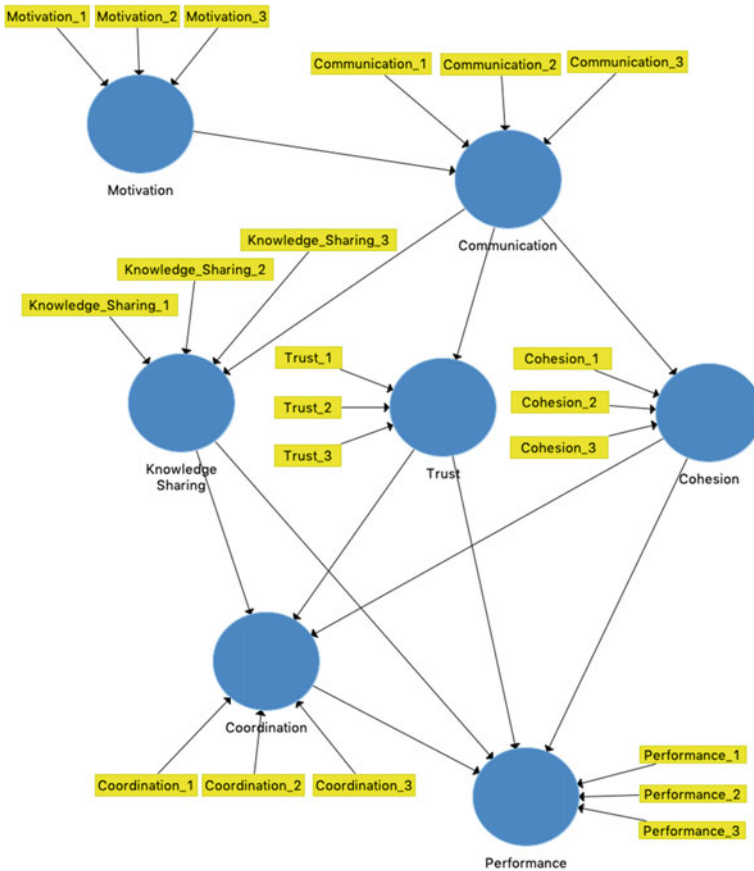


Fig. 16.1 The PLS path model

## Evaluation of Measurement Model

This section presents the measurement model evaluation of the PLS path model of applying PLS-SEM. This empirical study has considered using a formative measurement model only. It is to note that the same evaluation criteria used for reflective measurement cannot be applied directly to assess the formative measurement model [5]. Thus, a different set of evaluation criteria as recommended in existing literature (e.g. [2, 12, 14]) are considered to evaluate the formative measurement model. A systematic procedure of such measurement model evaluation criteria is compiled and mentioned in an article [17], which is followed in this study to assess the measurement model.

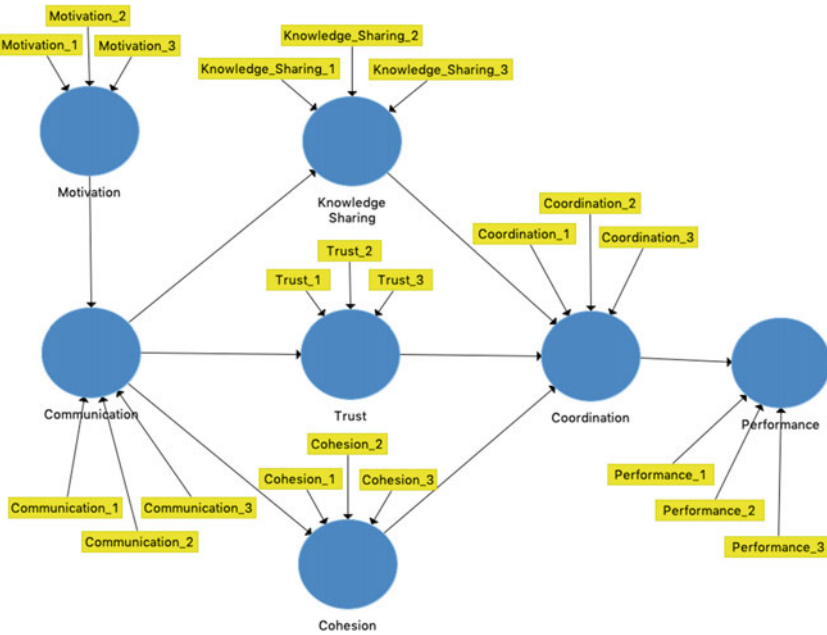


Fig. 16.2 The final PLS path model to be estimated

### Assessment of Convergent Validity

In a formative measurement model, the convergent validity assessment is served as the examination of construct validity. It examines whether the formatively measured construct is highly correlated with the same construct measured reflectively to check whether the constructs exhibit convergent validity. It is also called the redundancy analysis [5]. In this assessment, separate redundancy analysis is carried out for each construct in the measurement model. For doing redundancy analysis, a global indicator for each of the constructs needs to identify that summarizes the essence of the formatively measured construct [26]. Table 16.2 presents a set of global single-item measures with generic assessments of the 7 constructs, Motivation, Communication, Knowledge Sharing, Trust, Cohesion, Coordination, and Performance—which will be used as measures of the dependent construct in the redundancy analysis.

In this analysis, the formatively measured construct (as an exogenous construct) is connected with a reflective measure of the same construct (as an endogenous construct) with its corresponding single-item global measure and check the value of path coefficient (for definition see [22, 36]), and  $R^2$  value (for definition see [10, 31]) for convergent validity of the construct. A desirable minimum path coefficient value is 0.70, and  $R^2$  value is 0.50 or above. Anything below the threshold means that it does not contribute at a sufficient degree to its intended content [12].

**Table 16.2** Set of Global Indicators

Global Indicator Name	Description of Global Indicator
Motivation_Global	We feel valued as team members in our team.
Communication_Global	The methods used to communicate with each other were effective
Knowledge_Sharing_Global	Team members were open to sharing any knowledge and information
Trust_Global	Members of our team trusted each other
Cohesion_Global	Our team members help each other deal with problems or resolve issues
Coordination_Global	There has been coordination among the team members in the team to achieve the goals
Performance_Global	Our team met the team's objective

In the redundancy analysis, the path coefficients for motivation, communication, knowledge sharing, trust, cohesion, coordination, and performance constructs are 0.773, 0.765, 0.839, 0.748, 0.849, 0.900, and 0.808 respectively. As can be seen, all these values are above the recommended threshold of 0.70. Thus, it indicates that all the formatively measured constructs exhibit convergent validity.

### *Assessment of Collinearity Issues*

In the evaluation of the measurement model, the assessment of collinearity is served as the examination of construct reliability, which concerns the internal consistency of a measurement model [28]. This type of assessment checks whether each formative indicator in the measurement model contributes its intended meaning to its formative construct [12].

In the context of PLS-SEM, variance inflation factor (VIF) (for definition see [16, 32]) values are the standard approach to statistically assess the presence of critical collinearity levels in the formative measurement model. As a rule of thumb, VIF value is less than 5 is mostly acceptable in the literature (e.g. [12]), anything greater than or equal to 5 indicates the presence of collinearity problem [13]. The VIF values for all the indicators are shown in Table 16.3 to assess the collinearity issues of the measurement model.

As can be seen, the highest VIF value is 3.686 for *Motivation\_2* indicator, which indicates that all the VIF values of the indicators are below the threshold of five. Therefore, it can be said that collinearity for any constructs does not reach critical levels and hence, is not an issue for the PLS path model estimation.

**Table 16.3** Collinearity statistics (VIF values of indicators)

Indicators	VIF Values
Cohesion_1	1.836
Cohesion_2	1.656
Cohesion_3	1.579
Communication_1	2.402
Communication_2	2.469
Communication_3	2.890
Coordination_1	2.157
Coordination_2	2.419
Coordination_3	1.699
Knowledge_Sharing_1	2.805
Knowledge_Sharing_2	3.641
Knowledge_Sharing_3	2.258
Motivation_1	3.614
Motivation_2	3.686
Motivation_3	1.789
Performance_1	1.784
Performance_2	1.474
Performance_3	1.912
Trust_1	2.795
Trust_2	2.591
Trust_3	1.258

### ***Assessment of Significance and Relevance of Indicators***

In the previous step of measurement model evaluation, there was found no collinearity issues so it is time to assess the significance and relevance of the indicators next. The outer weights (for definition see [20]) of the indicators will be analyzed to assess the significance and relevance of the indicators. Later, the outer loadings (for definition see [20]) of the indicators will be analyzed to assess the absolute contribution (or absolute importance) of the indicators to (for) their constructs.

The significance of outer weights can be obtained by means of the bootstrapping procedure, where (recommended) 5000 subsamples and 0.05 Significance level are the parameter settings to execute the bootstrap procedure. The statistics in Table 16.4 exhibits that all the indicators in the measurement model are significant at a 5% level (i.e.  $p < 0.05$ ), except *Performance\_2* ( $p = 0.099$ ). However, this non-significant indicator should not delete as per the outer weight only, rather it should consider outer loading as well for examining the indicator's absolute contribution. The reason is that if an indicator's outer weight is non-significant but its outer loading is high (i.e. more than 0.50) then the indicator should be interpreted as absolutely important



**Table 16.4** Outer weights of the indicators

Indicators -> Constructs	Original	t Values	p Values
Cohesion_1 -> Cohesion	0.457	6.852	0.000
Cohesion_2 -> Cohesion	0.522	8.888	0.000
Cohesion_3 -> Cohesion	0.189	2.631	0.009
Communication_1 -> Communication	0.386	5.116	0.000
Communication_2 -> Communication	0.376	4.984	0.000
Communication_3 -> Communication	0.347	4.519	0.000
Coordination_1 -> Coordination	0.368	6.631	0.000
Coordination_2 -> Coordination	0.519	7.780	0.000
Coordination_3 -> Coordination	0.246	3.470	0.001
Knowledge_Sharing_1 -> Knowledge Sharing	0.244	2.548	0.011
Knowledge_Sharing_2 -> Knowledge Sharing	0.499	4.457	0.000
Knowledge_Sharing_3 -> Knowledge Sharing	0.353	3.664	0.000
Motivation_1 -> Motivation	0.413	3.334	0.001
Motivation_2 -> Motivation	0.309	2.205	0.028
Motivation_3 -> Motivation	0.395	4.146	0.000
Performance_1 -> Performance	0.560	4.493	0.000
Performance_2 -> Performance	0.138	1.651	0.099
Performance_3 -> Performance	0.450	3.371	0.001
Trust_1 -> Trust	0.439	2.531	0.011
Trust_2 -> Trust	0.444	2.870	0.004
Trust_3 -> Trust	0.297	2.560	0.010

but not as relatively important, and hence, in this situation, the indicator generally should be retained in the measurement model [12].

The outer loadings of the indicators are presented in Table 16.5, which indicates all the indicator's outer loadings are above the threshold of 0.50, and also all the p values of the indicator's outer loadings are clearly below 0.01%. So, it suggests that all outer loadings are significant at a level of 1%. Considering this fact, the only non-significant indicator as per the value of outer weight is *Performance\_2* but it has outer loading 0.651, which clearly above the threshold of 0.50, and so, it absolutely contributes to (absolutely important for) its construct. That's why it should be retained in the measurement model. Thus, there is no problem to proceed with the evaluation of the structural model.

**Table 16.5** Outer loadings of the indicators

Indicators -> Constructs	Original	t Values	p Values
Cohesion_1 -> Cohesion	0.877	25.104	0.000
Cohesion_2 -> Cohesion	0.890	28.641	0.000
Cohesion_3 -> Cohesion	0.712	8.195	0.000
Communication_1 -> Communication	0.898	33.738	0.000
Communication_2 -> Communication	0.898	25.498	0.000
Communication_3 -> Communication	0.912	30.530	0.000
Coordination_1 -> Coordination	0.878	26.485	0.000
Coordination_2 -> Coordination	0.937	36.903	0.000
Coordination_3 -> Coordination	0.774	11.354	0.000
Knowledge_Sharing_1 -> Knowledge Sharing	0.870	19.221	0.000
Knowledge_Sharing_2 -> Knowledge Sharing	0.956	47.832	0.000
Knowledge_Sharing_3 -> Knowledge Sharing	0.880	20.971	0.000
Motivation_1 -> Motivation	0.923	26.676	0.000
Motivation_2 -> Motivation	0.910	23.240	0.000
Motivation_3 -> Motivation	0.855	16.329	0.000
Performance_1 -> Performance	0.916	14.893	0.000
Performance_2 -> Performance	0.651	7.688	0.000
Performance_3 -> Performance	0.883	18.117	0.000
Trust_1 -> Trust	0.921	18.440	0.000
Trust_2 -> Trust	0.899	21.073	0.000
Trust_3 -> Trust	0.662	5.976	0.000

## Evaluation of Structural Model

This section presents the assessment of structural model using different evaluation criteria as recommended in existing literature (e.g. [4, 5, 12, 29]) in order to estimate the model of this research study. A systematic procedure of assessing the structural model is compiled and mentioned in [17], which is followed in this study to assess the measurement model. The structural model assessment builds on the results from the standard PLS-SEM algorithm, the bootstrapping routine, and the blindfolding procedure, which is presented thoroughly in the following subsections of this section.

### *Assessment of Collinearity Issues*

The first step is to check the structural model for collinearity issues by examining the VIF values (i.e. Inner VIF) of all set of predictor constructs in the structural

model. The VIF values of all combinations of endogenous constructs, and corresponding exogenous (i.e., predictor) constructs are presented by the following sets of (predictor) constructs for collinearity issues:

- Motivation as a predictor of Communication (VIF value is 1.000),
- Communication as a predictor of Knowledge Sharing, Trust, and Cohesion (VIF values are 1.000 for all three sets),
- Knowledge Sharing, Trust, and Cohesion as predictors of Coordination (VIF values are 4.314, 2.855, and 3.678 respectively), and
- Coordination as a predictor of Performance (VIF value is 1.000).

The results indicate that all the VIF values are clearly below the threshold of 5. Hence, the collinearity is not a critical issue among the predictor constructs in the structural model.

### Assessment of Coefficient of Determination ( $R^2$ Value)

The next evaluation of the structural model is the coefficient of determination ( $R^2$  values) (for definition see [10, 31]) of endogenous constructs, which measures the predictive power of the model. That means, it is an in-sample predictive power [23, 25] measurement. In addition, as there might have a possibility of inherent bias towards a complex model. That’s why the adjusted coefficient of determination ( $R^2$  adjusted value) is also considered here as the evaluation criteria to avoid the bias. The  $R^2$  value ranges from 0 to 1, of which higher value indicates the higher levels of predictive accuracy.

So, both  $R^2$  and  $R^2$  adjusted values of endogenous constructs of the model are presented in Table 16.6 to evaluate the predictive power of the model. As can be seen, both values of  $R^2$  and  $R^2$  adjusted of *Cohesion*, and *Coordination* are found substantial (i.e., above the threshold of 0.75), whereas, *Communication*, *Knowledge Sharing*, *Performance*, and *Trust* are found moderate (i.e., above the threshold of 0.50), which altogether statistically proves the predictive power of the model.

**Table 16.6**  $R^2$  and  $R^2$  adjusted values of endogenous constructs

Endogenous Constructs	$R^2$ Values	$R^2$ Adjusted Values
Cohesion	0.803	0.801
Communication	0.737	0.735
Coordination	0.835	0.831
Knowledge Sharing	0.711	0.709
Performance	0.680	0.678
Trust	0.587	0.585

### ***Assessment of Effect Size $F^2$***

In addition to exploring  $R^2$  values, the changes in  $R^2$  can also be explored in the evaluation of the structural model, which is known as effect size ( $f^2$ ) (for definition see [8, 33]). This assessment was firstly presented by Cohen, which examines the impact on the dependent construct by the independent construct of the structural model [6].

Following the rules of thumb (for interpreting  $f^2$  values), the  $f^2$  effect sizes of Motivation on Communication (2.799), Communication on Knowledge Sharing (2.464), Trust (1.424), and Cohesion (4.065), Cohesion on Coordination (0.453), and Coordination on Performance (2.125) are found large (i.e., above the threshold of 0.35), whereas, Knowledge Sharing on Coordination (0.091), and Trust on Coordination (0.080) are found small (i.e., above the threshold of 0.02), which statistically proves the effect of exogenous constructs on their corresponding endogenous constructs of the model. That means, there are no exogenous constructs in the model which have no effect on their corresponding endogenous constructs.

### ***Assessment of Significance and Relevance of Relationships***

Next to assess the significance and relevance of the structural model relationships which represent the hypothesized relationships among the constructs in the model. This can be examined by the path coefficients which have standardized values approximately between  $-1$  to  $+1$ . The path coefficients values close to  $+1$  represent strong positive relationships, whereas, path coefficients values close to  $-1$  are not statistically significant, which means represent weaker relationships.

The path coefficients of relationships in the structural model are represented graphically in Fig. 16.3. The statistics indicate that all the relationships in the model are positive and strong. Among all the relationships in the model, *Trust*  $\rightarrow$  *Coordination* relationship (0.194) has the lowest values in comparison to the other relationships but still the value is closer to  $+1$  than  $-1$ , and hence, it also can be considered as a positive relationship.

Another interesting evaluation is the examination of total effects, which assess the influence of predecessor constructs on the key target constructs (i.e. Performance). For example, among all the predecessor constructs Coordination (0.825) has the strongest effect on the key target construct Performance, followed by Communication (0.688), Motivation (0.590), Cohesion (0.433), Knowledge Sharing (0.210), and Trust (0.160). On the other hand, the Coordination target construct mostly influenced by Communication (0.834), followed by Motivation (0.716), Cohesion (0.525), Knowledge Sharing (0.255), and Trust (0.194) predecessor constructs. Besides, Communication has three direct effects on Knowledge Sharing, Trust, and Cohesion constructs by 0.843, 0.766, and 0.896 respectively, of which the strongest effect

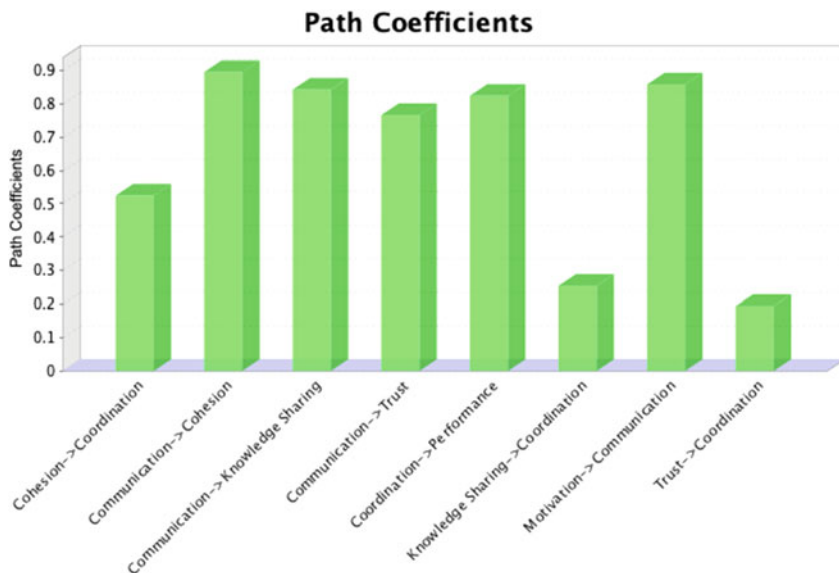


Fig. 16.3 Path coefficients of relationships in the model

is on Cohesion. So, it is clear that all the predecessor constructs influence the target constructs significantly.

Though the path coefficients of relationships obtained by the PLS-SEM algorithm are statistically significant that solely not enough to declare it. Therefore, the empirical t values (for definition see [30, 34]) for all path coefficients of the structural model is needed to prove the statistical significance, and also consolidate the statistical significance so far achieved. The empirical t values can be obtained by means of the bootstrapping procedure. Along with the t values, the empirical p values (for definition see [9, 35]) are also used here to assess the significance levels (in this study, the p value has to be smaller than 0.05 to be considered as a significance level of 5%).

After running the bootstrapping procedure, a detailed overview of the results of path coefficients for the model is shown in Table 16.7 including t values, p values, and bootstrap confidence intervals. The statistics indicate that all the relationships in the structural model are found statistically significant (i.e., all p values less than 0.05) at 5%.

Besides, Table 16.7 shows the bootstrapping confidence intervals (bias-corrected) which provides additional information on the stability of the estimated path coefficients of the structural model. Hence, it allows assessing whether a path coefficient is significantly different from zero, and its true value is somewhere within the range assuming a certain level of confidence (i.e. 95%). If the estimated path coefficient's confidence interval does not include zero then it can be considered as a significant effect. The statistics of confidence intervals for the path coefficients of relationships

**Table 16.7** Bootstrapping results for path coefficients of relationships in the model

Relationships	t Values	p Values	95% Confidence Intervals
Cohesion - > Coordination	6.784	0.000	[0.382, 0.691]
Communication - > Cohesion	38.634	0.000	[0.835, 0.930]
Communication - > Knowledge Sharing	25.679	0.000	[0.755, 0.891]
Communication - > Trust	15.951	0.000	[0.630, 0.839]
Coordination - > Performance	19.763	0.000	[0.708, 0.887]
Knowledge Sharing - > Coordination	2.515	0.012	[0.054, 0.455]
Motivation - > Communication	25.550	0.000	[0.758, 0.907]
Trust - > Coordination	2.430	0.015	[0.035, 0.351]

indicate that the true values of the path coefficients are somewhere within the range with a 95% probability. Also, all the relationships are significant as their confidence intervals do not include zero value.

So far the relationships of the structural model are found statistically significant. Now it is time to assess the relevance of significant relationships (by means of the bootstrapping procedure) because the path coefficients may be significant but their size may be small. For that reason, the relevance of relationships is examined here by the total effects (i.e. the sum of indirect and direct effects).

The following Table 16.8 shows the total effects of the predecessor constructs on the target constructs by considering both direct and indirect effects. As can be seen, all total effects are significant at a 5% level (i.e. all p values are less than 0.05). That means, it proves the relevance of significant relationships of the structural model.

Besides, Table 16.8 contains the bootstrap confidence intervals (bias-corrected) of total effects for significance testing. The statistics of confidence intervals for the total effects of predecessor constructs on the target constructs indicate that the true values of the total effects are somewhere within the range with a 95% probability. Also, all the total effects are significant as their confidence intervals do not include zero value.

### *Assessment of Predictive Relevance $Q^2$*

Previously, the  $R^2$  values are used as the evaluation criterion in the structural model for the model's predictive accuracy, which indicates the model's in-sample predictive power. In addition to this evaluation, there has another evaluation criterion to assess the model's predictive relevance, which indicates the model's out-of-sample predictive power. Stone-Geisser's  $Q^2$  value [11, 27] is used for testing the predictive relevance of the structural model, by using a blindfolding procedure with a specified omission distance to generate the  $Q^2$  values [5]. Omission distance value 7 is mostly recommended in the literature [2], providing that the number of observations (used

**Table 16.8** Bootstrapping results for total effects

Relationships	Total Effects	t Values	p Values	95% Confidence Intervals
Cohesion - > Coordination	0.525	6.784	0.000	[0.382, 0.691]
Cohesion - > Performance	0.433	6.187	0.000	[0.308, 0.583]
Communication - > Cohesion	0.896	38.634	0.000	[0.835, 0.930]
Communication - > Coordination	0.834	23.826	0.000	[0.732, 0.885]
Communication - > Knowledge Sharing	0.843	25.679	0.000	[0.755, 0.891]
Communication - > Performance	0.688	12.256	0.000	[0.542, 0.775]
Communication - > Trust	0.766	15.951	0.000	[0.630, 0.839]
Coordination - > Performance	0.825	19.763	0.000	[0.708, 0.887]
Knowledge Sharing - > Coordination	0.255	2.515	0.012	[0.054, 0.455]
Knowledge Sharing - > Performance	0.210	2.422	0.015	[0.042, 0.384]
Motivation - > Cohesion	0.769	16.929	0.000	[0.636, 0.836]
Motivation - > Communication	0.858	25.550	0.000	[0.758, 0.907]
Motivation - > Coordination	0.716	13.408	0.000	[0.568, 0.798]
Motivation - > Knowledge Sharing	0.724	14.068	0.000	[0.580, 0.800]
Motivation - > Performance	0.590	9.070	0.000	[0.427, 0.695]
Motivation - > Trust	0.658	10.869	0.000	[0.489, 0.749]
Trust - > Coordination	0.194	2.430	0.015	[0.035, 0.351]
Trust - > Performance	0.160	2.465	0.014	[0.029, 0.287]

in the model estimation) divided by omission distance value should not be an integer [12]. Hence, omission distance value 7 is also used herein the blindfolding procedure to generate the  $Q^2$  values because it does not yield an integer value while dividing the number of observations. In this assessment, if the  $Q^2$  values for the endogenous constructs are greater than 0 then they indicate the presence of predictive relevance of the path model, whereas, zero, or negative values of  $Q^2$  indicate the absence of predictive relevance.

The following Table 16.9 exhibits the blindfolding results, where the cross-validated redundancy approach is used to generate the  $Q^2$  values because this approach includes both structural model and measurement model, and hence perfectly fits in PLS-SEM. The specification of Table 16.9 is given below. Detailed information and definitions about  $Q^2$  ( $= 1-SSE/SSO$ ) can be found in [11, 12, 20] and [27].

- SSO shows the sum of the squared observations,
- SSE shows the sum of the squared prediction errors, and
- $Q^2$  is the final value obtained from the calculation of  $(1 - SSE/SSO)$  to judge the model’s predictive relevance with regard to each endogenous constructs in the structural model.

As can be seen in Table 16.9, all the endogenous constructs in the structural model have  $Q^2$  values clearly above zero. More specifically, *Coordination* has the highest  $Q^2$  value (0.559), followed by *Communication* (0.546), *Knowledge Sharing* (0.536), *Cohesion* (0.514), *Performance* (0.407), and *Trust* (0.380). These results provide clear support for the model’s predictive relevance regarding the endogenous constructs in the structural model.

## Conclusion

A complete evaluation of the model proposed by Jony and Serradell-Lopez in [18] is presented in this paper to justify its statistical support. As a statistical tool, PLS-SEM is used for assessing and analyzing the model. Based on the recommendation from the existing literature of PLS-SEM, all the required evaluation criteria have been applied to systematically assess the measurement model and structural model towards the statistical estimation of the conceptual model. In this model estimation process, the PLS-SEM algorithm, bootstrapping routine, and blindfolding procedure are applied for testing the significance and relevance of the model. However,

**Table 16.9**  $Q^2$  values for endogenous constructs

Endogenous Constructs	SSO	SSE	$Q^2$ ( $= 1-SSE/SSO$ )
Cohesion	450.000	218.904	0.514
Communication	450.000	204.111	0.546
Coordination	450.000	198.555	0.559
Knowledge Sharing	450.000	208.592	0.536
Motivation	450.000	450.000	
Performance	450.000	266.742	0.407
Trust	450.000	279.085	0.380



in general, the bootstrapping procedure is ultimately sufficient to assess the significance and relevance of the model's relationships (e.g., t values, p values, bootstrap confidence intervals, and total effects), and to conclude whether the model or in particular the relationships of the model are statistically significant and relevant. The results of the evaluation indicate clear statistical supports for the model's significance and relevance. So, according to the evaluation of the model, it is believed that the model would be useful for developing an effective virtual teamwork in online higher education.

**Acknowledgements** This work is part of a Doctoral Thesis funded by and conducted at *Universitat Oberta de Catalunya* (Barcelona, Spain).

## References

1. V. Anantatmula, M. Thomas, Managing global projects: a structured approach for better performance model. *Proj. Manage. J.* **41**(2), 60–72 (2010)
2. P. Andreev et al., “Validating formative partial least squares (PLS) models: methodological review and empirical illustration.” ICIS 2009 proceedings, 2009
3. R. Bennett, Employers' demands for personal transferable skills in graduates: a content analysis of 1000 job advertisements and associated empirical study. *J. Vocat. Educ. Training* **54**(4), 457–476 (2000)
4. Y.M. Chatelin et al., “State-of-art on pls path modeling through the available software.” HEC research papers series 764, HEC Paris, 2002
5. W.W. Chin, “The partial least squares approach to structural equation modeling.” *Modern methods for business research*. ed. by G.A. Marcoulides (Mahwah, NJ: Lawrence Erlbaum, 1998), pp. 295–358
6. S. Cohen, *Statistical Power Analysis for the Behavioral Sciences*. Lawrence Erlbaum, 1988
7. Company Name, “I torneo acbsp - companygame de simulacion empresarial.” *Company Game | Learn Simulating*, 2019, <http://www.companygame.com>
8. P.D. Ellis, *The Essential Guide to Effect Sizes*. Cambridge University Press, 2010
9. M. Fisz, “Significance Testing.” *Probability Theory and Mathematical Statistics*. 3rd edn. (John Wiley and Sons, New York, 1963)
10. B.S. Everitt, A. Skrondal. *The Cambridge Dictionary of Statistics*. 4th edn. (Cambridge University Press, 2010)
11. S. Geisser, A predictive approach to the random effects model. *Biometrika* **61**, 101–107 (1974)
12. J.F. Hair et al., *A Primer on Partial Least Squares Structural Equation Modeling (pls-sem)*, 2nd edn. (Sage, Los Angeles, 2017)
13. J.F. Hair et al., “Pls-sem: Indeed a silver bullet.” *J. Mark. Theory Pract.*, **19**, 139–151 (2011)
14. J.F. Hair et al., “When to use and how to report the results of pls-sem.” *Eur. Bus. Rev.* **3**(1), 2018, <https://doi.org/10.1108/ebr-11-2018-0203>
15. G. Hertel et al., Managing virtual teams: a review of current empirical research. *Hum. Resour. Manage. Rev.* **15**(1), 69–95 (2005)
16. G. James et al., *An Introduction to Statistical Learning*, 8th edn. (Springer, New York, 2017)
17. A.I. Jony, E. Serradell-Lopez, “A pls-sem approach in evaluating a virtual teamwork model in online higher education: why and how?” Rii Forum Proceedings of Research & Innovation Forum (rii forum) Annual Conference (Springer, Athens, Greece, 2020)
18. A.I. Jony, E. Serradell-Lopez. “Key factors that positively affects the effectiveness of virtual teamwork in online higher education.” Rii forum proceedings of research & innovation forum (rii forum) annual conference (Springer, Athens, Greece, 2020)

19. B.L. Kirkman et al., The impact of team empowerment on virtual team performance: the moderating role of face to face interaction. *Acad. Manag. J.* **47**(2), 175–192 (2004)
20. H. Latan, R. Noonan, *Partial Least Squares Path Modeling: Basic Concepts, Methodological Issues and Applications*. Springer, 2017
21. P. Ludden, A. Ledwith, “A typology framework for virtual project teams: An empirical investigation.” *Pmi research and education conference*, ed. by C. Messikomer (Portland, Project Management Institute, OR, 2014)
22. M.E. Olobatuyi, *A User’s Guide to Path Analysis*. UPA, 2006
23. E.E. Rigdon, Rethinking partial least squares path modeling: in praise of simple methods. *Long Range Plan.* **45**, 341–358 (2012)
24. C.M. Ringle et al., Smartpls3. SmartPLS GmbH. Bönningstedt. 2015, <http://www.smartpls.com>
25. M. Sarstedt et al., On the emancipation of pls-sem: a commentary on Rigdon (2012). *Long Range Plan.* **47**, 154–160 (2014)
26. M. Sarstedt et al., “Measuring reputation in global markets: a comparison of reputation measures’ convergent and criterion validities.” *J. World Bus.* **48**, 329–339 (2013)
27. M. Stone, Cross-validators choice and assessment of statistical predictions. *J. Royal Stat. Soc.* **36**, 111–147 (1974)
28. D. Straub et al., Validating guidelines for is positivist research. *Commun. Assoc. Inf. Syst.* **13**, 380–427 (2004)
29. M. Tenenhaus et al., Pls path modeling. *Comput. Stat. Data Anal.* **48**(1), 159–205 (2005)
30. R.E. Walpole, *Probability & Statistics for Engineers & scientists*, 7th edn, Pearson, 2006
31. Wikipedia. “Coefficient of determination.” 29 April 2020, [https://en.wikipedia.org/wiki/Coefficient\\_of\\_determination](https://en.wikipedia.org/wiki/Coefficient_of_determination)
32. Wikipedia. “Variance Inflation factor.” 8 June 2020, [https://en.wikipedia.org/wiki/Variance\\_inflation\\_factor](https://en.wikipedia.org/wiki/Variance_inflation_factor)
33. Wikipedia. “Effect size.” 6 June 2020, [https://en.wikipedia.org/wiki/Effect\\_size](https://en.wikipedia.org/wiki/Effect_size)
34. Wikipedia. “T-statistic.” 11 May 2020, <https://en.wikipedia.org/wiki/T-statistic>
35. Wikipedia. “p-value.” 19 May 2020, <https://en.wikipedia.org/wiki/P-value>
36. S. Wright, The method of path coefficients. *Ann. Math. Stat.* **5**, 151–215 (1934)