A STRUCTURE OF RISK FACTORS FOR INSTALLING FAÇADE OF BUILDINGS INFLUENCING THE SUCCESS OF CONSTRUCTION PROJECTS

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Abstract

At present, to make buildings be attractiveness, be identity and be energy-saving, façade work is popularly chosen to replace concrete wall. As such, there appear a number of façade subcontractors. Yet, some of them do not succeed in their business objectives. This is possibly because they do not consider its risk factors. Also, from the literature review, although many researchers have identified risk factors for various construction works, few of them have identified a structure of risk factors for façade work. Thus, the research was aimed to identify such a structure of risk factors influencing the success of construction projects through a questionnaire to survey opinions from façade subcontractors about the important level of risk factors for façade work. The data were analyzed, namely: (1) confirming the structure of risk factors and (2) finding the influence level of the structure of risk factors having on the success of construction projects in terms of cost, quality, time and safety. The result suggests that all risk factors can be structured into 7 sources of risk with their weights of relative importance: “risks from sub-subcontractor” (20.1%), “risks from designer” (16.9%), “risks from main contractor” (14.9%), “risks from façade consultant” (13.5%), “risks from owner” (12.8%), “risks from environment” (11.0%) and “risks from subcontractors” (10.7%). Also, this structure has 60% influence on the success of construction projects. This result is expected to help façade subcontractors identify all potential risks and determine appropriate risk treatment.

Keywords: Risk factor, Façade, Subcontractor, Project success, Factor analysis

1. INTRODUCTION

The evolution of buildings presents in terms of, e.g., modern design, different shape, more useful area or energy saving. This leads to changing outside buildings’ coverings from concrete wall to façade. The most popular façade of buildings is glass wall because it makes

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buildings modern-look and transparent. Accordingly, a number of façade subcontractors exist. However, some of them do not succeed in the façade work perhaps because most façade work of large buildings is complex and has high opportunity of risks occurring during construction that requires high-skilled subcontractors/laborers. As such, identifying risk factors for installing façade of buildings is necessary. Many researchers have identifying risk factors for various building and construction works. For example, Zou et al. (2007) have studied risk factors affecting projects in terms of cost, time, quality, security and environmental sustainability. These risk factors related to clients, designers, contractors, subcontractors, government agencies and external issues, which include "tight project schedule", "project funding problems", "variations by the client", "design variations", "inadequate program scheduling", "inadequate site information", "incomplete or inaccurate cost estimate", "contractors' poor management ability", "contractors' difficulty in reimbursement", "poor competency of labourer", "low management competency of subcontractors", "suppliers' incompetency to deliver materials on time", "excessive procedures of government approvals", "bureaucracy of government", "price inflation of construction materials". Tserng et al. (2009) have studied ontology-based risk management (ORM) framework of construction projects through project life cycle and found that the ORM framework was able to apply to the risk management (RM) workflow for contractors, and more importantly, it greatly increased the effectiveness of project risk management. The risk factors suggested were "external risks", "site conditions", "owner contractor agreement", "owner condition", "subcontractor condition", "project execution", "project preparation and planning", "contracting and administration procedure". Wang et al. (2011) have studied factors affecting contractors' risk attitudes in construction. They found that the most important three factors are: "consequences of decision making", "engineering experience" and "completeness of project information". Also, they suggest 4 groups of risk factors: (1) knowledge and experience, (2) contractors' character, (3) personal perception and (4) economic environment. These groups consisted of 16 risk factors, namely: "education background", "engineering experience", "social experience", "professional knowledge", "scope of knowledge", "completeness of project information", "boldness", "values", "decision motivation", "interest in the engineering", "sensitivity to external information", "desire for decision objectives", "consequences of decision making", "judgment ability", "company's economic strength" and "external economic environment".

From the above literature review, many researchers have suggested risk factors in building and construction works but few researchers have demonstrated risk factors influencing the success of installing façade of buildings. Thus, this research aim was to develop such a structure of risk factors affecting the success of construction projects.

2. METHODOLOGY

The Thai construction industry was surveyed. Subcontractors experienced in façade work were targeted. A questionnaire was sent to 14 subcontractors to gather data about the importance level of a structure of risk factors in façade work and about the influence levels of the structure of risk factors having on the success of building projects. The research method was as follows:

- reviewed the published papers on risk factors in various building and construction works, e.g., Terng et al. (2009), Wang et al. (2011), Zou, et al. (2007)
- determined a conceptual structure of risk factors in façade work influencing the success of construction projects
- developed a questionnaire based on the conceptual structure of risk factors in façade work
- tested the questionnaire with 4 practitioners experienced in façade work to assure content validity and the completeness of risk factors in façade work
- improved the questionnaire according to the practitioners' comments
- distributed the questionnaire to personnel of subcontractors.

A total of 143 questionnaires were sent out. 108 questionnaires were returned. The rate of return was 75.5%. This return rate is regarded as good (Babbie, 1989). The respondents had a total annual contract value of 150 million Bahts, and engaged 50 contracts annually. To test quality of the questionnaire, its validity and reliability was explored.

- Validity: here Spearman rank correlation was employed to investigate relationships amongst all factors in order to test construct validity. Risk factor correlation is shown in Table 1. From the table, all the risk factors are correlated confirming that these factors are valid (Prasith-rathsint, 1997).
- Reliability: the Cronbach's Alpha was used to test reliability of the scale (1-5) – a combination of a bipolar adjective and a Likert scale: 1 = very low importance to 5 = very high importance. Cronbach's Alpha ranges from 0 to 1: 1 = highest reliability and 0 = lowest reliability. The Cronbach's Alpha should be more than 0.7 (SPSS, 1998). Here, the Cronbach's Alpha valued at 0.893 for all the risk factors considered as good reliability.

After that, the data were analyzed using AMOS. Two main analyses were:

- testing the conceptual structure of risk factors using confirmatory factor analysis (CFA) through both 1st order CFA and 2nd order CFA
- finding the influence level of the conceptual structure of risk factors having on the success of construction projects through Structural Equation Modeling (SEM).

Table 1: Spearman rank correlation of risk factors in façade work

	Unclear study of contract documents by owner	Drawing change by owner	Low efficient monitoring of owner	Work acceleration	Delays in work approval	Lack of careful-work inspection	Delays in drawing delivery	Selection of hign price materials	Inaccurate planning of designer	Work delays of main contractor	Equipment non readyness of main contractor	Constructions not corresponding to drawings	Lack of skilled labors of main contractor	Drawing change by main contracto	Low sufficient monitoring of main contractor
Unclear study of contract documents by owner	1.000	.168	.163	.179	.176	.166	.016	-.080	.062	.029	.072	.135	.002	.013	.170
Drawing change by owner	.168	1.000	.016	.227*	.177	.023	.176	.112	.066	.093	.040	.157	.086	.086	.200*
Low efficient monitoring of owner	.163	.016	1.000	.142	.328**	.224*	.035	.093	.161	.078	.051	.141	.069	.061	.216*
Work acceleration	.179	.227*	.142	1.000	.211*	.000	.053	-.025	.076	-.009	.088	.246*	-.016	.108	.116
Delays in work approval	.176	.177	.328**	.211*	1.000	.229*	.116	.054	-.004	.249**	.184	.077	.227*	.108	.180
Lack of careful-work inspection	.166	.023	.224*	.000	.229*	1.000	.247**	.157	.280**	.182	.070	.119	.048	.114	.101
Delays in drawing delivery	.016	.176	.035	.053	.116	.247**	1.000	.265**	.101	.253**	.098	.156	.058	.141	.314**
Selection of hign price materials	-.080	.112	.093	-.025	.054	.157	.265**	1.000	.094	.218*	.209*	.174	.120	-.031	.226*
Inaccurate planning of designer	.062	.066	.161	.076	-.004	.280**	.101	.094	1.000	.055	.149	.203*	.362**	.070	.177
Work delays of main contractor	.029	.093	.078	-.009	.249**	.182	.253**	.218*	.055	1.000	.211*	.110	.131	.180	.195*
Equipment non readyness of main contractor	.072	.040	.051	.088	.184	.070	.098	.209*	.149	.211*	1.000	.203*	.286**	.086	.109
Constructions not corresponding to drawings	.135	.157	.141	.246*	.077	.119	.156	.174	.203*	.110	.203*	1.000	.253**	.234*	.138
Lack of skilled labors of main contractor	.002	.086	.069	-.016	.227*	.048	.058	.120	.362**	.131	.286**	.253**	1.000	.108	.089
Drawing change by main contractor	.013	.086	.061	.108	.108	.114	.141	-.031	.070	.180	.086	.234*	.108	1.000	.166
Low sufficient monitoring of main contractor	.170	.200*	.216*	.116	.180	.101	.314**	.226*	.177	.195*	.109	.138	.089	.166	1.000
Financial problem of subcontractor	.157	-.059	.169	-.203*	.055	.190*	.128	.056	.130	.146	-.002	.125	.094	.258**	.154
Work delays of subcontractor	-.018	.098	.075	.146	.080	.137	.279**	.208*	.261**	.194*	.135	.138	.123	.171	.073
Low responsibility of subcontractor	.177	-.008	.097	.079	.064	.164	.099	-.129	.074	.074	.021	-.058	.030	.239*	.142
Inaccurate planning of subcontractor	.091	.026	.114	.076	.097	.035	.029	.008	.106	.040	.170	.119	.139	.113	.014
Equipment non readyness of subsubcontractor	.064	.131	-.002	.043	.064	.084	.162	.170	.085	.170	.196*	.370**	.202*	.263**	.099
Lack of skilled labors of subsubcontractor	-.069	.159	.099	.127	.231*	.040	.189	.217*	.203*	.308**	.296**	.242*	.181	.085	.348**
Request for drawing change bysubsubcontractor	.124	.218*	.200*	.157	.378**	.252**	.292**	.154	.223*	.234*	.151	-.010	.051	.102	.245*
Low effficient monitoring of subsubcontractor	.044	.071	.091	.176	.331**	-.006	.127	.014	.100	.074	.132	.176	.265**	.333**	.047
Unclear study of drawings by subsubcontractor	.043	.204*	.158	-.040	.279**	.067	-.047	.088	.027	.176	.109	.058	.106	.200*	.037
Lack of control or inspection according to specification	.164	.161	.284**	.104	.012	.047	.200*	.126	.060	.085	.118	.269**	.138	.119	.132
Low effficient monitoring of consultant	.090	.066	.133	.079	.178	.188	.060	.205*	.202*	.071	.089	.064	.247**	.127	.150
Low responsibility of consultant	.345**	.091	.207*	-.054	.189*	.255**	.046	.143	.048	.064	.164	.069	.093	-.028	-.053
Political Chaos	.179	.056	.094	.052	.174	.183	.075	.119	.107	.162	.018	.196*	.202*	-.090	.066
Unsuitable environment	.066	-.034	.093	-.175	.172	.142	.249**	.235*	.187	.176	.098	.063	.211*	.056	-.011
Unexpected events	.235*	-.032	.159	.003	.098	.129	.285**	.067	.101	.205*	.069	.088	.161	.064	.083

	Financial problem of subcontractor	Work delays of subcontractor	Low responsibility of subcontracto	Inaccurate planning of subcontractor	Equipment non readyness of subsubcontractor	Lack of skilled labors of subsubcontractor	Request for drawing change bysubsubcontractor	Low effficient monitoring of subsubcontractor	Unclear study of drawings by subsubcontractor	Lack of control or inspection according to specification	Low effficient monitoring of consultant	Low responsibility of consultant	Political Chaos	Unsuitable environment	Unexpected events
Unclear study of contract documents by owner	.157	-.018	.177	.091	.064	-.069	.124	.044	.043	.164	.090	.345**	.179	.066	.235*
Drawing change by owner	-.059	.098	-.008	.026	.131	.159	.218*	.071	.204*	.161	.066	.091	.056	-.034	-.032
Low efficient monitoring of owner	.169	.075	.097	.114	-.002	.099	.200*	.091	.158	.284**	.133	.207*	.094	.093	.159
Work acceleration	-.203*	.146	.079	.076	.043	.127	.157	.176	-.040	.104	.079	-.054	.052	-.175	.003
Delays in work approval	.055	.080	.064	.097	.064	.231*	.378**	.331**	.279**	.012	.178	.189*	.174	.172	.098
Lack of careful-work inspection	.190*	.137	.164	.035	.084	.040	.252**	-.006	.067	.047	.188	.255**	.183	.142	.129
Delays in drawing delivery	.128	.279**	.099	.029	.162	.189	.292**	.127	-.047	.200*	.060	.046	.075	.249**	.285**
Selection of hign price materials	.056	.208*	-.129	.008	.170	.217*	.154	.014	.088	.126	.205*	.143	.119	.235*	.067
Inaccurate planning of designer	.130	.261**	.074	.106	.085	.203*	.223*	.100	.027	.060	.202*	.048	.107	.187	.101
Work delays of main contractor	.146	.194*	.074	.040	.170	.308**	.234*	.074	.176	.085	.071	.064	.162	.176	.205*
Equipment non readyness of main contractor	-.002	.135	.021	.170	.196*	.296**	.151	.132	.109	.118	.089	.164	.018	.098	.069
Constructions not corresponding to drawings	.125	.138	-.058	.119	.370**	.242*	-.010	.176	.058	.269**	.064	.069	.196*	.063	.088
Lack of skilled labors of main contractor	.094	.123	.030	.139	.202*	.181	.051	.265**	.106	.138	.247**	.093	.202*	.211*	.161
Drawing change by main contractor	.258**	.171	.239*	.113	.263**	.085	.102	.333**	.200*	.119	.127	-.028	-.090	.056	.064
Low sufficient monitoring of main contractor	.154	.073	.142	.014	.099	.348**	.245*	.047	.037	.132	.150	-.053	.066	-.011	.083
Financial problem of subcontractor	1.000	.083	.346**	.261**	.117	.123	-.052	.195*	.058	.112	-.046	.201*	.175	.332**	.263**
Work delays of subcontractor	.083	1.000	.103	.074	.160	.165	.306**	.138	.165	.211*	.180	.181	.219*	.197*	.187
Low responsibility of subcontractor	.346**	.103	1.000	.272**	-.063	-.030	.151	.131	.077	.244*	.078	.279**	.089	.191*	.337**
Inaccurate planning of subcontractor	.261**	.074	.272**	1.000	-.095	.075	.160	.261**	.157	.203*	.066	.134	.135	.307**	.122
Equipment non readyness of subsubcontractor	.117	.160	-.063	-.095	1.000	.298**	-.090	.153	.038	.004	.072	.020	.084	-.045	.067
Lack of skilled labors of subsubcontractor	.123	.165	-.030	.075	.298**	1.000	.250**	.084	.059	.074	.267**	.093	.092	.070	.085
Request for drawing change bysubsubcontractor	-.052	.306**	.151	.160	-.090	.250**	1.000	.163	.268**	.178	.223*	.153	.116	.256**	.139
Low effficient monitoring of subsubcontractor	.195*	.138	.131	.261**	.153	.084	.163	1.000	.322**	.148	.220*	.109	.019	.165	-.026
Unclear study of drawings by subsubcontractor	.058	.165	.077	.157	.038	.059	.268**	.322**	1.000	.117	-.056	.255**	.009	.233*	.021
Lack of control or inspection according to specification	.112	.211*	.244*	.203*	.004	.074	.178	.148	.117	1.000	.186	.263**	.207*	.098	.212*
Low effficient monitoring of consultant	-.046	.180	.078	.066	.072	.267**	.223*	.220*	-.056	.186	1.000	.222*	.061	.007	.022
Low responsibility of consultant	.201*	.181	.279**	.134	.020	.093	.153	.109	.255**	.263**	.222*	1.000	.214*	.260**	.367**
Political Chaos	.175	.219*	.089	.135	.084	.092	.116	.019	.009	.207*	.061	.214*	1.000	.170	.313**
Unsuitable environment	.332**	.197*	.191*	.307**	-.045	.070	.256**	.165	.233*	.098	.007	.260**	.170	1.000	.295**
Unexpected events	.263**	.187	.337**	.122	.067	.085	.139	-.026	.021	.212*	.022	.367**	.313**	.295**	1.000

**. Correlation is significant at the 0.01 level (2-tailed).,*. Correlation is significant at the 0.05 level (2-tailed).

3. RESULTS

The conceptual structure of risk factors was confirmed with the observed data using CFA – the usage of CFA can be read in Byrne (2010). Both first order and second order CFA was applied for this confirmation, which has 4 criteria as the following (Rangsungnoen, 2011; Silcharu, 2012).

- Chi-square Probability Level (CMIN-p): this criterion is used to test whether the conceptual structure is consistent with that obtained from the observed data. p-value reveals the consistency. If p-value is more than 0.05, the conceptual structure and the structure from the observed data are consistent.
- Relative Chi-square (CMID/df): this criterion relatively tests consistency between the two structures similar to CMIN-p. However, the consistency is displayed by CMID/df value. If CMID/df is less than 3, these two structures are consistent.
- Goodness of Fit Index (GFI): this criterion shows the difference ratio between the consistency functions of the conceptual structure and the structure obtained from the observed data. GFI value defines the consistency. GFI value ranges between 0 and 1. The closer the value of GFI to 1, the more consistency of both the structures.
- Root Mean Square Error of Approximation (RMSEA): this criterion statistically tests the hypothesis: whether the conceptual structure is compatible with the structure obtained from the observed data. If RMSEA is less than 0.08, there is compatibility between the two structures.

To find how much the structure of risk factors influences the success of building projects, SEM was applied. The results of both CFA and SEM are the following.

3.1 CONFIRMATORY FACTOR ANALYSIS: CFA

The CFA was employed to test the structure of risk factors, which started from testing 7 groups of risk factors: “risks from sub-subcontractor”, “risks from designer”, “risks from main contractor”, “risks from façade consultant”, “risks from owner”, “risks from environment”, “risks from subcontractors”. The testing result shows that all groups meet the requirements of all of the 4 criteria. This means all the 7 groups of risk factors are consistent with the observed data. Then, 1^{st} order and 2^{nd} order CFA was used to test the consistency of the conceptual structure of risk factors and that obtained from the observed data.

3.1.1 FIRST ORDER CFA

The result of 1^{st} order CFA is shown in Figure 1. In the figure, $p = 0.499$ (> 0.05), CMID/df = 1.044 (< 3), GFI = 0.789 (close to 1) and RMSEA = 0.10 (< 0.08). This shows that all the criteria are satisfied with the 4 criteria above, meaning all the groups of risk factors are consistent with the observed data.

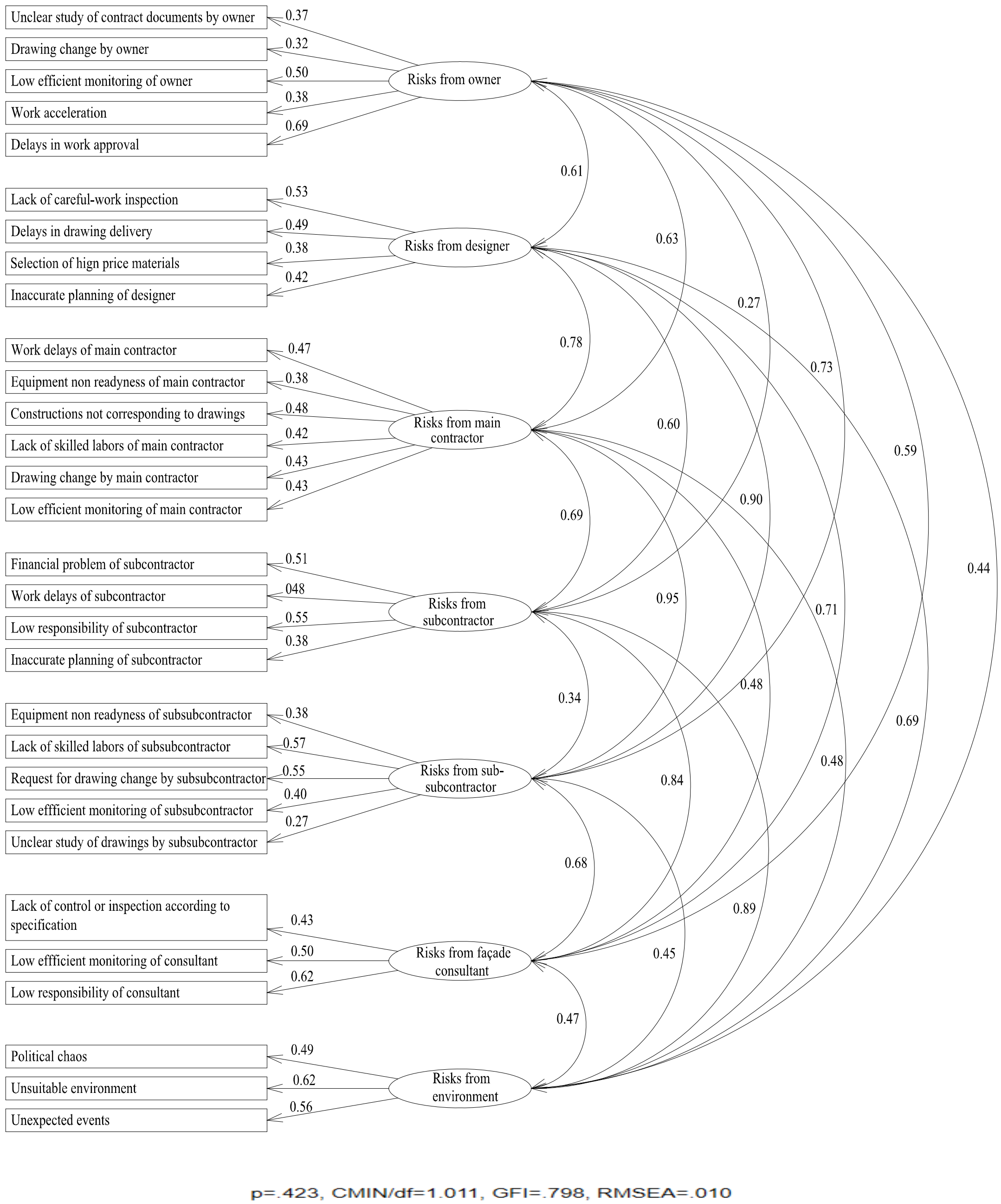

Figure 1: Analysis of all groups of risk factors by 1st order CFA.

3.1.2 SECOND ORDER CFA

Figure 2 shows the result of 2nd order CFA. Here, p = 0.987 (> 0.05), CMID/df = 0.842 (< 3), GFI = 0.849 (close to 1) and RMSEA = 0.000 (< 0.08). These 4 values meet the requirements of all of the 4 criteria, which mean that both the conceptual structure of risk factors and that obtained from the observed data are consistent.

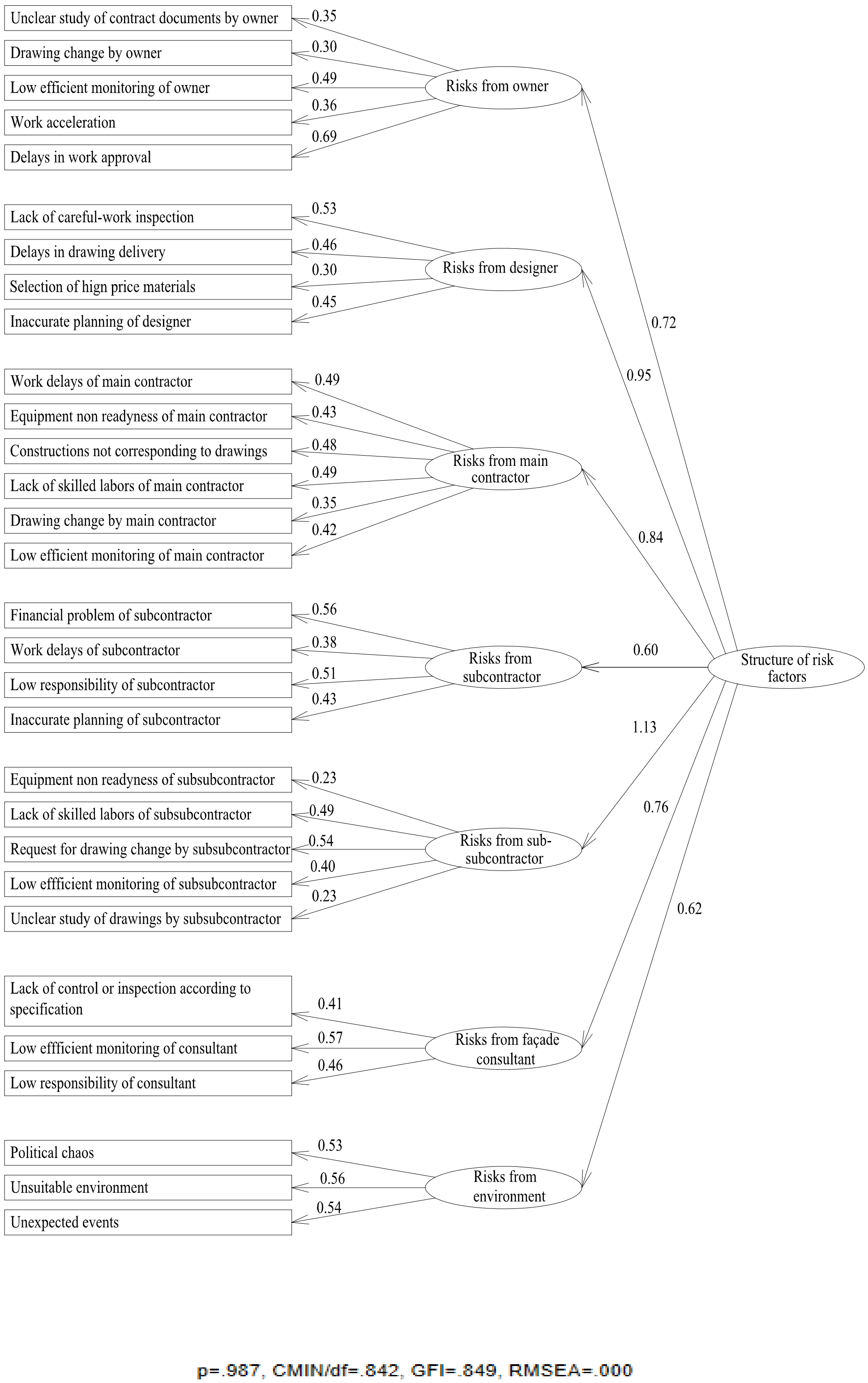

Figure 2: Analysis of the structure of risk factors by 2nd order CFA.

From Figure 2, the groups of risk factors with their regression weights were “risks from sub-subcontractor” (1.13), “risks from designer” (0.95), “risks from main contractor” (0.84), “risks from façade consultant” (0.76), “risks from owner” (0.72), “risks from environment” (0.62), “risks from subcontractors” (0.60). The regression weights of all groups can be normalized to the weights of relative importance as shown in Table 2. In the table, the most important group of risk factors is “risks from sub-subcontractor” (20.1%) whilst the least importance group is “risks from subcontractors” (10.7%).

Table 2: Groups of factors and factors with their weights of relative importance

Groups of factors and factors	Regression Weight	Weight of relative importance
Risks from sub-subcontractor	**1.13**	**20.1%**
Request for drawing change by sub-subcontractor	0.54	28.6%
Lack of skilled labors of sub-subcontractor	0.49	25.9%
Low efficient monitoring of sub-subcontractor	0.40	21.2%
Equipment non readiness of sub-subcontractor	0.23	12.2%
Unclear study of drawings by sub-subcontractor	0.23	12.2%
Risks from designer	**0.95**	**16.9%**
Lack of careful-work inspection	0.53	30.5%
Delays in drawing delivery	0.46	26.4%
Inaccurate planning of designer	0.45	25.9%
Selection of high price materials	0.30	17.2%
Risks from main contractor	**0.84**	**14.9%**
Work delays of main contractor	0.49	18.4%
Lack of skilled labors of main contractor	0.49	18.4%
Constructions not corresponding to drawings	0.48	18.0%
Equipment non readiness of main contractor	0.43	16.2%
Low sufficient monitoring of main contractor	0.42	15.8%
Drawing change by main contractor	0.35	13.2%
Risks from façade consultant	**0.76**	**13.5%**
Low efficient monitoring of consultant	0.57	39.3%
Low responsibility of consultant	0.46	31.7%
Lack of control or inspection according to specification	0.41	29.0%
Risks from owner	**0.72**	**12.8%**
Delays in work approval	0.69	31.2%
Low efficient monitoring of owner	0.49	22.2%
Work acceleration	0.38	17.2%
Unclear study of contract documents by owners	0.35	15.8%
Drawing change by owner	0.30	13.6%

Table 2: (Continued)

Groups of factors and factors	Regression Weight	Weight of relative importance
Risks from Environment	**0.62**	**11.0%**
Unsuitable environment	0.56	34.4%
Unexpected event	0.54	33.1%
Political Chaos	0.53	32.5%
Risks from subcontractor	**0.60**	**10.7%**
Financial problem of subcontractor	0.56	29.8%
Low responsibility of subcontractor	0.51	27.1%
Inaccurate planning of subcontractor	0.43	22.9%
Work delays of subcontractor	0.38	20.2%

3.2 STRUCTURAL EQUATION MODELING: SEM

The result of analyzing the SEM for the structure of risk factors for installing façade of buildings influencing the success of construction projects (called model) is shown in Figure 3 ($p = 0.998$ (> 0.05), CMID/df = 0.824 (< 3), GFI = 0.840 (close to 1) and RMSEA = 0.000 (< 0.08)). This means the model is consistent with the observed data.

In Figure 3, the structure of risk factors has 60% influence on the success of construction projects. Also, the success of construction projects consists of 4 factors with their weights: “cost” (0.65 or 30.0%), “safety” (0.59 or 27.1%), “time” (0.49 or 22.6%), “quality” (0.44 or 20.3%).

4. CONCLUSION

The research objective was to develop a structure of risk factors for installing façade of buildings influencing the success of construction projects. Two main analyses were performed: confirmatory factor analysis (CFA) and structural equation modeling (SEM). The first analysis was used to assure that the conceptual structure of risk factors corresponds to that gained from the observed data using 1st order and 2nd order CFA. The result shows that the structure of risk factors can be divided into 7 groups with weights of relative importance: “risks from sub-subcontractor” (20.1%), “risks from designer” (16.9%), “risks from main contractor” (14.9%), “risks from façade consultant” (13.5%), “risks from owner” (12.8%), “risks from environment” (11.0%), “risks from subcontractors” (10.7%). The group “risks from sub-subcontractor” was indicated as the highest important. A possible explanation is that most sub-subcontractors’ organizations are small and have the limit on knowledge, understanding and experience of façade work, which highly affects the success of construction projects. Also, the group “risks from designer” was indicated as the second highest important. A possible reason is that designers often lack approval for correct and workable design, resulting in waste of time due to repetition of design correction. In contrast, the result indicated the group "risks from subcontractors" as the least important. This is perhaps because most subcontractors have the highest specialization in managing risks of faç ade work. The second analysis found the influence of the structure of risk factors for installing façade of buildings having on the success of construction projects. The result s hows that this structure has 60% influence on the success of construction projects, which is reflected by "cost" accounted for 30.0% of weight, followed by "safety" accounted for 27.1%, "time" for 22.6% and "quality" for 20.3%. One possible reason why "cost" is accounted for the highest weight of the success of construction projects is that project cost highly affects project profit. The results of this research yield a clear understanding of a structure of risk factors in façade work of buildings influencing the success of construction projects, which results in improving risk management in façade subcontractors.

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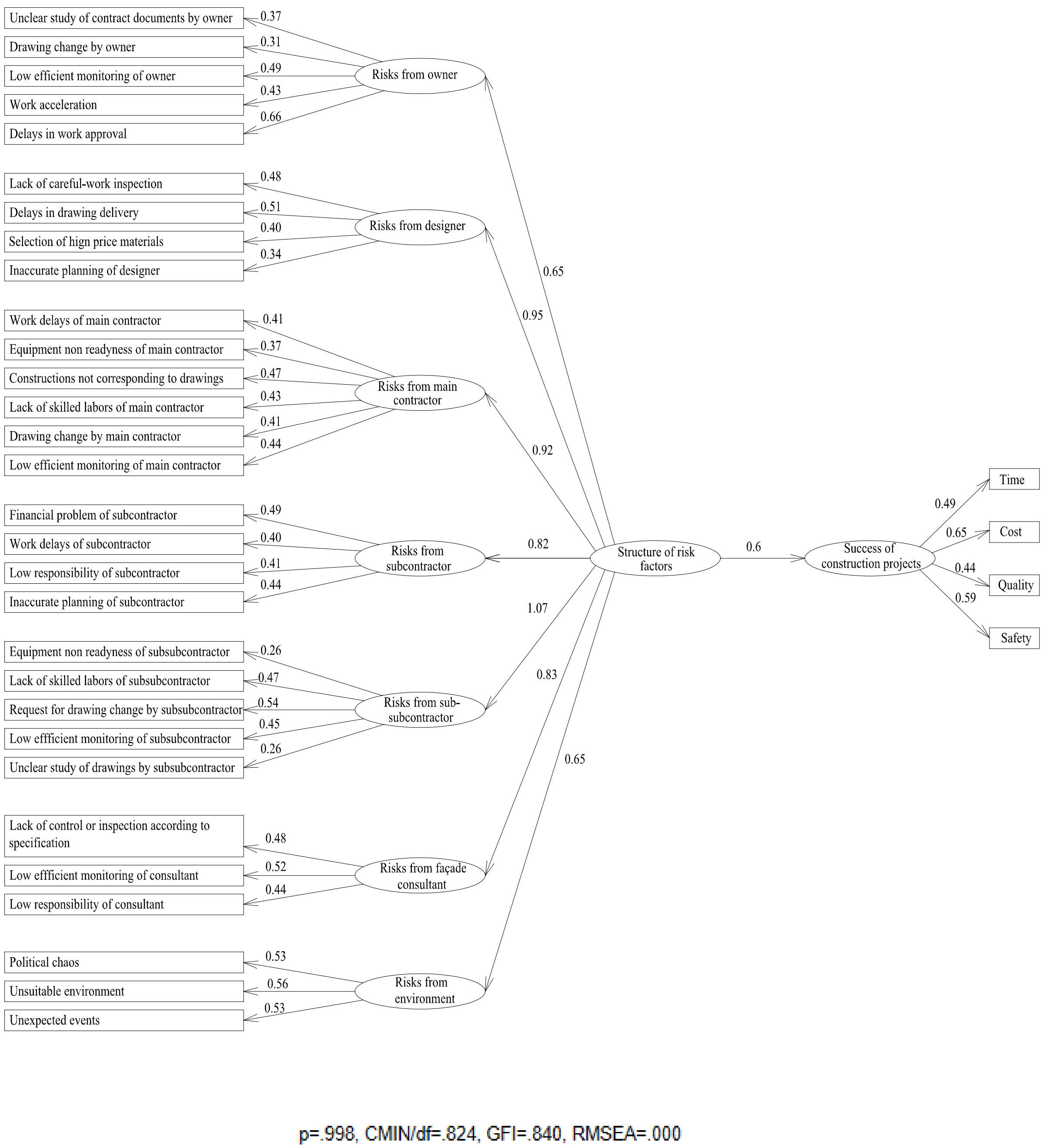

Figure 3: Analysis of the model of the structure of risk factors for installing façade of buildings influencing the success of construction projects by SEM.