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Application of TETRAD in Information Systems Theory Development using Knowledge Sharing Literature: Case-study based approach

Master Thesis

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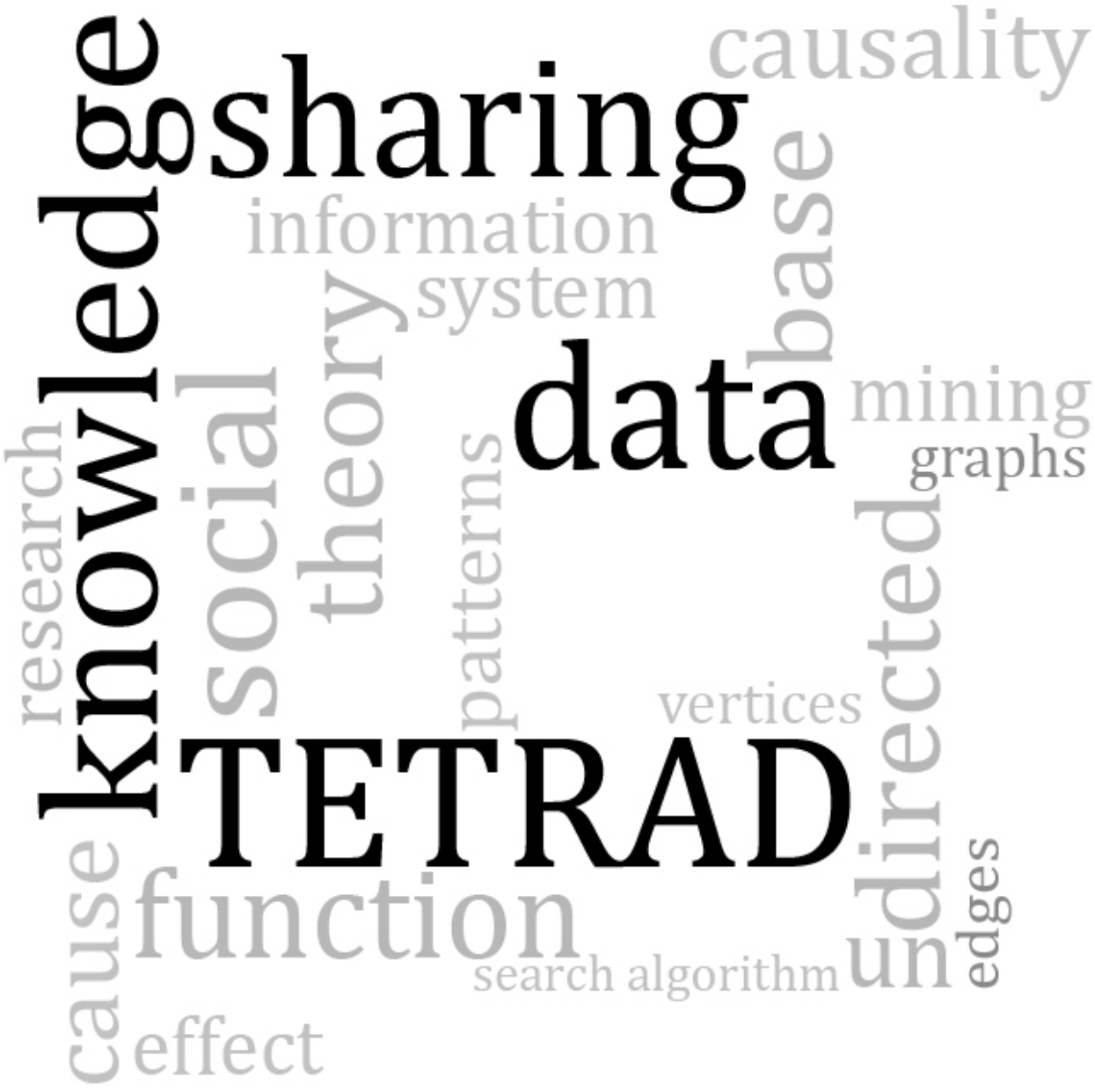

General Information

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Abstract

The discovery of causal relationships from empirical data is an important problem in theory development. We investigate the use of TETRAD IV to help researcher in a theory development phase. We applied TETRAD IV, a heuristic search software that used for discovering causal effect relationship between variables based on a specific model. To performed our task, we defined two case studies. First, we re-analyse an existing model or theory using original correlation matrix data from a paper in Knowledge Sharing field. Second, we validated the existing model by conducting a survey using data from 90 respondents (Bachelor, master, PhD candidate) in the University of Twente academic setting, which pointed out Blackboard as the primary online learning tools to support teaching as well as sharing the knowledge. The results give us suprising remarks. From the first case study, TETRAD IV discovered spurious relationship in the model, which are there is no causal effect between its variables. Furthermore, using our own data, we found the same results of causal linkage as we have in the first case study. These results give the idea of what truly occurs given the real data. Thus, it is critical to explore the relationships among the variables in the model using exploratory research tools, as TETRAD IV, to aid and guide the researcher in theory development phase.

Keywords: TETRAD, theory development, causality

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Abbreviation

DAG	Directed Acyclic Graph
IT	Information Technology
IS	Information Systems
SEM	Structural Equation Modelling
MIS	Management of Information System
OKSM	Online Knowledge Sharing Model
OKSB	Online Knowledge Sharing Behavior
POAM	Perceieved Online Attachment Motivation
PORC	Perceieved Online Relatiinship Commitment
TAM	Technology Acceptance Model
TRA	Theory of Reasoned Action

Chapter 1 Introduction

This chapter presents the motivation, objectives, approaches, and structure of this research. The first section gives the motivation of the research and then continues with the objectives and the research questions. The following section describes approaches and the steps to achieve research objectives. Finally, the last section outlines the structure of the thesis.

1.1 Research Motivation

This section presents the motivation for the thesis, developed from the concept of causality from previous studies, limitation of experimental data and the need to search for plausible alternative models derived from data, especially in the Information Systems field.

1.1.1 Why Causality?

Scientists always try to conduct their research intelligibly; thus, the results and the knowledge findings from their work can be well explained to their audience. It is commonplace that facts and findings in our everyday lives are formulated in a cause and effect relationship. As stated in the book "*Causality and Explanation*" by Salmon (1998):

> "*Causal concepts are universal: in every branch of theoretical science – physical, biological, behavioral, and social; in the practical disciplines – architecture, ecology, engineering, law, and medicine; in everyday life – making decisions regarding ourselves, our loved ones, other living persons and members of future generations*".

Statistical tools are often used to address causality and its questions for explaining cause and effect phenomena. Spiegel and Stephens (1999) reported

that a statistical approach helps researchers to collect, organize, summarize, present and analyze data. The final aim is to achieve valid conclusions and show reasonable decisions based on a certain analysis. Spirtes, *et al.* (2000), examined issues where the statistical approach is indeed promising; except for the standard warnings that "*correlation is not causation*". As cited in Liu (2009), Simon (1954) also proposed the idea about finding spurious link between two variables in a theory based on their correlation:

> "*To test whether a correlation between two variables is genuine or spurious, additional variables and equations must be introduced, and sufficient assumptions must be made to identify parameters of this wider system. If the two original variables are causally related in the wider system, the correlation is genuine.*"

Healey (2009) defined the term "Causation" as the relationship between variables in the research affecting the other variables being studied. Therefore, causation becomes a key concern of the scientific enterprise. Furthermore, Healey stated that practically every social science concept will discuss and debate that some variables will cause or affect the other variables. Moreover, the major goal of social research is to learn about the strength and direction of these causal relationships. The questions that arise are: *"How can we know such causal claims are true? How can we judge the credibility of arguments that one variable causes another?"* (Healey 2009).

1.1.2 Limitation of Experimentation

As cited in Glymour, *et al.* (1987) it is common that scientists, from field physics to sociology, have an aim to "*increase the understanding by providing explanations of the phenomena that concern us*". By this definition, Glymour *et al.* (1987) believe that the ideal form of such *explanations* is about "*why things happen as they do; by appealing to the causal relations among the events, and by articulating generalizations about causal relationships.*" When claiming causality for our framework or theory, experimental methods are often inadequate for predicting

phenomena. Non-experimental study is needed because there are many independent variables that cannot be controlled for some reasons (Johnson 2007); and the limitations both are practical and ethical (Glymour, Scheines et al. 1987). For practical reasons, Glymour *et al.* (1987) give an example that it is impossible for us to conduct a complete experiment with the economies for all nations. On the ethical side, Johnson (2007) illustrate the following situation:

> "*Randomly assign 500 newborns to experimental and control groups (250 in each group)c, where the experimental group newborns must smoke cigarettes and the controls do not smoke*."

It is imaginably unethical that we urge people to smoke (even voluntarily) to be part of such an experiment. Further, Johnson (2007) defines non-experimental research:

> "*Non-experimental research is research that lacks manipulation of the independent variable by the researcher; therefore, the researcher studies what naturally occurs or has already occurred; and the researcher studies how variables are related.*"

1.1.3 Causality in Semi-Automatic Theory Building

In the field of Information Systems (IS) research, Management Information Research (MIS) shares the challenges and problems of social sciences (Lee, Barua et al. 1997). Further, Lee *et al.* (1997) stated that MIS as the business discipline should emerge and evolve with regard to assisting managers to enhance and to improve the business processes and competitiveness through the utilization of information technology (IT). It is immensely crucial task for IT managers in understanding how IT can impact the organization performance. The key is to have the studies and research related to theory-based causal relationships between IT, organizational and economic factors (Lee, Barua et al. 1997).

According to Im and Wang (2007), as a social science discipline, Information Systems field uses two phases of research in developing theoretical models: exploratory and confirmatory research. Exploratory research is used:

(i) When facts, ideas, hypotheses or patterns are observed to make a theoretical case and,
(ii) When the prior knowledge about such phenomena is absent.

On the other hand, confirmatory research emphasizes on testing theoretical models developed through various rigorous processes of theory development (Im and Wang 2007). Lee *et al.* (1997) argued that researchers in the IS field have endeavored to reach maturity at the theoretical level, as well as methodological rigor. Lee *et al.* (1997) stated two related issues that have been pointed out in the empirical Management Information System (MIS) research, namely:

- the lack of theories, and
- methodological weaknesses.

These issues lead IS researchers to expose the need for building richer causal models and replacing the existing belief which is excessively dedicated to "what causes what" rather than "when" or "why" the causal relationship and causal discovery in the IS model has happened (Lee, Barua et al. 1997). Furthermore, Lee *et al.* (1997) argued that the need for richer causal models in the IS field is intended:

- "To increase the flexibility of model representation;
- To integrate the isolated worlds of pure latent variables and pure manifested variables[1]; and
- To provide a tighter linkage between the exploratory and confirmatory research phases."

[1] Pure latent variables can be associated with the term dependent or and endogenous variables; and pure manifested variables with independent or exogenous variables. We will discuss about these terms in TETRAD and its algorithm further in Chapter 3.

According to Im and Wang (2007), there are two fundamental processes in social science research: theory development and theory testing. For this matter IS researchers use statistical methods to help them in the process. The iterative stages in theory development are important especially in exploratory research and in the earlier stage of confirmatory research (Im and Wang 2007).

A group of researchers from Carnegie Mellon developed a program named TETRAD (Glymour, Scheines et al. 1988) that applies search techniques to help discover causal models from data. Exemplary, researchers (Lee, Barua et al. 1997; Im and Wang 2007; Liu 2009) mostly use TETRAD in the exploratory phase, to help them find a class of plausible models from a theory and not merely a single correct model[2]. Among its many algorithms (Glymour 2010), TETRAD provides two algorithms, so-called PURIFY and MIMBUILD, in order to help researchers discover a pure measurement model at item level and to discover a causal effect model between latent variables, respectively. These features can help researchers to find a whole set of relationships between the constructs/ variables within the model and provoke researchers to think outside their given model or theory[3]. Among others, Liu (2009) and Im and Wang (2007) give examples in explaining and performing the advantages of TETRAD, particularly in theory development of Information Systems (IS).

Related to this thesis, the idea of causation is proposed; to learn how we could gain more knowledge from data, and to learn about causal-effect phenomena behind variables through several parameters. In advantage, the artificial intelligence from the search algorithm can be used to observe the connectivity behind the variables from the data and to examine the causal–effect relationship between them. The connection between variables can improve our ability to investigate what are the hidden and uncovered relationships between the constructs or variables that build our theory or model. Following the work from

[2] We use the terms *model* and *theory* interchangeably.

[3] We adopt the wok of Liu (2009) and Im and Wang (2007) as the base of the approach conducted in this thesis.

Im and Wang (2007) and Liu (2009), the aim of this research is to use the same approach of TETRAD for theory development.

To obtain this goal, we conduct experiments in two case studies. First we will apply TETRAD on a model called *Online Knowledge Sharing Model* from a chosen paper published in the Knowledge Sharing field. The paper is from Ma and Yuen (2011) entitled "*Understanding Online Knowledge Sharing: An interpersonal relationship perspective*". Second we try to validate the model by conducting an experimental research – by doing survey in the University of Twente environment using "Blackboard" as the tool for online learning that supports academic teaching and online learning. The details about the two case studies are presented in Chapter 5.

1.2 Research Questions

The main goal of our research in this paper is to re-analyse and validate a model using software called TETRAD, applied to the chosen proposed problem in the Knowledge Sharing field. To be able to achieve this goal, we formulate a knowledge problem as the main research question stated:

Can causal mining with TETRAD help in theory development in the Information System area, e.g: Knowledge Sharing?

The main research question is then divided into several components, so that it can help the author answer the question more easily. The sub questions are:

Q1: Related to the use of TETRAD

Q1.1 Which TETRAD algorithms can be used for the case studies?

Q1.2 What are the possibilities and limitations of TETRAD application in both case studies?

Q2: Related to the chosen case study in Knowledge Sharing

Q2.1 Can TETRAD help in the exploratory phase to search for the pure model and search for the causal relationship from theory in Ma and Yuen's Online Knowledge Sharing Model?

Q2.2 What does TETRAD indicate in Ma and Yuen's Online Knowledge Sharing Model using the original data? (first case study)

Q2.3 What does TETRAD indicate in Ma and Yuen's Online Knowledge Sharing Model using "Blackboard" data survey? (second case study)

Q2.4 What are the lessons learned from TETRAD findings in both case studies?

1.3 Research Plan

This research emerges with the relevant and previous studies that have a link to our topic. We conducted a literature review on the causality and causal inference that relates to the use of TETRAD. Furthermore, we used the work of Im and Wang (2007) and Liu (2009) as references. Their research focused on TETRAD application as an approach of theory development in the IS field. TETRAD was used to assist them discovering causal relationships, especially when earlier knowledge of the fundamental theory bases are unknown (Im and Wang 2007) and to validate a theory both in isolation and in a larger nomological network (Liu 2009).

We conducted two experiments in this thesis. First, the case study is chosen from a paper that was published in the Knowledge Sharing field. The proposed model is going to be improved using TETRAD. We attempted to investigate the use of TETRAD and to test it by comparing the existing output with our test's result. The idea of understanding the relationships between constructs is to assure the importance of the exploratory research since the model or theory is still premature and the preliminary knowledge is lacking, particularly in the early phase of theory development. We used a paper from Elsevier, The Journal of Computers and Education. The paper is from Ma and Yuen (2011) titled "Understanding online knowledge sharing: An interpersonal relationship

perspective". We compare the findings from Ma and Yuen (2011) and our findings using TETRAD, to determine the usefulness of TETRAD for detecting potential theoretical relationships between the constructs, especially when underlying theory bases are still weak (Im and Wang 2007).

Second, we designed a case study for our own research. We used the constructs, hypotheses and structural model that are proposed in Ma and Yuen's (2011) paper. Ma and Yuen's paper proposed a model called OKSM: Online Knowledge Sharing Model. Adaptations were made for the second case study: we replaced Ma and Yuen's online learning tool called Interactive Learning Network or ILN with "Blackboard", as the online knowledge sharing in the University of Twente environment. The respondents for the survey are students from the University of Twente, including students from the newest faculty, ITC[4] (UTwente 2010). Details about both case studies and results are explained on Chapter 4 and 5 respectively. Figure 1 represents our framework for the research.

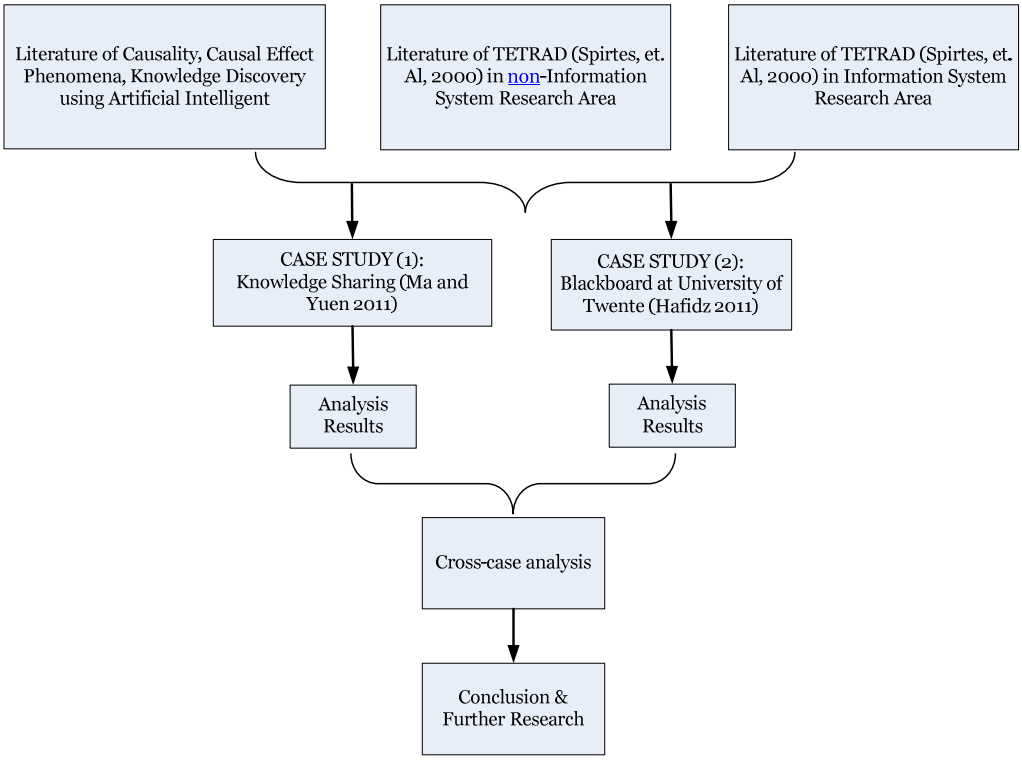

Figure 1. Research Framework

1.4 Thesis Structure

This thesis is structured in the following chapters:

1. Chapter 1 describes the motivation and aim, the research questions, and research framework.
2. Chapter 2 presents related research on causality that used TETRAD(Scheines, Spirtes et al. 2010) for causal mining and knowledge discovery.
3. Chapter 3 describes development and history behind Causal Model, the explanation of TETRAD (Scheines, Spirtes et al. 2010) software, and algorithms that are used in this thesis with an example.
4. Chapter 4 describes the research methodology.
5. Chapter 5 presents results and analysis for the two case studies.
6. Finally, Chapter 6 draws conclusions and discussions of TETRAD (Scheines, Spirtes et al. 2010) application in case studies conducted in previous chapter.

[4] Since 1 January 2010, ITC or International Institute for Geo-Information Science and Earth Observation is the 6th faculty of the University of Twente.

Chapter 2 Literature Review

This chapter provides the theoretical foundations of the major concepts that are relevant for this research. The author discusses the following related work: (1) Research using TETRAD in the area of causality or causation and (2) Research using TETRAD especially in theory development in the IS field. The discussions are shaped in a concept matrix that is available in Section 2.2. Instead of giving an in-depth analysis, this chapter just aims to allow the reader to become familiar with the concepts.

2.1 Literature Review Schema

The review of relevant literature is an important feature of any academic project. Literature Review is one of the mandatory steps to initiate the research, which provides the foundation for the research and which is critical to strengthening Information System as a field of study (Webster and Watson, 2002). For this thesis, two scientific journal search engines are used, as well as manual book resources; the search engines used are Scopus and Google Scholar. We searched for the relevant previous studies and adopted the methods proposed by Wesbter and Watson (2002), as follows:

1. Keyword Research

   For the first method, the author uses the most important or influential papers on the topic, and the most influential contributions are possibly to be issued in the leading journals (Webster and Watson 2002). Therefore, it is necessary to start reviewing the article based on its quality rather than quantity. To achieve this goal, we use the work from Peffers and Ya (2003) and use their list as reference on the top twenty-five journals as a premier

list in Information System journals. The journals that were reviewed by (Peffers and Ya 2003) are listed in Appendix A.

In addition, we used the following keywords related to our topic: "information system", "theory development", "causality", "causation", "causal discovery" and "TETRAD".

For Knowledge Sharing case studies, we used the following additional keywords: "knowledge sharing", "knowledge management", "individual intention" and "behavior". Furthermore, the author put two limitations to the research; first the study must consider knowledge sharing using a knowledge management system and focus on the individual intention and behavior towards knowledge sharing or knowledge management systems. Second, related to the requirement of the input for TETRAD, the original theory or framework must provide the correlation matrix at their item level[5].

2. Backward Research

According to Webster and Watson (2002), it is advisable to review citations from the identified articles that have deeper knowledge and understanding about the topic. The author determined the most important prior work by reviewing the references listed in the articles used.

3. Forward Research

Using the citation index of Scopus, we identified other relevant works that cite the most influential papers for our thesis topic. While performing these

[5] There are two conditions expressed by Im and Wang (2007) about the data used in their work; first that "a correlation matrix at the item level is available for analysis", second, the need for the articles to be explored in testing new variables in their models (i.e. trust and IT-enabled institutional mechanism in an e-commerce context). In our opinion, if these two conditions don't match, the data at least should fulfill the first criteria; which is providing the correlation matrix at the item level.

steps, evaluating the papers based on the abstracts and its keywords listed, only included studies with regard to:

- TETRAD used in theory development in the Information Systems research area,
- TETRAD used in Causality, causation or causal discovery from data.

2.2 Concept Matrix

In this section, we present three tables. We present the concept matrix about the scholarly article found in the field of causality and causation that explicitly relate[6] and use the idea of causal modelling with TETRAD program (Glymour, Scheines et al. 1988):

- Table 1 shows the global findings of the different studies on the use of TETRAD that is related to causation and causality. We divide the findings in two categories: *first*, the example of articles that are related to Information Systems and its theory development; and *second*, the example of articles which used TETRAD in terms of finding causal relationships from data, in other disciplines, e.g : economy and tourism.
- Table 2 presents the details of studies that use TETRAD related to Information Systems and its theory development (from the first category).
- Table 3 presents the details of studies that use TETRAD in non Information Systems area.

[6] The term "relate" here refers to the state that the article clearly identified and/or used TETRAD by C. Glymour *et al*. (1988) and its development until current year (2011) as one of the tools that assist the researchers in finding the plausible alternatives for their framework and aid researcher to look for the causal-effect phenomena using data. Because TETRAD is not yet commonly used, the articles chosen are not only limited to the Information Systems area, but are in related to TETRAD development in a global context.

Table 1. TETRAD used in causation

AREA	Author	Software		Research Method	#Cited		Journal Name	Field	Keywords
		Type	Function		GS	Scopus			
Information System related field	(Lee, Barua et al. 1997)	-	-	Literature Study	27	72	MIS Quarterly: Management Information systems (MISQ)	Research & Dev. Management	MIS research methodology, causality, exogeneity, endogeneity, manipulative account, LISREL, TETRAD
	(Im and Wang 2007)	TETRAD III	MIM Build Purify	Empirical research Data: Correlation data at item level from 2 published paper, they are (Gefen, Karahanna et al. 2003) and (Pavlou and Gefen 2004)	-	(*)[7]	Communications of the Association for Information Systems (CAIS)	Theory Dev., Information Systems	TETRAD, Theory Development
	(Liu 2009)	TETRAD III	MIM Build Purify	Experimental research Respondent: 90 medical school students from an online medical system	1	1	International Journal of Intelligent Systems	Electronic Commerce	E-commerce applications, Ease of use, Technology acceptance model, User acceptance

[7] In Scopus, Journal CAIS coverage started only from year 2009. All Volume started at Vol. 1 (1999) from CAIS can be accessed at http://aisel.aisnet.org/cais/

Causality (general) using TETARD	(Haughton, Kamis et al. 2006)	TETRAD III, IV	PC Algorithm	Empirical research Data: from Vietnam Living Standard Surveys (VLSS); (n=4272 households) interviewed both in 1992 and 1998	4	2	American Statistician	Statistical techniques, Directed Acyclic Graphs (DAG)	Bayesian networks, Causality, Data Mining, Indirect effects
	(Bessler and Loper 2001)	TETRAD II	PC Algorithm	Empirical Research Data: Cross section observational data from total 79 countries [The IDRB – World Bank][8]	16	8	Manchester School, with 2001 theme: Growth and Business Cycles in Theory and Practice[9]	Economic Development	Directed Acyclic Graph, Growth Domestic Product (GDP)
	(Mazanec 2007)	TETRAD	Search Build	Empirical Research Data: Austrian National Guest Survey, data sample of foreign visitors to Austria during the winter season in 1997-1998, excluding city travelers (n=2900)	2	-	Asia Pacific Journal of Tourism Research	Tourism, Behaviour Research	Tourist behaviour research, causal inference

[8] Bessler & Loper used data from 79 countries, world taken from World Tables - The International bank for Reconstruction and Development (IDRB) World Bank, Philadelphia 1993. The research is divided into 2 subsets, one subset for 79 world economic countries, and another subset for 59 economically less developed countries. The list of countries studied is available at Appendix A4.

Table 2. TETRAD used in causation related to Information Systems discipline

Article	Objective	Operationalization	Measurement instruments & model	Constructs	Findings from TETRAD & Temporal structure
Lee, Barua et.al (1997)	Propose the use of TETRAD in the Management of IS field: - as a non-parametric tool at exploratory phase for its ability to accomodate a wide variety of causal models (p.109); - as an alternative tool to parametric approaches such as exploratory analysis (p.111)	TETRADs' two Key elements in empirical approach: 1. ***Developing richer models*** → allows researcher to add new variables, and not suffering too much beliefs assuming that the variables to be exogenous or endogenous. 2. ***Using the algorithm to operationally and analyze such model*** →allows researcher to represent a model and perform exploratory analysis without setting restrictive	Not applicable	Not applicable	*Findings* Advantages about TETRAD: • **Non-parametric analysis** →no statistical parameters estimation for TETRADs' hypothesized causal model. • **Flexible representation** →TETRAD permits the linkage between latent and measured variables in any direction. • **Linking two research phases** →as a tool helping researcher to represent the theory or framework based on observational data in the preliminary research phase (or exploratory). *Temporal structure* Not reported.
Im & Wang (2007)	Study two papers published earlier in IS field, in an e-commerce context using TETRAD. They are:	TETRAD III • Purify: to establish measurement models	Measurement Models: - Used Purify: to generate pure	(Gefen, Karahanna et al. 2003) list constructs: 1. **CB**: Calculative Based 2. **IB**: Institution Based	*Findings from TETRAD* (Gefen, Karahanna et al. 2003): • 15 paths being compared between original model from Gefen et al. (2003)

[9] The Manchester School is a journal publishing distinguished papers covering issues in the economics field. Every year, they have different issues with special theme; in 2001 the theme was titled "*Growth and Business Cycles in Theory and Practice*". All issues can be accessed at http://onlinelibrary.wiley.com/journal/10.1111/(ISSN)1467-9957/issues (Accessed date: 28 March 2011).

	1. (Gefen, Karahanna et al. 2003): Trust and TAM in online shopping: An integrated model→ proposed to include Trust in order to extending TAM, which is in the context, belongs to exploratory phase. 2. (Pavlou and Gefen 2004): Building effective online marketplaces with institution-based trust → proposed the idea that perceived effectiveness of three IT-enabled institutional mechanisms (feedback mechanism, 3rd party escrow services and credit card guarantees) will generate buyer trust in online auction	• MIMBuild or Build: to discover structural models	sub-models from the original paper. - Varied the significance level: 0.05, 0.10, 0.20, 0.30 - Result from purify then used in LISREL: for confirmatory factor analyses based on the sub-models Measurement instruments: (Gefen, Karahanna et al. 2003) → 8 unmeasured latent variables and 34 measured latent variables (at item level)	Structural Assurances 3. **SN**: Institution Based Situational Normality 4. **KB**: Knowledge Based Familiarity **5. Trust** 6. **EOU**: Perceived Ease of Use 7. **PU**: Perceived Usefulness 8. **IU**: Intended Use (Pavlou and Gefen 2004) list constructs: 1. **FB**: Perceived effectiveness of feedback mechanism 2. **ES**: Perceived effectiveness of escrow	and TETRAD model from Im & Wang (2007) → 6 paths are the same and 9 paths differ from the original model[10] • IB change from exogenous variable into endogenous variable, which later connected with 5 other subsequent variables, including: Trust, IU, PU, EOU, and KB • KB change the direct impact from antecedent of EOU and Trust into antecedent of EOU and IB • EOU change from direct cause (antecedent) of PU into direct effect of PU • Trust change from direct cause of PU into not related at all with PU • Trust change from direct cause of IU into bi-directional relationship between both[11] *Temporal structure* Not reported. *Findings from TETRAD* (Pavlou and Gefen 2004): - 16 paths being compared between original model from Pavlou et al. (2004) and TETRAD model from Im & Wang

[10] The different paths are either: 1) a new path discovered or 2) a different direction from the original theory.

[11] The bi-directional relationship shows that there may be other latent common causes between Trust and SN (Situational Normality) and Trust and IU (Intended Use). Further graphical results from Im and Wang (2007) are presented in Appendix A2.

	sellers.	(Pavlou and Gefen 2004) → 7 unmeasured latent variables and 24 measured latent variables (at item level)	services 3. **CR**: Perceived effectiveness of credit card guarantees 4. **HT**: Trust in Intermediary 5. **ST**: Trust in Community of Sellers 6. **RK**: Perceived risk from the Community of sellers 7. **TR**: Transaction Intentions	(2007) → 3 paths are the same and 13 paths differ from the original model - The revised model from Pavlou et al. (2004) found that RK or "*perceived risk from the community of sellers*" is not associated (insignificant) with the four institutional structures (three IT enabled institutional mechanism and Trust in intermediary); which is <u>the same result from TETRAD's</u> model on the same data.[12] - Two variables (CR and HT) among the four institutional structures mechanism change from exogenous into endogeneous variables. - HT or "*Trust in intermediary*" become as important as ST or "*Trust in the Community of Sellers*" with the respect of the number of connections related to other contructs. - The insignificant path resulted from Pavlou et al. 2004 in the relation from CR and ST also detected with TETRAD by Im and Wang (2007). *Temporal structure* Not reported.

[12] As cited in Im & Wang (2007), the model had been revised for parsimony (Pavlou and Gefen (2004) p.49) and Pavlou et al. did not give any details to support the revised model. However, with the same data (correlation matrix resulted from Pavlou and Gefen, 2004), TETRAD <u>*successfully detected*</u> the important theoretical relationships; which is the insignificant link between the constructs without relying on any prior knowledge.

Liu (2009)	- To systematically infer which correlation in previous TAM theory is genuine and which is spurious. - Attempt to find genuine causal structure that best explains the data (p.1231)	TETRAD III; which use the function: • Purify: for finding unidimensioneal (or pure) measurement model; to obtain a pure measurement model, in which each scale item measures the construct that it intents to measure (p.1236) • MIM Build: to discover causal models among latent variables. Each of which is measured by multiple indicators (p.1238)	Measurement Models: - Used Purify: to generate pure sub-models from the original paper. - Varied the significance level: 0.05, 0.10, 0.20, 0.30 - Result from Purify then used in MIMBuild: for confirmatory factor analyses based on the sub-models Measurement instruments: 4 unmeasured latent variables and 21 measured latent variables (at item level) The 21 scale items measured using a 7-point	1. PSP: Perceived System Performance 2. PEU: Perceived Ease of Use 3. PU: Perceived Usefulness 4. BI: Behavioral Intention	*Findings from TETRAD* • TAM model from previous study was validated when tested in isolation but failed within the larger nomological network. • There are three relationships found by TETRAD and rejected 2 of 3 hypotheses made by TAM based on vanishing tetrads. • Found two spurious (not genuine/ insignificant) associations in the model; they are 1) between PEU and BI or and 2) between PEU and PU – which the regression analysis failed to detect. • Confirming the significance of PSP in predicting PEU and BI. *Temporal structure* Not reported

		likert scale ranging from "strongly disagree" to "strongly agree"	

Table 3. TETRAD used in causation related to non - Information Systems discipline

Article	Objective	Operationalization	Measurement instruments & model	Constructs	Findings from TETRAD & Temporal Structure
Bessler & Loper (2001) *Economic development: evidence from directed acyclic graphs*	Apply DAG (Directed Acyclic Graph) for construction and interpretation of models GDP growth from countries, based on cross-section data over the last 30 years (1971-1990) (p.462).	TETRAD II, which used the function: PC Algorithm	Measurement Models: - PC Algorithm to study the causal inference based on categorical data Measurement instruments: 4 unmeasured latent variables and 21 measured latent variables (at item level)	1. GRGDP: growth in GDP 2. IGDP: Initial GDP 3. GS: Government Savings 4. IQI: Institutional Quality Index 5. NREX: National Resource Exports 6. TCD: Tropical Climate Dummy 7. OPEN: Openness to Trade 8. LIFE: Natural Life Expectancy 9. APGR: Agricultural Product Growth	*Findings from TETRAD* 1. The country consist of 79 dataset may not react the same as 59 economically less developed dataset in GDP Growth. 2. Agricultural Productivity (APGR) does not have any relationships with any other variables in 79 country dataset (all data combined), while in 59 country dataset (alpha = 0.20), the variable Openness to Trade is a mediate variable between Agricultural Productivity (APGR) and Growth in GDP (GRGDP) (p.470). 3. In 59 country dataset, TETRAD shows that Agriculture Productivity (AGPR) is not a cause of Growth in GDP (GRGDP), which was "consistent with a current thought which running through the agricultural economies literature" (p.474). *Temporal structure* Not reported

Mazanec (2007) *New Frontiers in Tourist Behavior Research: Steps toward Causal Inference from Non-experimental Data*	Apply Inferred Causation Theory with TETRAD software; to search causal inferences from non-experimental data, especially to find the causal relationships in Tourist Bahavior Research using data from Austrian National Guest Survey, with the main object of study: foreign visitors to Austria during the winter season in 1997-1998.	TETRAD, which used the function: Search and Build	Measurement Models: - Search: Used *Search* algorithm to help detect relationships at measurement model, in order to improve the goodness of fit.[13] - Build: Used *Build* algorithm to discover causal – effect pattern Measurement instruments: 5 latent variables and 9 measured variables (based on Figure 1, Mazanec (2007), page 229)	1. Compositional Perceived Quality 2. Destination Loyalty 3. Satisfaction 4. Value for Money 5. Intention to Repeat Visit	Findings: 1. Word of Mouth (WoM), a measured variable in Satisfaction, has a link with Intention to Repeat Visit[14] *Temporal structure* Not reported

[13] According to Mazanec (2007), the search procedure looks for vanishing tetrads to make inferences on initial and new potential relationships in the graph. The explanation about vanishing tetrads can be seen in Spirtes et al (2000).
[14] The graphical result derived from Mazanec (2007) which illustrates this finding is available at Appendix A5.

2.3 TETRAD: An Aid for Theory Development

In the previous section (Chapter 2.2), we provide studies which explained and demonstrated the use of TETRAD in theory development, whether the studies belong to Information System field or other disciplines.

Table 1 describes the global explanation about the use of TETRAD to search for causation or search for causal effect between variables in the theory or certain model. From six studies explained, three studies are related to Information System area and three remaining studies are from other background disciplines, for example Statistics (Haughton, Kamis et al. 2006), Economic Development (Bessler and Loper 2001) and Tourism (Mazanec 2007). Five from six studies perform an empirical research which each alone has various background data. For example data in a university setting (medical student) – data used by Liu (2009); cross section data about countries from the World Bank – data used by Bessler and Loper (2001); until data about foreign visitor to Austria for holiday purpose from Austrian National Guest Survey – data used by Mazanec (2007). The results imply that TETRAD is a global heuristic search algorithm and capable for helping researchers find causal effect relationships and knowledge discovery based on data, with disregards to its background knowledge. From the findings in Table 1, three out of five literature papers use TETRAD III (Haughton, Kamis et al. 2006; Im and Wang 2007; Liu 2009), and one uses TETRAD II (Bessler and Loper 2001), the rest is a Literature Review research which did not impose on a certain TETRAD version (Lee, Barua et al. 1997), while one study did not state clearly which TETRAD version the researcher used (Mazanec 2007). From the Information Systems area, two out of three studies use the Purify and MIMBuild algorithm from TETRAD III, whereas in non-Information Systems research area, the papers use PC Algorithm from TETRAD III (Bessler and Loper 2001; Haughton, Kamis et al. 2006) and Search and Build Algorithm (Mazanec 2007).

Table 2 provide the detail research from three studies related to Information Systems field. According to Lee et al. (1997), the linkage research phase between exploratory and confirmatory phase is important to researchers, as in very early stages of the research, the phenomenon of interest is not well recognized. The need to build richer models in the early stage of a scientific study could help researchers to find alternatives of plausible and richer models, which best suit the data. It is a matter of fact that TETRAD is not yet popular in Information Systems researchers, especially to be used in theory development and theory building (Lee, Barua et al. 1997).

According to Im and Wang, Information Systems as a social research uses two types of research methods to develop their theoretical models; they are exploratory research and confirmatory research. Raykov and Marcoulides (2006) explain that structural equation modelling (SEM) is used as a common model to represent knowledge about phenomena that are being studied in particular substantive domains. Structural Equation Modelling (SEM) allows both confirmatory and exploratory research to be used in theory development and theory building. After a theory has been developed about some phenomena, the theory can be tested against empirical data. Henceforth, this process is often called the *confirmatory level* of SEM applications (Raykov and Marcoulides 2006).

Based on Raykov (2006), when SEM models used for theory development, the process often involves repeated applications of SEM on the same data set, in order to explore potential relationships between latent variables of interest. Contrary with *confirmatory level* of SEM applications, in theory development assumes that there is no prior theory exists in fundamental form of the phenomena interest. Because the method contributes both to clarification and development theories, it is commonly referred as *exploratory level* of SEM applications. Some definitions for exploratory and confirmatory analyses are presented in Table 4.

Table 4. On SEM applications: Confirmatory and Exploratory phase

Confirmatory Level/ Factor Analysis	Exploratory Level/ Factor Analysis	Source
• Confirmatory level focuses on testing theoretical models developed through rigorous process of theory development • In its early level, the understanding of the proposed theoretical model isn't clear or isn't strong	• In exploratory level, facts, ideas, patterns or hypotheses are examined to make a theoretical case in area where little information about a phenomenon exists • Relationships between constructs are unknown	(Im and Wang 2007)
• Confirmatory Factor Analysis (CFA) deals specifically with measurement models: the relationships between observed measures (indicators) and latent variables (factors) • A fundamental feature of CFA is its hypothesis-driven nature; that is researcher must have a firm a priori sense, based on past evidence and theory	• EFA is an exploratory or descriptive technique to determine the appropriate number of common factors, and to uncover which measured variables are reasonable indicators of the various latent dimensions • EFA is a data-driven approach such that no specifications are made in regard to the number of latent factors (initially) or to the pattern of relationships between the common factors and the indicators	(Brown 2006)

Im and Wang (2007) argued that it is important for researcher to conduct iterative practices and processes in the stage of theory development, between exploratory and confirmatory level, in order to achieve their final theoretical model. As cited in Im and Wang (2007), Technology Acceptance Model or TAM (Davis, Bagozzi et al. 1989) is one of the example of the iterative development in IS field. TAM evolved from a theory called Theory of Reasoned Action (Fishbein and Ajzen 1975). This theory has been changed in its development process. In the revised version of TAM called TAM2, Davis et al. (Venkatesh and Davis 2000) had exclude some variables and then added another new relationships to explain how

individuals made decisions about technology acceptance in their everyday-work manner. It is shown that even a strong theory such as TAM going through on a trial and error test within its development process (Im and Wang 2007).

Im and Wang (2007) perform important findings in their studies whether TETRAD discover different exogenous and endogenous variables from TAM[15] (Gefen, Karahanna et al. 2003) and TETRAD successfully detected the important theoretical relationship from Pavlou and Gefen's (2004) perceived effectiveness of IT and three institutional enabled mechanism[16]. Im and Wang (2007) notice an important finding, that they found the insignificant link between the constructs in the model without having any prior background knowledge and information. As Im and Wang (2007) did, Liu (2009) stated that TAM was validated when tested in isolation but failed in a different nomological network.

Table 3 provides the research details and important findings about the use of TETRAD in non Information Systems research areas. Bessler and Loper (2001) study a cross-section of 79 world economies and a subset of 59 less developed economies to determine which variables affect growth gross of domestic product (Growth in GDP). An important finding from Bessler and Loper's (2001) paper, is that that in 59 economically less developed countries[17], the variable Agricultural Productivity (AGPR) is shown as did not a direct cause to variable Growth in GDP (GRGDP). Bessler and Loper (2001) explained that their findings from TETRAD confirm the current thought on agricultural economies literature. The second paper explained in Table 3 is from Mazanec (2007), who studied about the application of TETRAD in tourism and leisure study. This study searches the factors that influence tourists to repeat the visitation of holiday destinations. Mazanec (2007) detected one spurious link from measurement variables into latent variable (p.231), that is one link from measurement item "word-of-

[15] The graphical illustration from TETRAD findings on TAM from Im and Wang (2007) research is available at Appendix A2.
[16] The graphical illustration from TETRAD findings on IT and three institutional-enabled mechanism from Im and Wang (2007) research is available at Appendix A3
[17] Further information on the countries studied by Bessler and Loper is presented at Appendix A4.

mouth"[18] (WoM) with another latent variable "intention to repeat visit". Mazanec (2007) distinguished that this finding is an exemplary contribution to researchers and could help them reflects on the model they've build as well as contribute to structure the theory development.

[18] According to Sprtes et. al (2000), there are four types of impurely measured variables. In the case study of Mazanec (2007), the measured variables "word of mouth" is regarded as ***a latent-measured impure***. The illustration of "word of mouth" as a latent measured impure is available at Appendix A5. The graphical explanation about type of impure measure variable is available at Appendix A6.

Chapter 3 TETRAD Software

This chapter contains concepts behind TETRAD and the explanation of two algorithms mainly used in this research: PURIFY and MIMBuild

3.1 Causal Models

As explained by Pearl (2000), there are two fundamental questions related to causality:

- First, "What empirical evidence is required for legitimate inference of cause-effect relationships?"
- Second, "Given that we are willing to accept causal information about phenomenon, what inference can we draw from such information and how?"

It is claimed by Pearl (2000) that these two questions, can only get poor answers since (i) there are no clear semantics for causal claims and (ii) there are no effective mathematical tools for illustrating causal questions or extracting causal answers.

3.1.1 Interpreting Causal Forms

As stated by Christensen *et al.* (2010), the basic foundation for causal-effect forms as well as quantitative research is a variable. A *variable* is defined as a characteristic or phenomenon that can vary across or within organisms, situations, or environments; that leads to different values or categories. Of many quantitative research and scientific projects, the causal model is a common goal for the kind of research (Christensen, Johnson et al. 2010). According to Christensen, Johnson et al. (2010), causation is seen more complicated; it is often that people realize *implicitly* the manipulation behind the causality. In this context, people often use the term *cause* and *effect* to describe the concept of

causality, or we could say, equate the causation with manipulation. The manipulation goes here; if we manipulate or do some act, we will expect to have something to happen. If something truly happens, then the act of manipulation is what we called *cause* and what happens is called *effect*. Then, the following questions arise: What if we have a set of variables observed in a particular range of time? Can we also have the causal-effect model from raw data without manipulation being made? Should all forms of cause-effect models be manipulated first, so we could have the cause-effect model derived from our (raw) data?

3.1.2 A Temporal Relationships

For example, parents perform action of giving a reward or money when their child gets the good grade at school. If the child has good grades, he/she receives a reward, which could be in the form of money. It is being assumed that when the money is being given, it causes the child to get good grades. In fact it does not (truly) happen, except in a few cases. In this case, a temporal relationship is sometimes established in a causal model. The temporal relationship of a reward and the good grades provides us the intuitive meaning of a cause effect relationship. In this context, something that is presumably causes changes in another variable is called an independent variable (i.e: reward or money), and one is presumably influenced, effected by one or more variables is a dependent variable (i.e: good grades). Normally, temporal precedence is being assumed to be important regarding causation, it is certainly the most important initial – that people will distinguish causality from other associations (Pearl 2000). As cited in Pearl (2000) most theories of causation (Reichenbach 1956; Good 1961; Suppes 1970; Shoham 1988) arouse an explicit requirement that a *cause* will precede its *effect* in time.

3.1.3 Direct and Indirect Graph Representation

Readers also understood causation as a relation between particular events: something happens and causes something else to happen; and a *cause* can be distinguished relatively in such events between two forms of causes, direct and

indirect (Spirtes, Glymour et al. 2000). Causal relations are commonly represented as variables and a directed edge goes from vertex X to vertex Y (X→Y) (Glymour and Scheines 1986). From that relationship, X can be regard as independent given the state of Y, or Y is dependent on X. In other words Y is the dependent variables (or endogenous variable) and X is the independent variables (or exogenous variable). According to Spirtes et al. (2000), p.42, there are three types of causation from two events[19], i.e. X and Y:

(i) **Transitive**; is X is a cause of Y and Y is a cause of Z, the X is also the cause of Z,
(ii) **Irreflexive**; an event X cannot cause itself, and
(iii) **Antysymmetric**; if X is a cause of Y then Y is not a cause of X.

Furthermore, Spirtes et al. (2000) also describe the explanation about a direct cause. For example, **V** is a set of events including *C* and *A*. *C* is called a *direct cause* of *A* relative to **V,** just in case *C* is a member of some set **C** included in V\{A}, such that:

(i) The events in **C** are causes of *A*,
(ii) The events in **C**, were they to occur, would cause *A* no matter whether the events in **V**\({A}∪**C**) were or were not to occur,
(iii) No proper subset of **C** satisfies (i) and (ii).

Define a graph *G* is a set vertices *V* and edges *E*. We can say a graph is an undirected graph if it contains only undirected edges, whereas a graph is a directed graph if it contains only directed edges. Figure 2 presents the illustration for directed and undirected graphs.

[19] Spirtes et al (2000) p.43, regard events as variables, such that some events of kind X (X variable) cause some events of kind Y (Y variable).

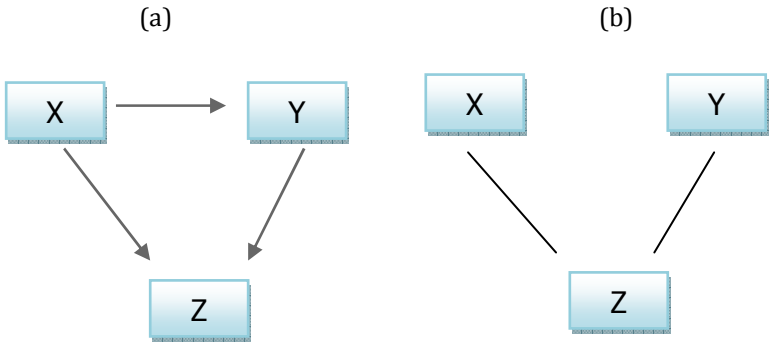

Figure 2. Directed Graph and Undirected Graph

A path that contains no vertex more than once is acyclic; otherwise is cyclic. From Figure 2 the path shown is acyclic, since there is no cyclic path as in X→Y→; and X →Z. If the direction in Z to X is reverse as in Z→X; then we considered the graph is a cyclic graph since it has the cyclic path as: X→Y→Z→X.

According to Spirtes et al. (2000), p.30, A directed acyclic graph is *a directed graph that contains no directed acyclic paths*. A causal structure for a population is an ordered pair <**V,E**> where **V** is a set of variables and **E** is a set of ordered pairs of V, where <X,Y> is in **E** and only X is a direct cause of Y relative to **V**. Firthermore, Spirtes et al. (2000) defined a causal graph as *a directed acyclic graph that represents a causal structure*. Figure 3 is represents a causal graph from variable X, Y and Z.

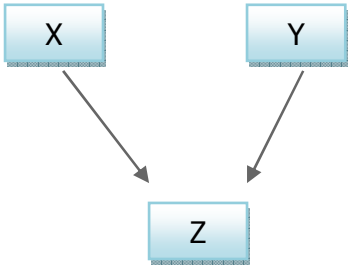

Figure 3. A causal graph

Suppose that, we call a graph with P, P is a causal graph and there is a vertex X in P and a directed path from X to Z (X→Y) that does not contain Z, and a directed

path from X to Z (X→Z) that does not contain Y, we can say that X is a common cause from Y and Z. Figure 4 illustrate the definition of X as a common cause.

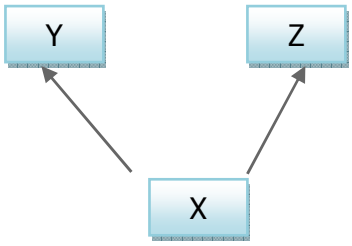

Figure 4. X as a common cause of Y and Z

3.2 TETRAD Software

3.2.1 TETRAD Development

TETRAD is a computer program developed by philosophy researchers from the Department of Philosophy, Carnegie Mellon University in the 1980s. Clark Glymour, Richard Scheines and Peter Spirtes develop the program and its search algorithm over several years with the support from NASA[20] and the Office of Naval Research. TETRAD is one of the software packages that estimates directed acyclic graphs (DAG) from data (Haughton, Kamis et al. 2006). The software is downloadable and accessible for everyone who wants to use it. The users also reserve the right to alter the program at any time without notification (Glymour 2004). Until now, the software has been developed from TETRAD II, TETRAD III until the latest version of TETRAD IV[21]. We would like to refer the reader to read the website of the project for detail development of TETRAD.

According to Liu (2009) TETRAD II limits the number of variables being used for both platforms, to 17 for DOS and 100 for UNIX respectively. TETRAD III has one

[20] National Aeronautics and Space Administration; http://www.nasa.gov/
[21] The detail development and documentation of this project can be access online on http://www.phil.cmu.edu/projects/tetrad/ (Accessed date 28 August 2011)

added module compared to TETRAD II, and the latest one is TETRAD IV with better graphical user interface or GUI (Liu 2009). Haughton, Kamis et al. (2006) also confirmed that the latest version of TETRAD, TETRAD IV is menu driven software which provides a friendly graphical user interface. To run TETRAD IV, it requires Java Runtime Environment 1.6 or higher installed in our computer[22]. Table 5 presents the TETRAD development from version TETRAD II until the latest version TETRAD IV.

The input for TETRAD is presented as (i) raw data or (i) a sample size and a covariance or correlation matrix among the variables, and (iii) a graph which specifies the known causal connections among the variables (measured or latent). The output consists of suggested modifications to the initial model which will improve the fit of the model with the data (Glymour, Scheines et al. 1988). For this research, we will use the latest version of TETRAD, that is *tetrad-4.3.10-4.jnlp*. For *tetrad-4.3.10-4.jnlp* version, there are 15 functions represented as a box list in the left panel, consist of 13 functions box to input the data (Graph, Search, etc.), do the data manipulation (i.e. calculate correlation matrix from raw data) and search algorithm function (i.e. Purify, MIMBuild, PC Algorithm), 1 function for moving any object in the workplace and 1 function used as note for inserting the annotation or explanation for the work that we did.

TETRAD program works by estimating a directed acyclic graph with the modification of conditions and requirements needed for its input, to gain the knowledge about causal models from the data (Haughton, Kamis et al. 2006). Relying on Haughton et al. (2006), by concept the causal model can be summed in a graph, where a directed arrow linking X to Y is the representation when X is a cause of Y. As cited in Haughton et al. (2006), an introduction of TETRAD work can be seen in the work of Bessler and Loper (2001) in economics as introduced in Chapter 2. In this study, we will use its two search algorithms in particular

[22] For the latest version of JRE, user can go to the website http://java.com/en/download/index.jsp

used in Information Systems field [i.e research from Liu (2009) and Im and Wang (2007)], Purify and MIMBuild. In the following section we will discuss the search algorithms used in TETRAD to find the causal discovery.

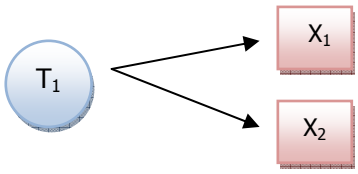

Figure 5. An example of measurement model

There are two types of variables in TETRAD IV: measured and latent. Measured variables (often called "observed" variables) are variables for which data have been measured. Latent variables are variables for which data has not been measured but which you believe might be required to explain the causal relationships between measured variables adequately. A measured variable in a graph is presented by rectangular boxes (i.e. X_1) around their variable names and latent variables using oval shapes (i.e. T_1) around their variable names.

Temporal Tiers in TETRAD IV

If we want to have temporal tiers between variables, we can use Knowledge function box in TETRAD IV. The knowledge box takes as input a graph or a data set and imposes additional constraints onto it, generally to make search algorithms easier. There are three types of constraints you can add using the knowledge box:

- tiers of occurrence,
- forbidden or required groups, and
- forbidden or required edges.

Table 5. TETRAD version (Scheines, Spirtes et al. 2010)

Tetrad Version	Platform	Modules
TETRAD II (1994)	DOS and UNIX	10 Modules included: Build Purify Makemodel Estimate MIMbuild Monte Update Search STATwriter Tetrads
TETRAD III (October, 1996)	DOS and UNIX	11 Modules (same as TETRAD II), with addition: Gibbs
TETRAD IV[23]	Java platform; Tetrad IV is an executable software with GUI written in Java; needed JRE 1.6 or higher installed on your PC	• Mostly the same with previous versions of TETRAD, but with better graphical user interface with much additional functionality related to current development and research for the software. The latest version from TETRAD IV is tetrad-4.3.10-4.jnlp. • The main difference distinguishable from TETRAD IV from older version is that our work can be saved as a *Session* and saved in *.tet* format. A *Session* in TETRAD is built up by placing boxes on the main workspace area, connecting the boxes using the arrows, and building modules in each box depend on parent modules that have already been built. • Logging menu: help the researcher save the log file during the certain *Session*. • Window menu: help the researcher manage and interchange more than one *Session* work at any time. • Templates menu: in tetrad-4.3.10-3 version, Tetrad provides 10 templates that already being put together for a certain task which is a sequence of boxes connected by flowchart arrows all at once.

[23] The older version of TETRAD available at its launch directory http://www.phil.cmu.edu/projects/tetrad/old.html (Accessed date 28 August 2011)

3.2.2 Purify

Purify helps to search the initial pure or unidimensional measurement model that fits the data. The input given is an initial measurement model and correlation or covariance matrix sample data. We could say a measurement model is pure or unidimensional if the condition holds as follows:

(i) If each indicator Xi is the cause of no variable and Xi is a direct effect of exactly one latent variable, and
(ii) An error term ε*i* and for every other error ε*j*, ε*i* and ε*j* are uncorrelated.

A structural equation models in which each latent variables is measured by several indicators is often called multiple indicator models. Purify helps to find the pure relationship between the latent variable and its set of observed variables.

3.2.3 MIMBuild

MIMbuild is able to look into different structural models to find sets of recursive linear structural equation models with latent variables, as each model is translated as hypothesis about causal structure. The input measurements that can be used are: (i) a unidimensional measurement model and (ii) covariance matrix or as raw data. To find unidimensional measurement models, Purify module is allow to be used. If the data are multivariate and the measurement model pure, MIMbuild can test for vanishing correlations and vanishing first order partial correlations between latent variables in the model. According to Spirtes et al. (Spirtes, Glymour et al. 2010) MIMBuild search algorithm is the search algorithm intended for multiple indicator model, a model whose variables need to measured using observed variables or measured variables. Multiple indicator models mostly included measurement of several indicators for each latent variable in structural equation. MIMBuild output consist of**:** (i) statistical conclusions in regards to its set of correlations and first order partial correlations that vanish among the latent variables and (ii) a pattern that represents a set of structural models that produce the same set of vanishing correlations and

vanishing first order correlations. As the results, the output from MIMBuild is regarded as causal structure of the relationships among the variables in a model.

Chapter 4: Approach and Methodology

This chapter presents the approach and methodology for two case studies conducted within the research. To demonstrate the use of TETRAD in theory development, we use a paper published in the Knowledge Sharing field. The detail about the research methodology and the approach operationalized for each case study is discussed in the following sections.

4.1 Paper Selection

A paper which was published in the Information Systems area was selected. The goals are (i) to re-analyse the proposed model in the paper using PURIFY and MIMBuild of TETRAD and (ii) to validate the model with experimental research done at the University of Twente. Several criteria were taken into consideration when selecting the paper.

We limited the papers to those that were published in the last two years. We chose papers that discuss online knowledge sharing from an individual perspective in particular. As a result, the article from Ma and Yuen (2011) entitled "Understanding online knowledge sharing: An interpersonal relationship perspective" was selected. The paper describes a study about the motivational factors which engage users for sharing knowledge using online learning tools. The paper was published in the Journal of Computers and Education from Elsevier[24]. Two criteria that we used as a basis for selecting the paper are listed as follows:

1. The paper provides a structural model with a correlation matrix at item level.
2. The paper is considered in exploratory context; since Ma and Yuen (2011) proposed two new constructs called Perceived Online Attachment

[24] The Journal of Computers and Education by Elsevier is available at http://www.elsevier.com/locate/compedu/

Motivation (POAM) and Perceived Online Relationship Commitment (PORC).

A correlation matrix is needed at item level in TETRAD to search the first measurement model using the PURIFY algorithm. It is believed that TETRAD can be applied in the exploratory phase (Im and Wang 2007). However, Liu's (2009) research provides the option that TETRAD can also be applied to a model that already passed the confirmatory level such as Technology Acceptance Model (TAM).

4.2 Experimental Research

There are two case studies conducted in this thesis. First, a case study to demonstrate the use of TETRAD using Ma and Yuen's (2011) inter-item correlation matrix data. Second, an experimental research done at the University of Twente to validate Ma and Yuen's (2011) model. For both case studies we utilize the version of TETRAD IV[25] and LISREL 8.8. The detail of two experiments conducted in this thesis described below.

4.2.1 Case study: OKSM

The goal of the first case study is to re-analyse the model from Ma and Yuen (2011) called Online Knowledge Sharing Model (OKSM) using TETRAD IV. The first case study follows the approach from Im and Wang (2007). A correlation matrix data (item-level) from Ma and Yuen (2011) was used. Furthermore, we run the correlation matrix at item-level data using PURIFY and MIMBuild from TETRAD. Finally, we re-analyse and compare the measurement model and structural model from TETRAD discovery and original results from Ma and Yuen (2011).

[25] The version that we used from TETRAD is TETRADIV tetrad-4.3.10-4.jnlp, the software is available at TETRAD Project homepage at http://www.phil.cmu.edu/projects/tetrad/current.html (Accessed 26 August 2011).

We employed TETRAD to get the measurement model – subtracting from PURIFY and structural model – subtracting from MIMBuild, and LISREL 8.8 to get the parameter for Fit Indices, both for the measurement model and structural model. We adopted the approach of Im and Wang (2007) to discover the causal-effect model among the constructs. The organization of the approaches and techniques is listed as follows:

Measurement Model

1. First, we used PURIFY algorithm from TETRAD and used the correlation matrix at item level provided by Ma and Yuen (2011) to produce initial pure sub-models. We used PURIFY algorithm in TETRAD and developed the same initial measurement model as Ma and Yuen (2011) had. Furthermore, we varied the significance level (α=0.05, 0.10, 0.20 and 0.30) in order to conduct a sensitivity analysis to search the best class from the models.
2. Second, we employed in LISREL 8.8 to produce the Fit Indices for the Measurement Model. The input to LISREL 8.8 is the sub-model results[26] from PURIFY algorithm in TETRAD in the first step.
3. Third, a comparison table (of six criteria: Df, χ^2, SRMR, CFI, RMSEA, AIC) for Fit Indices Measurement Models resulted from steps one and two. The comparison was made from both the findings of Ma and Yuen (2011) and our results using TETRAD.

Structural Model

4. We used LISREL 8.8 to test Ma and Yuen's (2011) paths and our paths resulted from step 3.
5. A comparison table for the same criteria in step two. A table representing Fit Indices for the Structural Models is produced.

[26] The sub-model resulted consists of items that already been pruned using PURIFY from TETRAD. This sub-model and its correlation matrix (based on the remaining variables) will be the input for LISREL 8.8 in order to obtain the fit indices to search for the best model.

6. The best model resulted from Fit Indices Structural Models was used as the input for MIMBuild in TETRAD. We vary α=0.05, 0.10, 0.20 and 0.30 to search for the best structural model.
7. Finally, we had a structural path comparison for the causal effect relationship for the OKSM model using Ma and Yuen's (2011) data. A comparison of structural paths between the original model from Ma and Yuen (2011) and our discovery using TETRAD is produced.

Fit Indices

We use LISREL 8.8 (for students) to measure appropriateness of the model resulted from TETRAD. We adopt the parameters used by Im and Wang (2007) for the first case study. The parameters measured for fit indices are: Df (degree of freedom), Chi Square (χ^2), SRMR (standardised root mean square residual), CFI (comparative fit index), RMSEA (root mean square error of approximation) and AIC (Akaike's criterion). Hu and Bentler's (1999) combination rule are used to evaluate and test the appropriateness fit (Im and Wang 2007):

1. SRMR (standardised root mean square residual) ≤ .08 and
2. CFI (comparative fit index) ≥ .95 or RMSEA (root mean square error of approximation) ≤ .06

An additional fit for the two rules above, called AIC or Akaike's Criterion from Akaike (1974) is used for comparison for untested models (Im and Wang 2007). The lower the AIC index, the better the model was considered.

4.2.2 Case Study: Blackboard – University of Twente

The second case study uses Blackboard as the main object of the study. "Blackboard" is defined as the online learning system used at University of Twente teaching and learning environment. The second case study aims to validate the model from Ma and Yuen (2011) by conducting survey. An experimental research is needed to determine whether the theory is still valid in a different nomological network (Liu 2009). We conducted a survey in the University of Twente and define Blackboard as the online learning systems. The item levels used in the survey are adopted from Ma and Yuen (2011). Finally, we

ran TETRAD and reported the discovery of causal-effect relationships between the constructs.

For the second case study, several adaptations were used in the survey are:

- Firstly, we replaced the term from Ma and Yuen (2011) "ILN" or Interactive Learning Network, as the targeted online learning with "Blackboard". The survey is targeted toward students (Bachelor and Master students, and PhD candidates) at University of Twente, The Netherlands.

- Secondly, the term (subject) used by Ma and Yuen (2011) was replaced by (course). We explained to our respondent to assume that the (subject) is the one of the courses that they were following. For example, if they had a course named: Data Mining, then the sentence would be read as:
  [OKSB-5] *"The advice I receive from other members using the "Blackboard" allows me to conduct similar (Data Mining) tasks with greater independence."*

For the second case study, we adopted the approaches and techniques from Liu (2009). This survey is required to validate the (original) latent structural model. First, we measured the reliability of the variable in the model by using Cronbach alpha and calculated the median and mode for the descriptive analysis of the instrument. Second, we conducted linear regression to the relation between the constructs in the model. According to Druzdzel (1994), the linear regression between the constructs is conducted in order to obtain a quantitative measure for the relationships within the model.

Subsequently, we searched for causal-effect relationship among the constructs for our Blackboard data and utilised TETRAD's algorithm: PURIFY and MIMBuild. As already discussed in Chapter 4.2.1, the major goals are to obtain pure Measurement model using PURIFY and to discover causal-effect model between the latent variables using MIMBuild. The sub-model results (i) from PURIFY and

(ii) causal-model from MIMBuild will be measured using LISREL 8.8. The confirmatory factor analysis in LISREL 8.8 is utilized with the maximum likelihood as the model estimation technique and the correlation matrix from data as the input. By varying the significance level (α=0.05, 0.10, 0.20 and 0.30), we are able to compare the fit indices from each model—in order to search for the best result. Finally, we draw analysis for "Blackboard" survey on Ma and Yuen's (2011) Online Knowledge Sharing Model.

Chapter 5: Case Studies

The two case studies conducted as well as the results and analyses are explained in this chapter. The subjects, data collection and the fit indices for each case study are described. The explanation of the results of the causal-effect model among the constructs using TETRAD is given. Finally, case analyses are presented for both case studies.

5.1 CASE STUDY 1: Online Knowledge Sharing Model

The first case study aims to re-analyse and compare the findings from the proposed model in a chosen paper using TETRAD. Ma and Yuen (2011) observed the motivational factors that engage users to perform knowledge sharing in an online learning environment. They build a model called OKSM, or Online Knowledge Sharing Model. We considered this study to be defined as exploratory research since the two new constructs are introduced in OKSM.

5.1.1 Subjects

Ma and Yuen (2011) conducted the experiment in a university setting (n=581 undergraduate students, response rate 88.2%). The proportion of undergraduate students who responded in the survey of this study was: 37% in Year 1, 26.8% in Year 2, 26.8% in Year 3, and 9.3% in Year 4, or the final year. Only selected courses were involved in this study. The considerations taken by Ma and Yuen's (2011) are: (a) only courses that employed online learning systems were selected and (b) the courses with the most students enrolled were given the most priority. The online learning systems used in this study is called Interactive Learning Network or ILN. There is no further detail in the paper about the exact university of the targeted user and where the experiment was conducted. The demographics reported by Ma and Yuen (2011) are presented in Table 6.

Table 6. Demographics and Characteristics of the Subjects, reported by Ma and Yuen (2011)

Courses using ILN	Male	Female	Not reported
English (336)	98	237	1
MIS (124)	62	62	0
Accounting (121)	54	67	0
Sub Total	214	366	1
Total		581	

5.1.2 Measures

Ma and Yuen (2011) proposed a model, namely OKSM: Online Knowledge Sharing Model, which involves three constructs. All three constructs consist of measurement items which have already been validated by previous studies (Ma and Yuen 2011). The three constructs are mentioned below:

- OKSB: Online Knowledge Sharing Behavior,
- POAM: Perceived Online Attachment Motivation, and
- PORC: Perceived Online Relationship Commitment.

OKSB

Online Knowledge Sharing Behaviour (OKSB) is defined as "*the online communication of knowledge so that knowledge is learned and applied by an individual*" (Ma and Yuen 2011). According to Ma and Yuen (2011), this construct is operationalized from the study of Ko *et al.* (2005). The five item measurements in OKSB are taken from Ko *et al.*'s "*Knowledge Transfer*". "*Knowledge Transfer*" is defined by Ko et al. (2005) as how knowledge is transferred from a source (consultant) so it can be learned and applied by a recipient (client) within the ERP (Enterprise Resource Planning) implementation in an organisation.

POAM

Perceived Online Attachment Motivation (POAM) is defined as "*the degree to which an individual believes that he or she can improve his or her social interaction and the sense of communion with others in an online learning platform*" (Ma and Yuen 2011). According to Ma and Yuen (2011) this construct is operationalized using five measurement items from Hill's (1987) Interpersonal Orientation Scale,

or IOS. Hill's research sought to determine if the motivation for social contact can be considered a major influence for human behaviour. The IOS emphasised four dimension postulates behind the human affiliation motivation. The four dimensions are: social comparison, emotional support, positive simulation and attention. The five measurement items used in POAM were represented by two items from "*Emotional Support*", and three items from "*Attention*"; these items were derived from Hill's four dimensions.

PORC

Perceived Online Relationship Commitment (PORC) is defined as "*the degree to which an individual believes that he or she can persist in a relationship with others on an online learning platform*" (Ma and Yuen 2011). According to Ma and Yuen (2011), this construct is operationalized using the five measurement items from Rusbult *et al.* (1998). Rusbult *et al.* (1998) evaluated the reliability and validity of the Investment Model Scale. The Investment Model Scale is a research study of three experiments conducted by Rusbult *et al.* (1998) to measure the satisfaction level, quality of alternatives and investment size that shape the theory called Investment Model. Investment Model from Rusbult *et al.* (1998) focusses on commitment process, an extension from Interdependence Theory.

> "*Interdependence Theory suggests that dependence on a relationship is greater to the extent that an individual wants to persist with a given partner (i.e. satisfaction level is high), and to the extent that an individual has no choice but to persist with that partner (i.e. alternatives are poor).*" Rusbult *et al.* (1998) p.358

Emerging from Interdependence Theory which regards "*dependence*" as a main factor to understand persistence in a relationship, Rusbult *et al.* (1998) proposed another question: "*How do individuals become dependent on their relationships?*" The Investment Model then extends Interdependence Theory by proposing that "*feelings of commitment emerge as a consequence of increasing dependence*" (Rusbult, Martz et al. 1998). There are four constructs that comprise the Investment Model Scale, namely: "*Commitment level*" and three bases of

dependence – "*Satisfaction level*", "*Quality of alternatives*" and "*Investment size*". According to Rusbult *et al.* (1998), commitment is believed to be the key factor in understanding why some relationships persist and why others vanish in time. PORC is represented by five measurement items from the "*Commitment Level*" of Rusbult *et al.* (1998).

Each construct in OKSM consists of five measurement item levels. As cited in Ma and Yuen (2011), the wording from each sentence at item level was revised to adapt to survey environments as follows: (i) the students or the learner and (ii) the online learning setting. The wording or the measurements item-level for the three constructs is presented in Table 7.

Table 7. Contructs Definition from Ma and Yuen (2011)

Construct	Item	Source
Perceived Online Attachment Motivation (POAM)	1. If I feel unhappy or kind of depressed in learning (subject), I usually try to be around other members using the "ILN" to make me feel better. 2. I usually have the greatest need to have other members using the "ILN" around me when I feel upset in learning (subject). 3. I often have a strong need to be around other "ILN" users who are impressed with what I am like and what I do in (subject). 4. I mainly like to be around other "ILN" users who think I am an important, exciting person in learning (subject) together. 5. I often have a strong desire to get other "ILN" users around to notice me and appreciate what I am like in learning (subject) together.	(Hill 1987)
Perceived Online Relationship Commitment (PORC)	1. I am committed to maintaining my relationship with other members using the "ILN" to learn (subject). 2. I want my relationships with other members using the "ILN" to learn (subject) to last for a very long time. 3. I feel very strongly linked to my relationship with other members using the "ILN" to learn (subject). 4. I would feel very upset if my relationship with	(Rusbult et al., 1998)

	other members using the "ILN" to learn (subject) were to end. 5. I seek the long-term future of my relationship with other members using the "ILN" to learn (subject).	
Online Knowledge Sharing Behavior (OKSB)	1. The advice I receive from other members using the "ILN" has increased my understanding of (subject). 2. The advice I receive from other members using the "ILN" has increased my knowledge of (subject). 3. The advice I receive from other members using the "ILN" allows me to complete similar tasks in (subject) more efficiently. 4. The advice I receive from other members using the "ILN" allows me to improve the quality of similar work in (subject). 5. The advice I receive from other members using the "ILN" allows me to conduct similar (subject) tasks with greater independence.	(Ko, Kirsch et al. 2005)

5.1.3 Latent Structural Model

There are three first-order latent constructs involved in Ma and Yuen's (2011) original model. The original latent structural model from Ma and Yuen (2011) is presented in Figure 6.

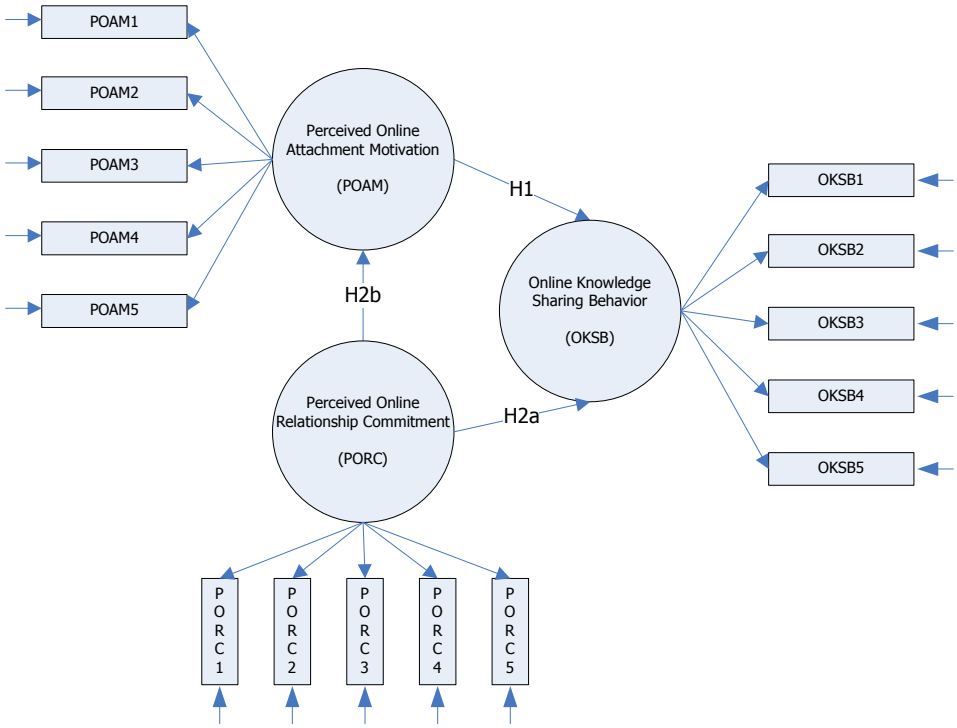

Figure 6. Ma and Yuen's (2011) model for OKSM

Ma and Yuen (2011) described that when a person builds and develops a relationship, he or she will be more willing to engage in greater interaction in wider environments in the online learning community. Since all learners share the same goal of learning, sharing knowledge is an excellent way to develop relationships (Ma and Yuen 2011). This argumentation leads to hypothesis H1.

According to Ma and Yuen (2011), relationship commitment "*reflects an individual's internal perception of dependence on an established relationship*". When an individual needs to maintain his or her relationship, the greater commitment he or she has in relationship (Ma and Yuen 2011). As a result, he or she will spend more time and effort to stay and continue to have contact with the other partner in particular communication. In this context, knowledge sharing is regarded as a positive attitude that benefits other parties in online learning systems. Thus, the individual learner in an online learning system desires to have commitment and share their knowledge in an online learning environment (Ma and Yuen 2011). This argumentation leads to hypothesis H2a.

As cited in Ma and Yuen (2011), *belonging* is considered a dominant factor in shaping human thought. The more the learner engages in an online learning platform, the stronger the sense of belonging to that particular community. Ma and Yuen (2011) argue that the sense of belonging is related to switching cost; the higher the switching cost to another community, the stronger attachment and commitment to a particular online learning community. This argumentation leads to hypothesis H2b.

The three hypotheses for OKSM model from Ma and Yuen (2011) are proposed:

H1: The perceived attachment motivation of an individual learner on an online learning platform will have a positive effect on his or her knowledge sharing behaviour on the online learning platform.

H2a: The perceived online relationship commitment of an individual learner on an online learning platform will have a positive effect on his or her knowledge sharing behaviour on the online learning platform.

H2b: The perceived online relationship commitment of an individual learner on an online learning platform will have a positive impact on his or her perceived online attachment motivation on the online learning platform.

5.1.4 Data

There are 15 inter item correlation coefficients from Ma and Yuen (2011) ready to be used as the main input for TETRAD. The correlation matrix from Ma and Yuen (2011) is presented in Appendix B2.

5.1.5 OKSM: A Measurement Model using TETRAD IV

Ma and Yuen study the factors that encourage users to use an online knowledge sharing to better understand the behavior of online knowledge sharing users. First, we used the initial measurement model from Ma and Yuen (2011) and the correlation matrix reported in Ma and Yuen (2011). Figure 7 presents the General Graph from TETRAD IV's workspace.

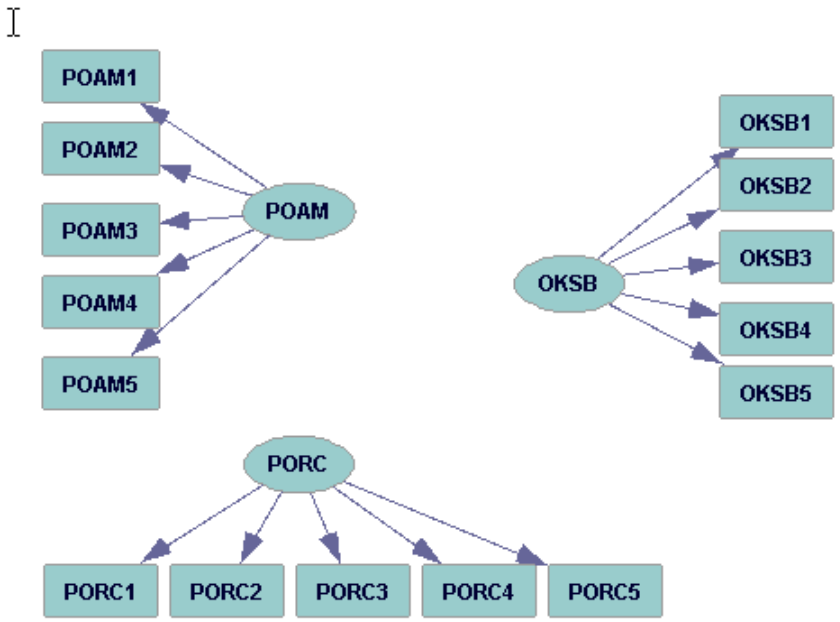

Figure 7. Initial Measurement Model on OKSM (Ma and Yuen 2011)

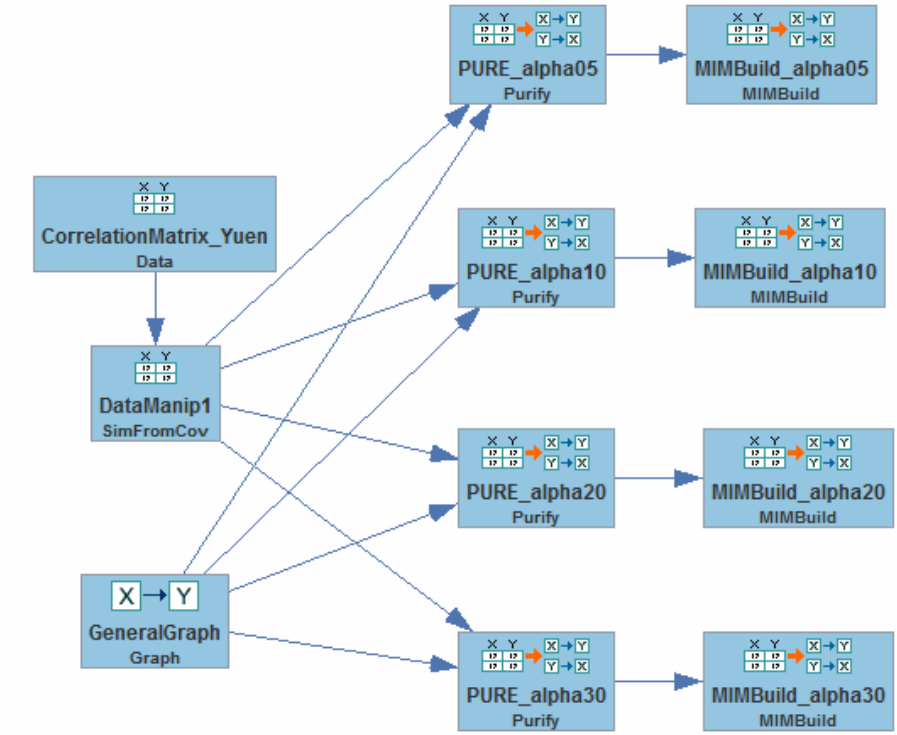

Figure 8. PURIFY and MIMBuild in TETRAD IV for Ma and Yuen's correlation matrix data (2011)

The next step was to search for the pure measurement items using PURIFY. PURIFY detects the impure measurement items by vanishing tetrads value. We varied the significance level (α=0.05, 0.10, 0.20 and 0.30) to have the sensitivity analysis from our data. Figure 8 presents the workspace from TETRAD IV search for the pure measurement model and structural model. From TETRAD results, we got the pure measurement model from each model based on the significance level. TETRAD eliminated nine items for the model with significance level 0.05, 0.10 and 0.20 with different list measured variables. Moreover, the model with significance level 0.30 was only left with 5 measurement items, meaning that TETRAD eliminated 10 measured items from the model. Table 8 shows the list of the measured items that were pruned by TETRAD IV from each model.

Table 8. List of Items Pruned from Ma and Yuen's (2011) correlation matrix data, OKSM model, using PURIFY from TETRAD IV

Ma and Yuen's (2011) Model	**TETRAD's Model**			
Final Model[Yuen]	Model A[1] α=0.05	Model B[2] α=0.10	Model C[3] α=0.20	Model D[4] α=0.30
No items pruned reported.	POAM1	POAM1	POAM2	POAM1
	POAM2	POAM2	POAM3	POAM2
	POAM3	POAM3	POAM4	POAM3
	PORC1	PORC1	PORC1	POAM4
	PORC4	PORC2	PORC2	PORC1
	PORC5	PORC3	PORC5	PORC4
	OKSB2	PORC5	OKSB1	PORC5
	OKSB3	OKSB2	OKSB2	OKSB2
	OKSB4	OKSB4	OKSB5	OKSB3
				OKSB5

Furthermore, we tested the four sub-measurement models from Table 8 in LISREL 8.8. As a result, Table 9 presents the Fit Indices Measurement model (sub-measurement model resulted from PURIFY) using confirmatory factor analysis in LISREL 8.8.

Table 9. Fit Indices Measurement Model

Measurement Model	(Suggested values)	TETRAD's Model			
		Model A[1] α=0.05	Model B[2] α=0.10	Model C[3] α=0.20	Model D[4] α=0.30
Df		6	6	6	2
X²		3.64	5.47	28.64	6.09
RMSEA	≤ 0.06	0.000	0.000	0.080	0.058
RMR	<.05 [q]	0.0082	0.0089	0.024	0.011
SRMR	≤ .08	0.0082	0.0089	0.024	0.011
AIC					
Independence		2542.71	2946.28	2607.62	1655.52
Model		33.63	35.53	58.33	31.93
Saturated		42.00	42.00	42.00	30.00
GFI	>0.9 [q]	1.00	1.00	0.98	1.00
AGFI	>0.9 [q]	0.99	0.99	0.94	0.97
CFI	>0.9 [q]	1.00	1.00	0.99	1.00
IFI	>0.9 [q]	1.00	1.00	0.99	1.00
NFI	>0.9 [q]	0.98	1.00	0.99	1.00
NNFI	>0.9 [q]	1.01	1.00	0.98	0.99

Note:
[b] Model 1: Nine items pruned by TETRAD IV
[c] Model 2: Nine items pruned by TETRAD IV
[d] Model 3: Nine items pruned by TETRAD IV
[e] Model 4: Ten items pruned by TETRAD IV
[q] Combinational rule adopted from Ma and Yuen (2011) p.216

We adopted the suggested value for the parameters from Ma and Yuen (2011). From Table 9, we can conclude that the best measurement model using PURIFY in TETRAD IV using Ma and Yuen's (2011) data, is results from using significance level 0.05. The values are exceed the threshold From Model A[1], it is suggested that the model is pure if the model eliminates the seven items suggested by PURIFY, which are POAM1, POAM2, POAM3, PORC1, PORC4, PORC5, OKSB2, OKSB3, OKSB4. The next step was to search for structural model using MIMBuild.

5.1.6 OKSM: A Structural Model

We used the measurement models generated from TETRAD IV in Table 8 as the input, then tested the hypothesized path using LISREL 8.8. Once again, we varied the significance level to determine which model best suited the data.

Table 10. Fit Indices Structural Model, Ma and Yuen's (2011) correlation matrix data, OKSM model, using MIMBuild from TETRAD

Measurement Model	(Suggested values)	Ma and Yuen's model	TETRAD's Model			
			Model A[1] α=0.05	Model B[2] α=0.10	Model C[3] α=0.20	Model D[4] α=0.30
Df		n/a	6	6	6	2
X^2		n/a	3.64	12657.87	28.64	6.09
RMSEA	≤ 0.06	0.061	0.000	0.63	0.080	0.058
RMR	<.05 q	0.033	0.0082	106.37	0.024	0.011
SRMR	≤ .08	n/a	0.0082	0.53	0.024	0.011
AIC						
Independence		n/a	2542.71	2946.28	2607.62	1655.52
Model		n/a	33.63	1422.26	58.33	31.93
Saturated		n/a	42.00	42.00	42.00	30.00
GFI	>0.9 q	0.95	1.00	-50.13	0.98	1.00
AGFI	>0.9 q	0.92	0.99	-3.89	0.94	0.97
CFI	>0.9 q	0.97	1.00	0.0	0.99	1.00
IFI	>0.9 q	0.97	1.00	-3.32	0.99	1.00
NFI	>0.9 q	0.96	1.00	-3.31	0.99	1.00
NNFI	>0.9 q	0.96	1.00	-9.83	0.98	0.99

Table 10 presents the confirmatory factor analyses using LISREL 8.8. The combinational rule discussed in Chapter 4.2.1 was adopted for the threshold of suggested values. The final testing results show that the model proposed by TETRAD in three models (all significance values) exceeded the threshold or the suggested value from each parameter, except for one model with alpha=0.10. The models which best suited the threshold were from model A[1], C[2] and D[4], while model B[2] suffered from its fit indices testing criteria.

In further observation, Model A[1] (alpha=0.05) was the best model among the others. The result from Model A[1] had lower RMR than Ma and Yuen's model (RMR=0.0082), with the values from GFI, AGFI, IFI, CFI, NFI and NNFI all above the threshold as well as exceeding Ma and Yuen's model (2011). It is an indication that the model well suited with to the data. Thus, we used the Model A1 as the final structural model resulted from TETRAD IV. Figure 9 presents the

results from MIMBuild (alpha = 0.05) as well as the final conclusion for the causal effect relationships for our first case study.

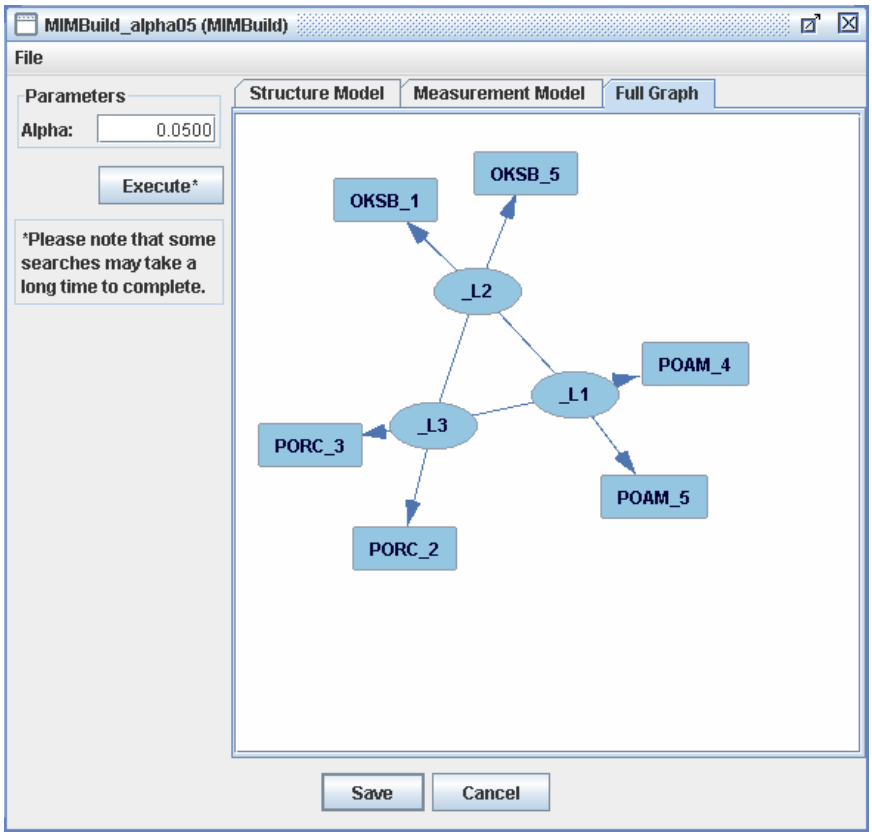

Figure 9. TETRAD's Structural Model on OKSM, Ma and Yuen's (2011) data (alpha = 0.05)

Table 11. Structural Path Comparison Based on Ma and Yuen's (2011) Framework

Path	Ma and Yuen (2011)	TETRAD's Model
PORC → OKSB	→	–
POAM →OKSB	→	–
PORC → POAM	→ (n.s)[27]	–

Table 11 shows the two structural paths that resulted from TETRAD and Ma and Yuen's (2011) self reported, in which three paths are compared. We found that all the paths resulting from TETRAD were undirected graphs. From the final model chosen (MIMBuild, alpha 0.05) all the paths, which are (i) perceived online relationship commitment (PORC) to online knowledge sharing behaviour (OKSB),

(ii) perceived online relationship commitment (PORC) to perceived online attachment motivation (POAM), (iii) perceived online attachment motivation (POAM) and online knowledge sharing behaviour (OKSB) were found undirected. There is no dependency between variables in MIMBuild's model and our findings did not support the three hypothesis proposed by Ma and Yuen (2011). In our chosen model, no evidence for causal linkage between the three variables was found based on Ma and Yuen's (2011) data. MIMBuild suggested that all the variables are related, but not in causal effect condition.

5.1.7 OKSM using TETRAD: An Analysis

There is an interesting finding from our self reported results and Ma and Yuen's results (2011). We found undirected paths from the relationship between online knowledge sharing behavior (OKSB) with perceived online relationships commitment (PORC), meaning that there is no causal relationships occur between OKSB and PORC. While, in Ma and Yuen's (2011) final model, this path was found nonsignificant and not supported the model hypothesis.

Furthermore, two remaining paths from POAM to OKSB and PORC to OKSB were also presented as undirected edges; it implying that TETRAD found the measurement items from the variables to be impure. Thus, there was no evidence found in TETRAD to support the three hypotheses proposed by Ma and Yuen (2011). TETRAD findings confirmed that the relationships between the variables (POAM, PORC and OKSB) in Online Knowledge Sharing Model are were not causative. TETRAD found in the model (alpha=0.05) that:

- Perceived attachment motivation of an individual learner in an online learning platform (or POAM) did not have a positive effect on his or her knowledge sharing behaviour on the online learning platform (OKSB)*;* meaning that the learner was not motivated to used the online learning platform as a tool to share his or her

[27] In their final result, Ma and Yuen (2011) stated that this path is not supported the hypothesis proposed in the model, that is H2a.

information as well as learned knowledge with the other users in the online learning system.

- Perceived online relationship commitment of an individual learner on an online learning platform (PORC) did not have a positive effect on his or her online knowledge sharing behaviour (OKSB) on the online learning platform[28], meaning that the user did not commit in their relationship with other user, therefore they did not use the online learning system as a tool to share and increase their knowledge.
- Perceived online relationship commitment of an individual learner (PORC) on an online learning platform did not have a positive impact on his or her perceived online attachment motivation on the online learning platform (POAM), meaning that the user did not have a commitment in their relationship with the other user, therefore the user did not have the motivation to use the online learning system.

[28] Without any prior knowledge given, TETRAD successfully detected one non causal relationship, which was also found not supported from the final model in Ma and Yuen (2001),.

5.2 CASE STUDY 2: Blackboard, Hafidz - 2011

The goal for the second case study is to validate the latent structural model from Ma and Yuen (2011). Experimental research is needed to see whether the theory is still valid in different nomological network (Liu 2009). We tested the model with "Blackboard" as the object of the study in the University of Twente and the students (Bachelor, Master student, PhD candidate) as the main user for the online learning systems.

5.2.1 Blackboard: Survey Research

We collected survey at the University of Twente via a 15 items questionnaire. The questionnaire was prepared for the targeted users using the online learning system or "Blackboard" and delivered in two manners: online and in paper form. We delivered the questionnaire over nine days, from 5 August 2011 to 13 August 2011. As a result, surveys with 15 questions were completed by 80 respondents. We relied on statistical analysis in order to quantitatively measure our results.

5.2.2 Measures

As discussed in Chapter 5.1.2 the operationalisation of the constructs is adopted from Ma and Yuen (2011). We used 15 measurement item levels as the questions in the survey, which is similar in Chapter 5.1.2. The wording represented the students at the University of Twente as the targeted users and "Blackboard" as the online learning system. 15 questions were measured using the Likert scale, i.e. points from 1 (strongly disagree) to 7 (strongly agree). The adaptation described in Chapter 4.2.2 is realized in Table 12.

Table 12. Contructs Definition adopted from Ma and Yuen (2011)

Construct	Item	Source
Perceived Online Attachment	1. If I feel unhappy or kind of depressed in learning (course), I usually try to be around other members using the "Blackboard" to make me feel	(Hill 1987)

Motivation (POAM)	better. 2. I usually have the greatest need to have other members using the "Blackboard" around me when I feel upset in learning (course). 3. I often have a strong need to be around other "Blackboard" users who are impressed with what I am like and what I do in (course). 4. I mainly like to be around other "Blackboard" users who think I am an important, exciting person in learning (course) together. 5. I often have a strong desire to get other "Blackboard" users around to notice me and appreciate what I am like in learning (course) together.	
Perceived Online Relationship Commitment (PORC)	1. I am committed to maintaining my relationship with other members using the "Blackboard" to learn (course). 2. I want my relationships with other members using the "Blackboard" to learn (course) to last for a very long time. 3. I feel very strongly linked to my relationship with other members using the "Blackboard" to learn (course). 4. I would feel very upset if my relationship with other members using the "Blackboard" to learn (course) were to end. 5. I seek the long-term future of my relationship with other members using the "Blackboard" to learn (course).	(Rusbult et al., 1998)
Online Knowledge Sharing Behavior (OKSB)	1. The advice I receive from other members using the "Blackboard" has increased my understanding of (course). 2. The advice I receive from other members using the "Blackboard" has increased my knowledge of (course). 3. The advice I receive from other members using the "Blackboard" allows me to complete similar tasks in (course) more efficiently. 4. The advice I receive from other members using	(Ko, Kirsch et al. 2005)

	the "Blackboard" allows me to improve the quality of similar work in (course). 5. The advice I receive from other members using the "Blackboard" allows me to conduct similar (course) tasks with greater independence.

5.2.3 Survey and Data Collection

For the experimental data, two surveys have been designed[29]. The only difference from both surveys is the medium of deliverable: online form and paper form. The International Institute for Geo-Information Science and Earth Observation (ITC) as the newest and becomes the 6th faculty in the University of Twente is also included for the targeted user. For the online version, we use the Spreadsheet provided by Google Docs. We ask the participants to filled-in their university email to assure that they are the students from the University of Twente. We put all the questions in "Required" mode, which means that they can only submit their final answer by filling-in the entire questionnaire. The online form is getting more respondents than the paper forms. In total there are 80 respondents filled in the questionnaire, 51 via online and 29 via paper form. We delivered 60 paper forms, out of 29 completed the paper survey. The response rate for the paper survey is 48.3%. For the online form we delivered it in diverse medium as listed follows:

1. Via ESN Twente Facebook Page (667 members, per 21 August 2011) at: http://www.facebook.com/people/Esn-Twente/100001872379565,
2. Via Persatuan Pelajar Indonesia di Enschede (PPIE, 440 members, alumni and current students of University of Twente and ITC in Enschede, per 21 August 2011) mailing list or Indonesian Student Association in Enschede mailing list at Yahoo groups,
3. Via Indonesian Moslems in Enschede Association (IMEA, 237 members, per 21 August 2011) mailing list at Yahoo groups, can be reached at http://groups.yahoo.com/group/imea/,

[29] The online form for our Blackboard case study can be viewed at http://goo.gl/0PA77. The paper form for the questionnaire is attached on Appendix D1.

4. Via 22 Facebook private messages, out of 15 people completed online, 3 people replied stated they never use "Blackboard" and 4 people did not respond the messages at all,
5. Via 14 Google mail private messages, out of 3 people completed online, 8 people replied stated they never use "Blackboard" and 3 people did not respond the messages at all.

From 51 online forms completed, 15 or 29.41% initiate from Facebook private messages, 3 or 5.88% initiate from Google mail private messages, 33 or 64.71% initiate from unknown source. In order to include as many respondents we could, we give incentive for 2 people, cash value 50€ and 25€. We randomly selected two people in the end of time (at 13 August 2011, 23:59 CET[30]) of accepting the responses via online form. Finally, the demographics and characteristics of the subjects can be seen on Table 13.

Table 13. Demographics and Characteristics of the Subjects

Characteristic	Online Forms		Paper Forms	
Gender	Female	16	Female	10
	Male	35	Male	19
Faculty	GW	5	GW	1
	MB	6	MB	5
	CTW	2	CTW	-
	EWI	3	EWI	3
	TNW	6	TNW	-
	ITC	29	ITC	20
Study	Bachelor	-	Bachelor	5
	Master	44	Master	24
	PhD candidate	7	PhD candidate	-
Subt Total		51		29
Total (N)	80			

Note: The faculty in the University of Twente, listed:

1. GW: Behavioural Sciences
2. MB: School of Management and Governance
3. CTW: Engineering and Technology
4. EWI: Electrical Engineering, Mathematics and Computer Science

[30] CET: Central European Time.

5. TNW: Science and Technology
6. ITC: International Institute for Geo-Information Science and Earth Observation

5.2.4 Structural Model

We utilised the latent structural model proposed by Ma and Yuen (2011). Their three constructs were used along with 15 measurement items for the latent variables. Figure 10 represents the latent structural model for Blackboard research using OKSM Model.

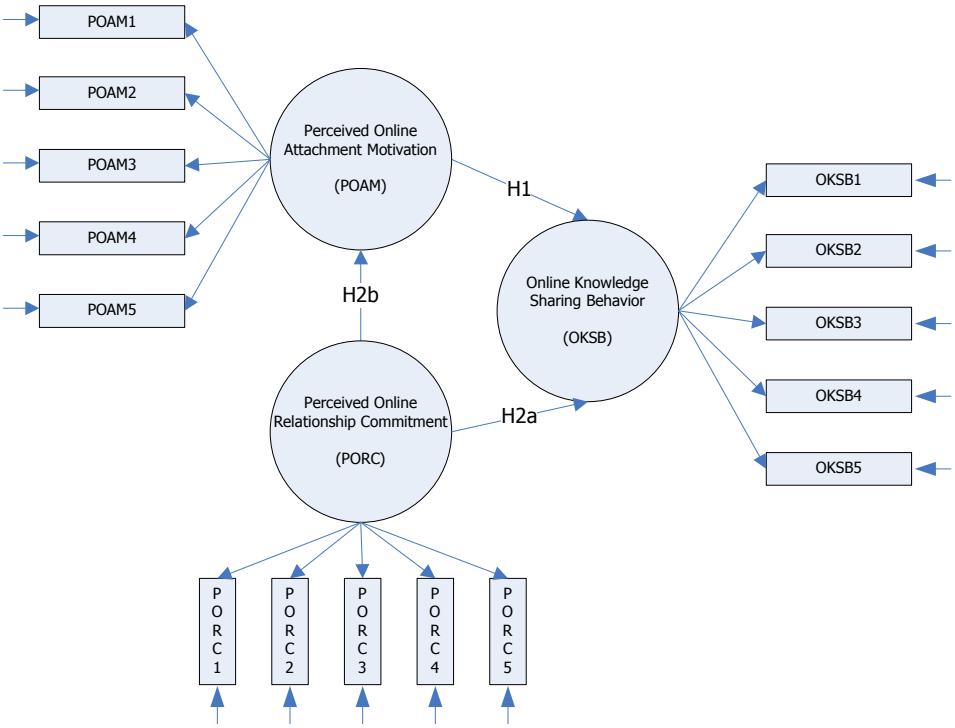

Figure 10. Latent Structural Model adopted from Ma and Yuen (2011)

5.2.5 Data Preparation

First, we collected 80 students' data[31] and calculated the Correlation Coefficient for the 15 measurement variables. The correlation matrix at item level for the Blackboard experiment is presented in Appendix C1. To conduct reliability

[31] The data from 80 respondents is (anonymously) presented in Appendix D4.

measurements for the data, we separated two data sets: : the online dataset and the paper dataset, and searched for the correlation matrix for each dataset. The correlation matrix for the online dataset and paper data set is presented in Appendices C2 and C3 respectively.

5.2.6 Data Analysis

Descriptive Analysis

The descriptive analysis of the instrument for ordinal data consists of median or mode as the central tendency (Jamieson 2004). Standard variation is a measure of the dispersion of its data from its mean. Jamieson (2004) argued that the mean and standard deviation is inappropriate for ordinal data (i.e. data that using Likert-scale), since the ordinal data don't have the true value and "*where the numbers generally represent verbal statements*" (i.e. the Likert-scale 1-7, represented the order from 1—strongly disagree until 7—strongly agree). Calculating its standard deviation meant that we calculated the variance of the sample data, which was based on the average values. For example, if we had the average value of 1.19, the values lied between 1—strongly disagree and 2—quite disagree. *How can we turn this value into a verbal statement?* A clear representation could not be made, thus it was suggested to use another descriptive analysis that was better suited for the type of the data.

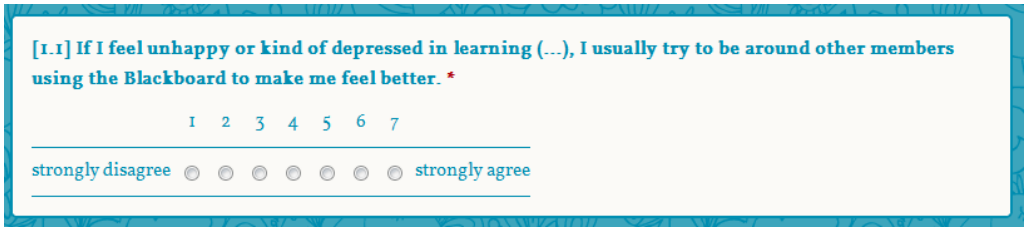

Figure 11. Example of the question and Likert scale for Blackboard survey

The median is the middle of a distribution, while mode is the most frequently occurring score in a distribution. The measurement for our Likert-scale in the Blackboard survey was 1-7; representing the order from 1—strongly disagree until 7—strongly agree. One example of our online questionnaire and its Likert-

scale is presented in Figure 11. The degree of the Likert-scale measurement is presented in Table 14.

Table 14. Likert-scales

Degree	Meaning
1	Strongly disagree
2	Quite disagree
3	Slightly disagree
4	Neither agree nor disagree, neutral
5	Slightly agree
6	Quite agree
7	Strongly agree

The median and the mode for our dataset are presented in Table 15. We used Microsoft Excel 2007 to obtain the median and mode for three datasets from the Blackboard Survey: the online dataset, the paper dataset and the combined dataset[32].

Table 15. Descriptive Analysis of the Instrument (Mean and Mode) of three datasets for Blackboard Survey

Constructs	All data combine (n=80)		Paper dataset (n=29)		Online dataset (n=51)	
	Median	Mode	Median	Mode	Median	Mode
Perceived Online Attachment Motivation (POAM)						
POAM1	2	1	2	1	2	1
POAM2	2	1	1	1	2	1
POAM3	2	1	2	1	2	1
POAM4	2	1	2	1	2	1
POAM5	2	1	2	1	3	1
Perceived Online Relationship Commitment (PORC)						
PORC1	3	1	2	1	3	1
PORC2	4	4	3	1	4	4
PORC3	3	1	2	1	3	4
PORC4	2	1	2	1	2	1
PORC5	3	1	2	1	4	1
Online Knowledge Sharing Behavior (OKSB)						
OKSB1	4	3	4	6	4	5
OKSB2	4	3	4	1	4	4

[32] For further information, the histogram that provided the distribution for the combined dataset (n=80) is available inAppendix E4.

OKSB3	4	6	4	6	4	3
OKSB4	4	4	4	1	4	4
OKSB5	4	4	4	6	4	4

From Table 15, we can see that for all POAM items, all three datasets show the tendency of a respondent to choose 1 (strongly disagree), with the median 2 (quite disagree) for all items from POAM in all datasets, except for POAM5 in the online dataset, which had median 3 (slightly disagree). By looking at the first group of measurement items, the three groups' datasets show consistency and the same response.

Meanwhile, there is a bit variation for each item in PORC. For our first dataset (n=80), the respondents answered mostly 1 (strongly disagree) for all PORC items, except for item PORC2, in which the respondents answered mostly 4 (neither agree, nor disagree, neutral). For the paper dataset (n=29), the respondents answered mostly 1 (strongly disagree) for all PORC items. In the last dataset, the online dataset (n=51), the respondents answered PORC items with mostly 1 (strongly disagree), with the exception of PORC2 and PORC 3 which were mostly answered with 4 (neither agree, nor disagree, neutral). For the combined dataset, items PORC1, PORC3, PORC5 had the median value 3 (slightly disagree); PORC2 had the median value 4 (neither agree, nor disagree, neutral) and PORC4 had the median value 2 (quite disagree). For the paper dataset, the median value for all PORC items was 2 (quite disagree), except for PORC2 which had the median of 3 (slightly disagree). Finally, for the online dataset, the median values for PORC1 and PORC3 were 3 (slightly disagree), were 4 (neither agree, nor disagree, neutral) PORC2 and PORC5 were and were 3 (slightly disagree) for PORC3.

The last item group is OKSB. The variation of the answer is the highest among the other items (PORC and POAM) for all datasets. For the first dataset (n=80), most people answered 3 (slightly disagree) for OKSB1 and OKSB2, answered 6 (quite agree) for OKSB3, 4 (neither agree, nor disagree, neutral) for OKSB4 and OKSB5. For the paper dataset, the people mostly answered 6 (quite agree) for OKSB1,

OKSB 3, OKSB5 and 4 (neither agree, nor disagree, neutral) and answered 1 (strongly disagree) for OKSB2 and OKSB4. In the last dataset, the online dataset (n=51), people answered mostly 5 (slightly agree) for OKSB1, mostly answered 4 (neither agree, nor disagree, neutral) for OKSB2, OKSB4 and OKSB5, and mostly answered 3 (slightly disagree) for OKSB3. For OKSB, the median value for all datasets: the online, the paper and the combined dataset was 4 (neither agree, nor disagree, neutral.

Reliability and construct validity

We conducted a principal factor analysis to measure the models' reliability and validity. Validity is the degree and the strength of our conclusions, inference or propositions. As cited in Ma and Yuen (2011) *validity* defined by Hair *et al.* (2006) is the degree to which a measurement veridically represents what it is supposed to represent, and *reliability* is the degree to which an instrument measures its consistency. Cronbach alpha is regarded as the numerical coefficient of reliability (Santos 1999). Furthermore, Santos (1999) described that Cronbach alpha measures whether the response from such a set of questions generated to a variable, is a stable response . Variables which were derived from a test instrument are considered to be reliable if they provide stable responses over repeated tests. Nunnally (1994) has suggested that 0.7 is the acceptable value for Cronbach alpha.

We did three tests for the reliability; the two tests are generated from our two separated data: 51 from the online dataset and 29 from the paper dataset and the third test is generated from all the combined data: 80 respondent data. We tested the reliability from all three datasets to see whether the paper dataset, the online data and the combined dataset were consistent in their reliability. In order to obtain the Cronbach alpha value from each dataset, the correlation matrix from each dataset was produced[33]. Table 16 presented the Cronbach alpha values for the reliability of three data sets.

[33] The correlation matrix for the online and paper datasets is available in Appendix E2 and E3.

Table 16. Cronbach alpha three datasets for Blackboard Survey

Data sets	Cronbach Alpha		
	POAM	PORC	OKSB
Paper data (29)	0.9316	0.9317	0.9826
Online data (51)	0.8967	0.8875	0.9668
All data (80)	0.9089	0.9063	0.9656

All values in the table exceed the threshold value suggested by Nunally (1994). From the paper dataset (29 data), the Cronbach alpha ranges from 0.9316, 0.9317 and 0.9826 for POAM, PORC and OKSB respectively. For the online dataset (51 data), the Cronbach alpha for POAM was 0.8967, for PORC was 0.8875 and for OKSB was 0.9668. Finally, the dataset that presented all data combined (80 data) showed Cronbach alpha values 0.9089 for POAM, 0.9063 for PORC and 0.9656 for OKSB. From Table 11, each dataset indicated that the constructs were internally consistent. For the following section, we only analysed the combined dataset (n=80).

Model Testing using LISREL 8.8

We employed LISREL 8.8 (for Student)[34] to obtain fit indices for our measurement model and structural model. The aim was to find the fit indices for our sub-measurement model results using (i) PURIFY Algorithm and (ii) structural model results using MIMBuild in TETRAD. The entire model testing results are presented in Chapter 5.2.6 and 5.2.7. Finally, analyses for the comparison are presented in Chapter 5.2.8.

5.2.7 Measurement Model using PURIFY

We used PURIFY from TETRAD IV to generate the sub-model from 15 items from Online Knowledge Sharing Model adopted from Ma and Yuen (Ma and Yuen 2011). The goal was to determine a pure measurement model from the initial model built. PURIFY tests the initial pure measurement model from the data and validates the initial measurement model by vanishing tetrads. If the model does

not fit, then PURIFY will eliminate measured variables (i.e. POAM1-5, PORC1-5, and OKSB1-5) from the initial measurement model until it is left with the smaller pure measurement model which does fit the data. There are three input for PURIFY in TETRAD IV as follows:

a. a correlation matrix[35] from the observed measurement items,
b. its sample size (written in correlation matrix), and
c. a general graph from the initial measurement model.

The illustration for the PURIFY algorithm in TETRAD's workspace and its input is presented in Figure 12.

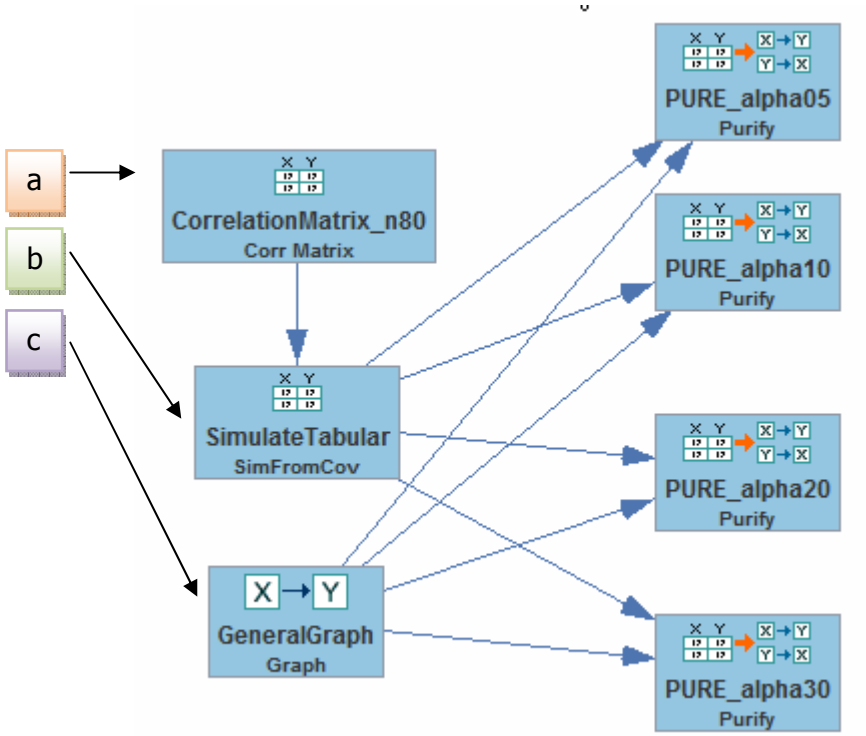

Figure 12. Pure Measurement Model using PURIFY

Note:

a and b — The Correlation Matrix and Simulate Tabular from Correlation Matrix shown in TETRAD IV workspace are available in Appendix E5.

c — The General Graph shown in TETRAD IV workspace is presented in Figure 13

[34] The software is available at http://www.ssicentral.com/lisrel/student.html.
[35] The correlation matrix used is the combined dataset (n=80) and available at Appendix E1.

The search for the pure initial measurement model using PURIFY in TETRAD IV work space is shown in Figure 8. There are three function boxes needed for PURIFY algorithm completion:

1. Data Wrapper >> load the raw data and calculate correlation matrix (n=80),
2. Data Manipulation >> Simulate Tabular from Covariance, this function is used to change the lower triangular correlation matrix into tabular data. The correlation matrix (n=80) in Appendix E1 must be converted into a tabular data[36], therefore it can be used together with General Graph (which shown in Figure 8) as the input for PURIFY[37].
3. Graph >> General Graph, to add the initial measurement model. The initial measurement model for Online Knowledge Sharing adopted from Ma and Yuen (2011) is shown in Figure 13.

[36] The tabular data from correlation matrix with n=80 is available in Appendix E6.
[37] The PURIFY Algorithm in TETRAD IV can not read the lower triangular correlation matrix from data, thus the correlation matrix had to be converted into tabular data using the function from Data Manipulation >> Simulate Tabular from Covariance. We are grateful to have the insight for this step from one of the current TETRAD IV developers from Carnegie Mellon University, Dr. Joseph Ramsey. The list of the people related to current TETRAD project is available at http://www.phil.cmu.edu/projects/tetrad/people.html (Accessed 27 Augusts 2011).

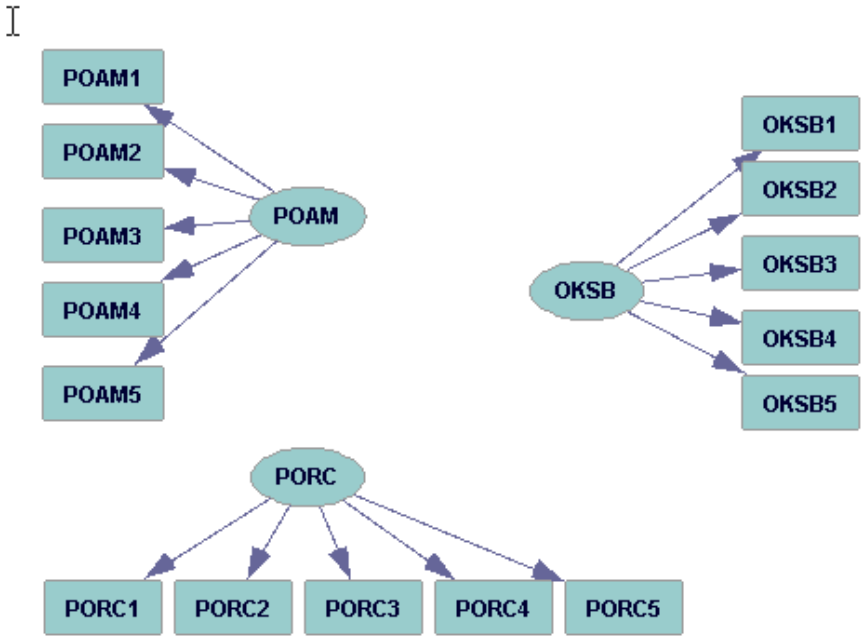

Figure 13. Initial Measurement Model (General Graph) adopted from Ma and Yuen (2011)

The PURIFY algorithm uses vanishing tetrads to validate the initial model, it searches the impure measured variables and eliminates them until the model becomes pure. As discussed in Chapter 4.2.2, we varied the significance level to conduct sensitivity analysis (α=0.05, 0.10, 0.20 and 0.30)[38]. Table 17 shows the items pruned as a results of PURIFY algorithm using TETRAD IV. Furthermore, we tested the four sub-measurement models from Table 17 into LISREL 8.8. Table 18 presents the Fit Indices Measurement model (sub-measurement model resulted from PURIFY) using confirmatory factor analysis in LISREL 8.8.

[38] As cited in Im and Wang (2007, p.327), it is important to determine the significance level in regard to the size of our sample. Since TETRAD does not have any specific requirement for setting the alpha, it is advisable to have a moderate values for this measurement. Im and Wang (2007) suggested that users may set:

- α=0.20 when sample size is 100 or smaller,
- α=0.10 when sample size is 100 to 300, and
- α=0.05 when sample size is larger than 300.

Table 17. List of Items Pruned, Blackboard Survey (n=80), Hafidz – 2011

Ma and Yuen's (2011) Model	**TETRAD's Model**			
Final Model[a]	Model 1[b] α=0.05	Model 2[c] α=0.10	Model 3[d] α=0.20	Model 4[e] α=0.30
No items pruned reported.	POAM1 POAM4 PORC1 PORC2 PORC5 OKSB1 OKSB2	POAM1 POAM4 PORC1 PORC2 PORC3 OKSB1 OKSB2 OKSB3	POAM1 POAM4 PORC2 PORC3 PORC5 OKSB1 OKSB2 OKSB3	POAM1 POAM4 PORC1 PORC2 PORC3 PORC5 OKSB1 OKSB2 OKSB3

There are four models compared based on their significance level[39]. From Model 1b with α=0.05 and Model 4e with α=0.30, there are seven and eight items pruned by TETRAD, respectively. The remaining models which are Model 2c with α=0.10, Model 3d with α=0.20, in which TETRAD eliminated 8 items. Next, we used LISREL 8.8 based on the measurement model suggested by PURIFY in Table 17.

[39] The TETRAD results for all significance level are presented in Appendix D6.

Table 18. Fit Indices of Measurement Models[40]

Measurement Model	(Suggested values)	TETRAD's Model			
		Model 1[b] α=0.05	Model 2[c] α=0.10	Model 3[d] α=0.20	Model 4[e] α=0.30
Df		17	17	11	6
X^2		13.31	10.56	7.35	1437.88
RMSEA	≤ 0.06 [p]	0.000	0.000	0.000	0.56
RMR	<.05 [q]	0.11	0.12	0.11	242.81
SRMR	≤ .08 [p]	0.037	0.039	0.035	0.53
AIC					
Independence		676.45	689.21	444.99	332.07
Model		51.65	48.30	41.78	185.86
Saturated		72.00	72.00	56.00	42.00
GFI	>0.9 [q]	0.96	0.97	0.97	-0.99
AGFI	>0.9 [q]	0.91	0.93	0.93	-5.97
CFI	>0.95 [p]	1.00	1.00	1.00	0.0
IFI	>0.9 [q]	1.01	1.01	1.01	-3.56
NFI	>0.9 [q]	0.98	0.98	0.98	-3.49
NNFI	>0.9 [q]	1.01	1.02	1.02	-10.73

Note:

[b] Model 1: Seven items pruned by TETRAD IV

[c] Model 2: Eight items pruned by TETRAD IV

[d] Model 3: Eight items pruned by TETRAD IV

[e] Model 4: Nine items pruned by TETRAD IV

[p] Combinational rule adopted from Im and Wang (2007) discussed in Chapter 4.2.1 (Fit Indices)

[q] Combinational rule adopted from Ma and Yuen (2011) p.216

Table 18 presents the confirmatory factor analyses using LISREL 8.8. The combinational rule discussed in Chapter 4.2.1 was adopted with the additional combinational rule from Ma and Yuen (2011), p.216. The final testing results showed that the model proposed by TETRAD in all models (all significance values) exceeded the threshold or the suggested value from each parameter. From our observation, Model 3[d] (alpha=0.20) was the best model among other model. The result from the lowest SRMR (SRMR=0.035) among other models. From four models, model 3[d] has the lowest AIC values, it indicating it to be the

[40] The Fit Indices Measurement Models were assessed by confirmatory factor analysis (CFA) using LISREL 8.8. The input for the CFA in LISREL 8.8 are (i) the initial measurement model and the list of pure items derived from PURIFY algorithm in TETRAD IV results.

better model among the others. Models 3d's value for GFI, AGFI, NNFI, NFI, CFI, and IFI are 0.97, 0.93, 1.00, 1.01, 0.98 and 1.02 respectively. All these values also passed the threshold that suggested the best fit of the model. Figure 14 shows the TETRAD result from Model 3d.

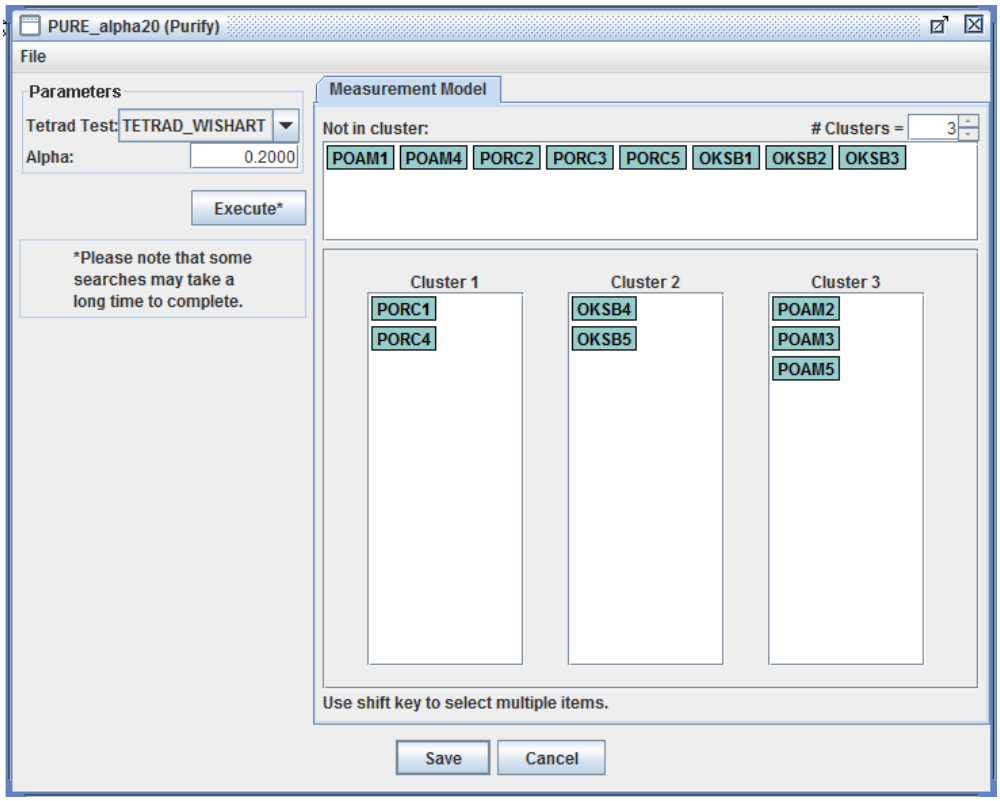

Figure 14. PURIFY for Blackboard data survey (alpha = 0.20)

5.2.8 Measurement Model using MIMBuild

The next step was to use MIMBuild to determine the structural model based on PURIFY results. The goal from MIMBuild was to search for structural model among the latent variables. The input for MIMBuild was the unidimensional model resulting from PURIFY. Figure 15 shows the illustration for the MIMBuild algorithm in TETRAD's workspace.

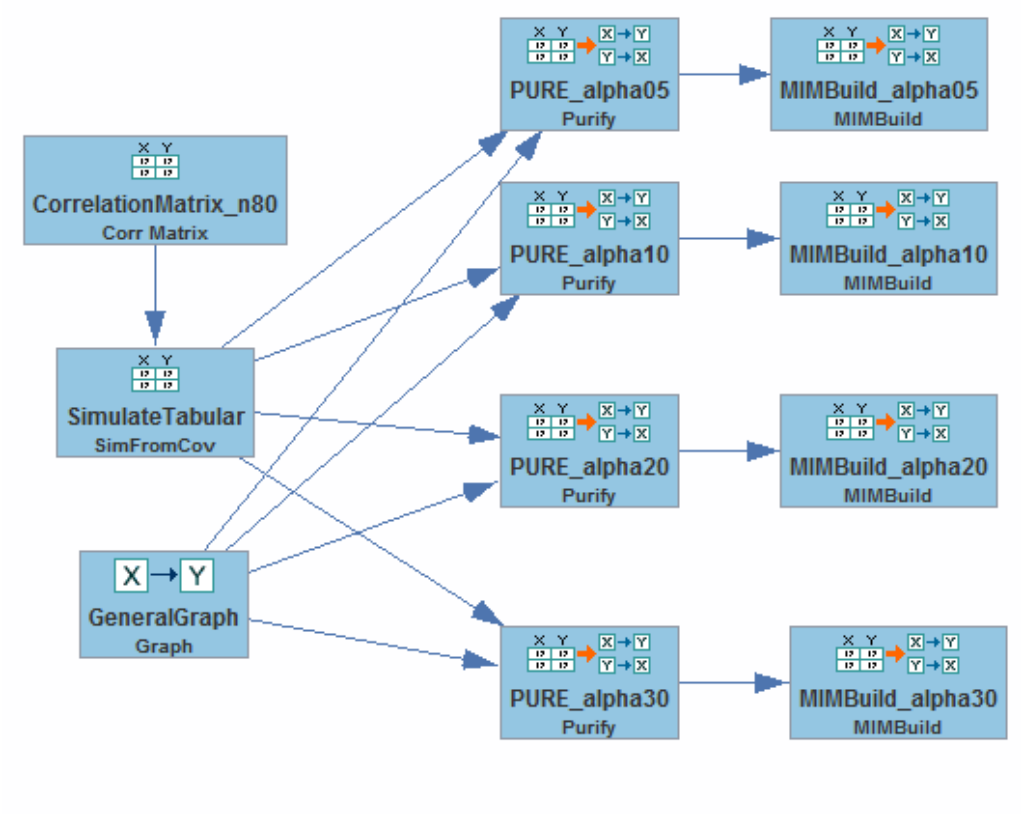

Figure 15. Structural Model using MIMBuild

Table 19. Fit Indices Structural Model - Blackboard Survey (n=80), Hafidz – 2011

Measurement Model	(Suggested values)	Ma and Yuen's (2011) Model	TETRAD's Model			
		Final Model[a]	Model 1[b] α=0.05	Model 2[c] α=0.10	Model 3[d] α=0.20	Model 4[e] α=0.30
Df		-	17	11	11	6
X^2			13.31	7.7	7.35	1708.39
RMSEA	≤ 0.06 [p]	0.061	0.000	0.000	0.000	0.56
RMR	<.05 [q]	0.033	0.11	0.12	0.11	548.29
SRMR	≤ .08 [p]	-	0.037	0.038	0.035	0.57
AIC						
Independence		-	676.45	483.61	444.99	332.01
Model		-	51.65	41.72	41.78	187.18
Saturated		-	72.00	56.00	56.00	42.00
GFI	>0.9 [q]	0.95	0.96	0.97	0.97	-1.08
AGFI	>0.9 [q]	0.92	0.91	0.93	0.93	-6.27
CFI	>0.95 [p]	0.97	1.00	1.00	1.00	0.0
IFI	>0.9 [q]	0.97	1.00	1.01	1.01	-4.42
NFI	>0.9 [q]	0.96	0.98	0.98	0.98	-4.34
NNFI	>0.9 [q]	0.96	0.91	1.01	1.02	-12.95

Table 19 shows the fit indices resulted from MIMBuild. Model 3[d] (significance level = 0.20) provided the best results compared to the remaining models. Figure 16 shows the causal model resulted from TETRAD IV with alpha 0.20.

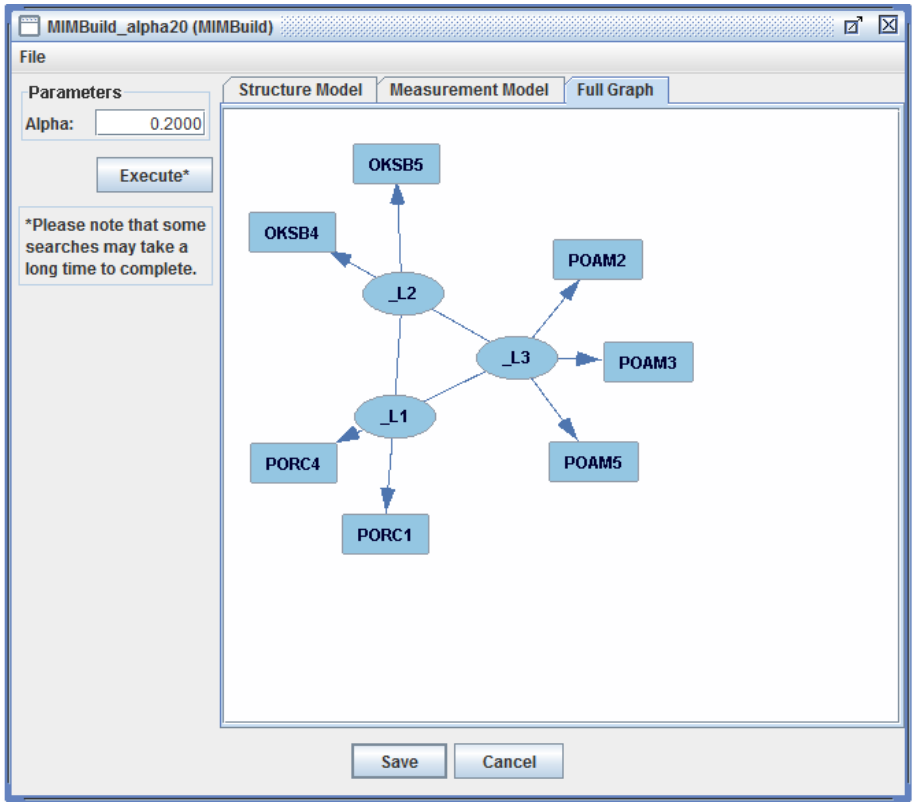

Figure 16. TETRAD's Structural Model on OKSM, Blackboard data (alpha = 0.20)

We present the paths of the structural model from significance level=0.20 discovered by TETRAD's MIMBuild in Figure 16.

Table 20. Structural Path (Causal Model) using TETRAD IV, Blackboard Data (n=80)

Ma and Yuen's model	TETRAD's Model
PORC → OKSB	PORC – OKSB
POAM →OKSB	POAM – OKSB
PORC → POAM	PORC – POAM

From Table 20 and Figure 16, we can see that all the relationships from latent variables consist of undirected edges. The graph from Figure 13 is considered to be an undirected graph, which means that the graph only consists of undirected edges (Spirtes, Glymour et al. 2000), p.25.

5.2.9 OKSM using TETRAD: An Analysis

From the graph in Figure 16, we can conclude that there is inadequate evidence to define the causal relationships between the constructs or the variables within the model. In other words, there are no causal links between the constructs in Online Knowledge Sharing Model (OKSM).

Perceived Online Relationship Commitment (PORC) is the degree to which an individual believes that he or she can persist in a relationship with others in onlinelearning platform. The relationship is shown as an undirected path between perceived online relationship commitment (PORC) and online knowledge sharing behaviour (OKSB). Based on our final model, the results show that the results show that the learner did not want to persist and did not want to commit to their relationships with the other users to use Blackboard as an online learning platform. Therefore, the learners did not use Blackboard to learn or obtain knowledge in a specific course enrolled in his or her Blackboard system.

Perceived Online Attachment Motivation (POAM) is defined as degree to which a person believes he or she can improve his orher social interaction and the sense of communion in an online learning platform, and Online Knowledge Sharing Behaviour (OKSB) is defined as the online communication of knowledge so that knowledge can be applied and learned by each individual. The final model showed that POAM did not have a causal link with OKSB, it indicated that he or she was not motivated by social contact with the other users of Blackboard, therefore he or she did not use Blackboard system as a tool for sharing or learning and applying the knowledge to a specific course.

The last relationship is shown between PORC and POAM. The undirected path discovered among these two variables implies that the user from Blackboard was not committed to the relationship between other users, therefore he or she was not motivated to use Blackboard as a tool for learning in a specific course.

Chapter 6: Discussions and Conclusions

6.1 Conclusions

6.1.1 Related with the use of TETRAD

Q1.1 Which TETRAD algorithms can be used for the case studies?

- Based on the Literature Review in Chapter 2, the algorithm used depends on the type of variable involved in the case studies. If the case studies include the measurement items from its latent variable, then it's best to use PURIFY and to then use the MIMBuild algorithm from TETRAD. If not, the researcher may use another algorithm that can be used for categorical data and which did not involve any measurement items, i.e. the research from Bessler and Loper (2001).
- The extensive aim from Purify in TETRAD is that it searches and detects for impure relationships between each observed variable (or measured variables) and the corresponding factors (latent variables). When the initial measurement model is pure, then MIMBuild is needed to search for the causal structure or the structural model that best suits the data.
- Since observed items and corresponding factors are used in our two case studies (multiple indicator model), Purify and MIMBuild are employed to search for causal link among the variables within the model.

Q1.2 What are the possibilities and limitations of TETRAD application in both case studies?

- Possibilities: PURIFY helps to search for those which are the only pure measurement items from the initial measurement model. The algorithm helps detect the impure measured variables, which fall into four categories: latent-measured impure, intra-construct impure, cross-constructs impure and common cause impure. Based on both of the case studies, by finding

the pure measurement initial model, PURIFY eliminates the uncorrelated measurement items from its corresponding factor, or in the other words, eliminates the uncorrelated measured variables from its latent variables.

- Possibilities: MIMBuilds helps to search for the causal structure based on pure measurement models resulted from PURIFY. In the first case study, TETRAD results show that all the values from fit indices testing exceed the threshold values and fit indices values reported from Ma and Yuen (2011), and fit data well. This is an indication that TETRAD models fit better based on correlation data from Ma and Yuen (2011). Interestingly, our findings in the second TETRAD case study are the same as the causal relationships in OKSM model found in first case study. Although we use the model in different nomological networks, TETRAD detects the same causal link between the variables in OKSM Model.
- Limitations: TETRAD only proposed a set of plausible alternative models for researchers and detects the impure relationships among variables, both in measurement models and structural models. However accurate and precise the results, the results from TETRAD should be regarded as a starting point to search for the causal link (Im and Wang 2007). The researcher should look at his or her model and seek additional information to choose the best model available.

6.1.2 Related to the chosen case study in Knowledge Sharing

Q2.1 Can TETRAD help in the exploratory phase of searching for the pure model and searching for the causal relationship from theory in Ma and Yuen's Online Knowledge Sharing Model?

- Yes. From our observations, TETRAD helps to detect the impure relationship in measurement level and helps to define the causal link based on data in OKSM Model.

Q2.2 What does TETRAD indicate in Ma and Yuen's Online Knowledge Sharing Model using the original data? (first case study)

- TETRAD results in the first case study indicate that there is no causal link between the variables in OKSM Model. All the variables are connected; somehow they are connected by undirected edges, which mean that there is no causal effect link connects one variable to other, and vice versa.
- From our observations, the model from Ma and Yuen (2011) is regarded as an exploratory study. Thus, it is best to (i) first explore which parameters or measured variables best suit the data, (ii) indicate which parameters are not true measurement items corresponding their parents or their latent variable.

Q2.3 What does TETRAD indicate in Ma and Yuen's Online Knowledge Sharing Model using "Blackboard" data survey? (second case study)

- We validated the model from Ma and Yuen (2011) by conducting a survey using original measurement items from OKSM Model. TETRAD found that there is no indication of causal relationships between the variables in OKSM Model.
- Compared to the results from our first case study, we found the same structural models, which are: all the variables in the model are connected; they are somehow connected by undirected edges, meaning that there is no causal effect link connecting one variable to other, and vice versa.

Q2.4 What are the lessons learned from TETRAD findings in both case studies?

- The results found implies that TETRAD helps detect impure measurement models, on the measurement level, PURIFY from TETRAD helps detect the uncorrelated measurement items, i.e: impure measured items between the cluster of POAM1-5 and POAM; cluster of PORC1-5; and the cluster of OKSB1-5 and OKSB.
- If the relationship is impure, then there is a possibility that the measured items in one cluster were not independent of every other measured item within the clusters. For example POAM1 is not independent of every othermember's measured item in its own cluster (measured items connected to PAM). Also, there is a possibility that POAM1 is not

independent of other member'smeasured items in other clusters (i.e measured items from OKSB and PORC) or that POAM1 is not independent of other member's unobserved variables (the latent variable or OKSB and PORC) within the model. The parameter or measured items are impure and cannot be considered as a causal and effect relationship.

- TETRAD already indicates an important remark in regard to the OKSM model from Ma and Yuen (2011). With these results, we can better understand the causal relationship given the real data.

6.2 Discussions

The results from two case studies show that interesting facts. Our results from two case studies using TETRAD are consistent in the context of the causal effect relationship. From both case studies, TETRAD found no evidence of causal effect between the variable from the final graph resulted from MIMBuild. It is discussed that TETRAD is regarded as a powerful tool for uncover hidden relationship between variables in the model using real data and TETRAD is a useful algorithm to be used in exploratory level, that is when the model is still not mature and prior knowledge is void (Im and Wang 2007). It is suggested that researcher explore first what are the possibilities regarded to the relationship among variables, so that it will help researcher to define their model and allows their theory fit better with the data. However, instead of using TETRAD in exploratory level, TETRAD also can be used in the confirmatory level; it can be seen in the work of Liu (2009) on Technology Acceptance Model (TAM). Liu (2009) argued that TAM's validity (which is already been regarded pass the confirmatory level) is challenged and vanquish the foundation of other related studies.

When used to search for causal relationships, it is advisable that TETRAD is regarded as the tool to guide researcher in finding causal effect relationship in the model based on their non-manipulative data. And by applying TETRAD, it is advisable, to have in mind, what are the other potential relationship that can be

change from its initial measurement model, by collecting valuables information which specifically related with the corresponding theory.

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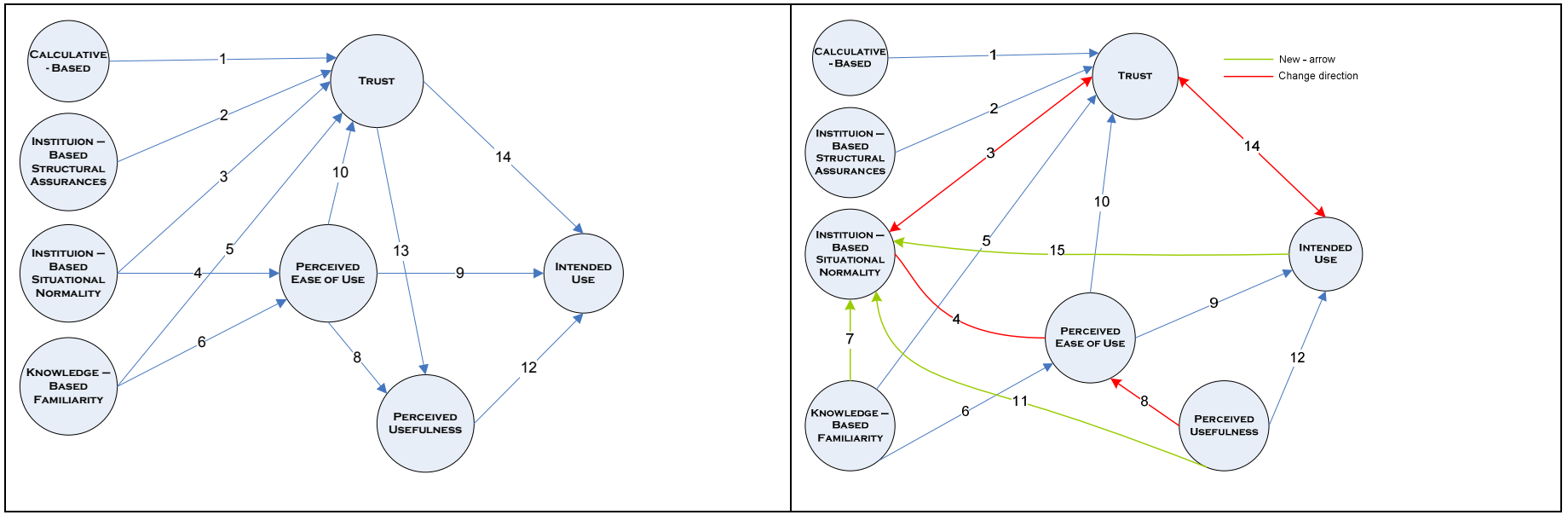
Appendices

Appendix A1. Top 25 Journal in Information Systems field

The listed journal being reviewed and used in this research is obtained from (Peffers and Ya 2003). The list helps us in providing information about evaluations concerning the quality of Management of IS journals.

No	Journal
1	Communications of the ACM
2	MIS Quarterly
3	Information Systems Research
4	Harvard Business Review
5	Decision Sciences
6	Journal of Management Information Systems
7	Management Science
8	European Journal of Information Systems
9	Information and Management
10	Communications of the AIS
11	Decision Support Systems
12	Academy of Management Journal
13	Academy of Management Review
14	Database
15	Administrative Science Quarterly
16	ACM Computing Surveys
17	Sloan Management Review
18	ACM Transactions on Database Systems
19	Computer (IEEE Computer Society)
20	Journal of the Association for Information Systems
21	California Management Review
22	Organization Science
23	Information Systems Journal
24	IEEE Transactions on Software Engineering
25	IEEE Transactions on Knowledge and Data Engineering

Appendix A2. Im and Wang (2007) on Technology Acceptance Model using TETRAD



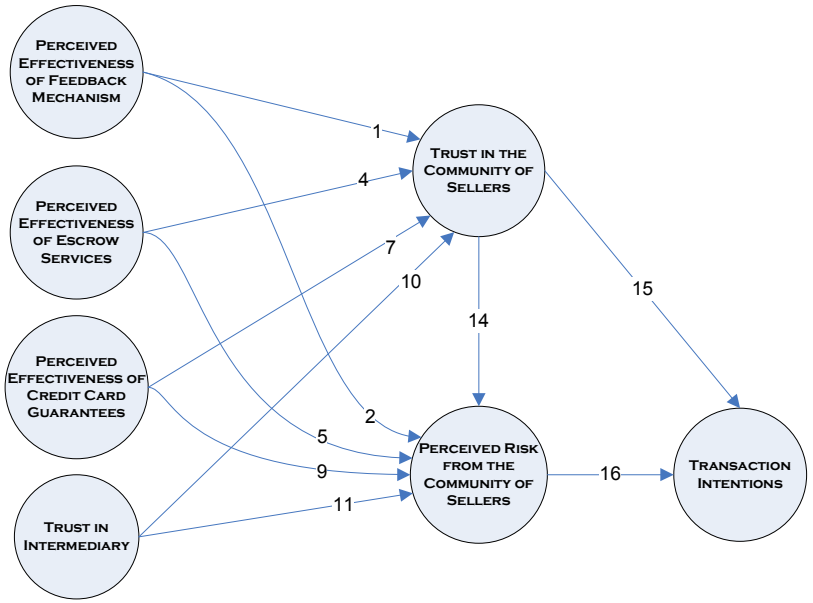
1.a. Original Structural Mode on Trust and TAM, Source: Gefen, Karahanna and Straub's (2003)

1.b. TETRAD Structural Model on Trust and TAM, Source: Im and Wang's (2007)[41]

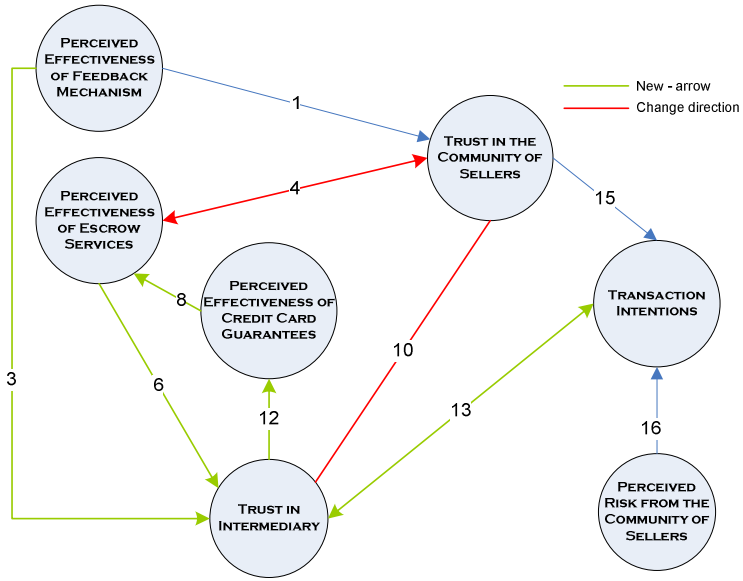
Framework Comparison Structural Model on Trust and TAM from Gefen et al. (2003) and Im and Wang (2007)

[41] Obviously presented in Figure 10.b, the green arrows present the new arrows discovered by TETRAD (path 7, 11, 15) and the red arrows present the change direction arrows (path 3, 4, 8, 14). The rest of those are shown the same structural paths compared to the original (path 1, 2, 5, 6, 9, 10, 12) and the one that eliminated by TETRAD (path 13 from Figure 10.a).

Appendix A3. Im and Wang (2007) on Trust and IT-Enabled Mechanism using TETRAD



2.a. Original Structural Model on Trust and IT-Enabled Mechanism,
Source: Pavlou and Gefen (2004)



2.b. TETRAD Structural Model on Trust and IT-Enabled Mechanism,
Source: Im and Wang's (2007)[42]

Framework Comparison Structural Model on Trust and IT-Enabled Mechanism from Pavlou & Gefen (2004) and Im and Wang (2007)

[42] The differences are distinctively shown in Figure 11.b. Same as previous comparison, the green arrows present the new arrows discovered by TETRAD (path 3, 6, 8, 12, 13) and the red arrows presents the change direction arrows (path 4, 10). The rest of the direction shown the same structural paths compared to the original (path 1, 15, 16) and the one that eliminated by TETRAD (path 2, 5, 7, 9, 11 from Figure 11.a).

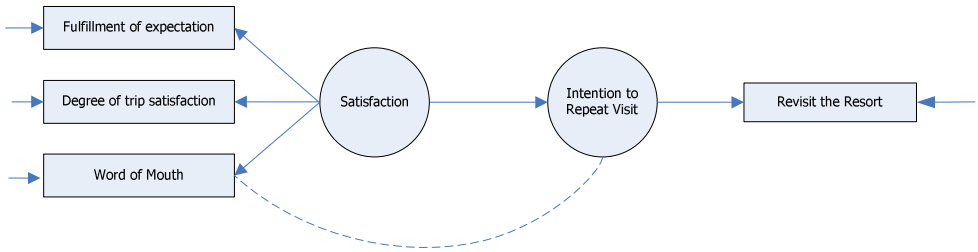
Appendix A4. Countries Studied by Bessler and Loper (2001)

Countries Studied (Source: Bessler and Loper 2001, p.463)

#	Continent					
	Africa	America		Asia	Europe	Australia
		North America	South America			
1	Bostwana	Canada*	Argentina	India	Austria*	Australia*
2	Burkina Faso	Costa Rica	Bolivia	Indonesia	Belgium*	New Zealand*
3	Cameroon	Dominican Republic	Brazil	Israel	Denmark*	
4	Congo	El Savador	Chile	Japan	Finland*	
5	Egypt	Guatemala	Columbia	South Korea	France*	
6	Gabon	Haiti	Ecuador	Malaysia	West Germany*	
7	Gambia	Honduras	Guyana	Pakistan	Greece*	
8	Ghana	Jamaica	Paraguay	Philippines	Ireland*	
9	Ivory Coast	Mexico	Peru	Singapore	Italy*	
10	Kenya	Nicaragua	Uruguay	Sri Lanka	Netherlands*	
11	Madagascar	Trinidad	Venezuela	Syria	Norway*	
12	Malawi	USA*		Thailand	Portugal*	
13	Mali				Spain*	
14	Morocco				Sweden*	
15	Niger				Switzerland*	
16	Nigeria				Turkey	
17	Senegal				UK*[43]	
18	Sierra Leone					
19	Somalia					
20	South Africa					
21	Tanzania					
22	Tunisia					
23	Zaire					
24	Zambia					
25	Zimbabwe					

[43] 20 countries that ended with (*) are removed in the 2nd data subset from Bessler and Loper's (2001) study. The idea is that those developed countries may have different pattern for the causal effect on growth for GDP from the other less developed countries. No further details from Bessler and Loper on how they decided to choose the 20 countries over the 79 countries.

Appendix A5. Findings derived from *Search* Algorithm in TETRAD (Mazanec, 2007)



TETRAD Findings using Search Algorithm (Mazanec, 2007)

Note:

As a measured variable from Satisfaction, Word of Mouth is having impure relationships with its latent variable, which is Satisfaction. This relationship is fall to the category in impure measured from (Spirtes, 2000) called latent-measured impure.

Appendix A6. Type of Impure (Spirtes, 2000) p.309

According to Spirtes et al. (Spirtes, 2000) there are four types of what is called an impure measure:

(i) If there is a directed edge from some *Ti* in **T** to some *V* in ***V(Ti)*** but also a trek between *V* and *Tj* that does not contain *Ti* or any member of ***V*** except V – then V is a **latent-measured impure**.

(ii) If there is a trek between a pair of measured variables V_1, V_2 from the same cluster *V(Ti)* that does not contain any member of **T** then V_1 and V_2 are **intra-construct impure**.

(iii) If there is a trek between a pair of measured variables in V_1, V_2 from distinct clusters ***V(Ti)*** and ***V(Tj)*** that does not contain any member of *T* then we say V_1 and V_2 are **cross-construct impure**.

(iv) If there is a variable in *C* that is the source of trek between *Ti* and some member of *V* if ***V(Ti)*** we say *V* is **common cause impure**.

Define:

T: a set of latent variables

V: a set of measured variables

C: Set if latent common cause, unobserved common cause, not in T, of two or more variable in T ∪ V

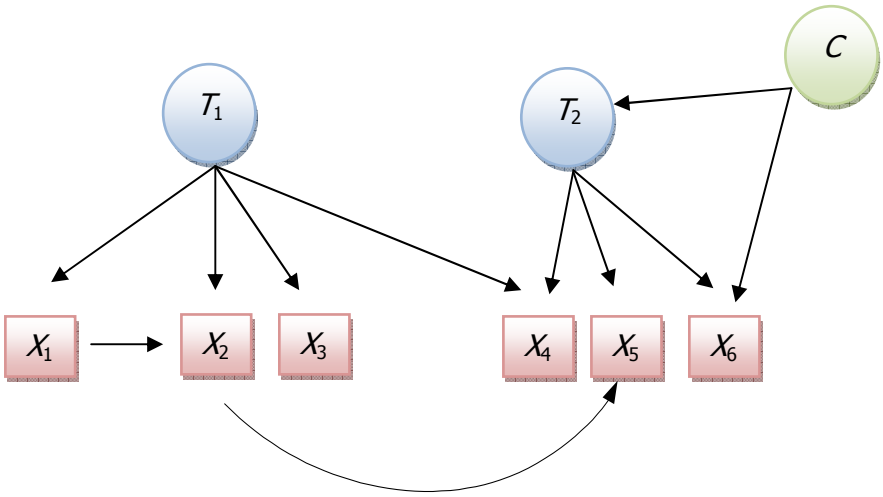


Figure A. Impure Measure (Spirtes, 2000) p.309

For example, in Figure A, if $\boldsymbol{V}(T_1)$ = (X_1, X_2, X_3) and then $\boldsymbol{V}(T_1)$ = (X_4, X_5, X_6), then X_4 is a latent-measured impure, X_1 and X_2 are intra-contsruct impure, X_2 and X_5 are cross-construct impure, and X_6 is a common cause impure. Only X_3 is a pure measurement of T_1.

Appendix B1. Paper Form

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Master Thesis – Questionnaire

CAUSAL MINING with TETRAD: Understanding Online Knowledge Sharing(*)

INTRODUCTION || Blackboard is the new electronic learning environment at the University of Twente since the academic year 2010/2011. By that time, Blackboard replaces TeleTOP and has the major advantage of being more compatible with the university teaching systems, facilitates better interfaces and provides new learning environment.

This research aims to see whether Blackboard plays an important role as one of the tools of online knowledge sharing. To search how far Blackboard engage and motivate as well as provide the need for its users, especially in University of Twente environment. There are 15 questions available below need to be filled in.

To fill in this questionnaire, you must:

1. Still study/ work in University of Twente or ITC
2. Have used Blackboard from last year or still using Blackboard in everyday study/ work
3. Have [at]utwente.nl or [at]itc.nl email domain

NOTE || (...) The blank in the question below indicates the course name that you've taken and available in your own Blackboard -- which specialized and related to your study. Since everybody has their own course and level of study, this research only differentiates: which level of study and which faculty are you from.

For example:

You have a course named Data Mining then you can read the sentence as
"[1.1] If I feel unhappy or kind of depressed in learning (Data Mining), I usually try to be around other members using the Blackboard to make me feel better."

(*) *All construct listed below is derived from Ma and Yuen (2011) with the replacement of Interactive Learning Network or "ILN" with "Blackboard".*

Please write down your university email:

.....

* is required to be answered

You are: *

- ☐ Male
- ☐ Female

What faculty are you from? *

- ☐ Faculteit Gedragswetenschappen (GW)
- ☐ Faculteit Management en Bestuur (MB)
- ☐ Faculteit Construerende Technische Wetenschappen (CTW)
- ☐ Faculteit Elektrotechniek, Wiskunde en Informatica (EWI)
- ☐ Faculteit Technische Natuurweten-schappen/ Faculty of Science and Technology (TNW)
- ☐ International Institute for Geo-Information Science and Earth Observation (ITC)

What is the level of your study? *

- ☐ Bachelor
- ☐ Master
- ☐ Doctoral
- ☐ Post-doctoral

[1.1] If I feel unhappy or kind of depressed in learning (...), I usually try to be around other members using the Blackboard to make me feel better. *

	1	2	3	4	5	6	7	
strongly disagree	☐	☐	☐	☐	☐	☐	☐	strongly agree

[1.2] I usually have the greatest need to have other members using the Blackboard around me when I feel upset in learning (...). *

	1	2	3	4	5	6	7	
strongly disagree	☐	☐	☐	☐	☐	☐	☐	strongly agree

[1.3] I often have a strong need to be around other Blackboard users who are impressed with what I am like and what I do in (...) *

	1	2	3	4	5	6	7	
strongly disagree	☐	☐	☐	☐	☐	☐	☐	strongly agree

[1.4] I mainly like to be around other Blackboard users who think I am an important, exciting person in learning (...) together. *

	1	2	3	4	5	6	7	
strongly disagree	☐	☐	☐	☐	☐	☐	☐	strongly agree

[1.5] I often have a strong desire to get other Blackboard users around to notice me and appreciate what I am like in learning (...) together. *

	1	2	3	4	5	6	7	
strongly disagree	☐	☐	☐	☐	☐	☐	☐	strongly agree

[2.1] I am committed to maintaining my relationship with other members using the Blackboard to learn (...). *

	1	2	3	4	5	6	7	
strongly disagree	☐	☐	☐	☐	☐	☐	☐	strongly agree

[2.2] I want my relationships with other members using the Blackboard to learn (...) to last for a very long time. *

	1	2	3	4	5	6	7	
strongly disagree	☐	☐	☐	☐	☐	☐	☐	strongly agree

[2.3] I feel very strongly linked to my relationship with other members using the Blackboard to learn (...). *

	1	2	3	4	5	6	7	
strongly disagree	☐	☐	☐	☐	☐	☐	☐	strongly agree

[2.4] I would feel very upset if my relationship with other members using the Blackboard to learn (...) were to end. *

	1	2	3	4	5	6	7	
strongly disagree	☐	☐	☐	☐	☐	☐	☐	strongly agree

[2.5] I seek the long-term future of my relationship with other members using the Blackboard to learn (...). *

	1	2	3	4	5	6	7	
strongly disagree	☐	☐	☐	☐	☐	☐	☐	strongly agree

[3.1] The advice I receive from other members using the Blackboard has increased my understanding of (...). *

	1	2	3	4	5	6	7	
strongly disagree	☐	☐	☐	☐	☐	☐	☐	strongly agree

[3.2] The advice I receive from other members using the Blackboard has increased my knowledge of (...). *

	1	2	3	4	5	6	7	
strongly disagree	☐	☐	☐	☐	☐	☐	☐	strongly agree

[3.3] The advice I receive from other members using the Blackboard allows me to complete similar tasks in (...) more efficiently. *

	1	2	3	4	5	6	7	
strongly disagree	☐	☐	☐	☐	☐	☐	☐	strongly agree

[3.4] The advice I receive from other members using the Blackboard allows me to improve the quality of similar work in (...). *

	1	2	3	4	5	6	7	
strongly disagree	☐	☐	☐	☐	☐	☐	☐	strongly agree

[3.5] The advice I receive from other members using the Blackboard allows me to conduct similar (...) tasks with greater independence. *

	1	2	3	4	5	6	7	
strongly disagree	☐	☐	☐	☐	☐	☐	☐	strongly agree

Appendix B2. Correlation Matrix Inter-Item Level (Ma and Yuen 2011)

Pearson Correlation Matrix from Ma and Yuen (2011)

	POAM1	POAM2	POAM3	POAM4	POAM5	PORC1	PORC2	PORC3	PORC4	PORC5	OKSB1	OKSB2	OKSB3	OKSB4	OKSB5
POAM1	**1.0**														
POAM2	**0.60**	**1.0**													
POAM3	**0.56**	**0.58**	**1.0**												
POAM4	**0.57**	**0.60**	**0.72**	**1.0**											
POAM5	**0.52**	**0.53**	**0.59**	**0.66**	**1.0**										
PORC1	0.46	0.49	0.49	0.51	0.52	**1.0**									
PORC2	0.43	0.43	0.49	0.49	0.45	**0.63**	**1.0**								
PORC3	0.49	0.49	0.52	0.52	0.51	**0.56**	**0.55**	**1.0**							
PORC4	0.60	0.54	0.62	0.55	0.51	**0.49**	**0.49**	**0.45**	**1.0**						
PORC5	0.31	0.33	0.37	0.36	0.36	**0.47**	**0.52**	**0.4**	**0.34**	**1.0**					
OKSB1	0.47	0.53	0.55	0.56	0.52	0.49	0.48	0.51	0.49	0.33	**1.0**				
OKSB2	0.52	0.50	0.61	0.62	0.60	0.50	0.52	0.53	0.56	0.39	**0.67**	**1.0**			
OKSB3	0.52	0.51	0.61	0.63	0.60	0.50	0.49	0.53	0.53	0.35	**0.65**	**0.8**	**1.0**		
OKSB4	0.48	0.52	0.59	0.63	0.57	0.49	0.51	0.50	0.54	0.34	**0.69**	**0.84**	**0.77**	**1.0**	
OKSB5	0.54	0.58	0.60	0.62	0.58	0.50	0.50	0.52	0.52	0.36	**0.58**	**0.66**	**0.67**	**0.66**	**1.0**

Appendix B3. 80 Respondent Data, Blackboard Case Study, Hafidz 2011

Respondent Data (Anonym) Blackboard Case Study[44]

#	POAM1	POAM2	POAM3	POAM4	POAM5	PORC1	PORC2	PORC3	PORC4	PORC5	OKSB1	OKSB2	OKSB3	OKSB4	OKSB5
1	2	1	1	1	1	4	4	4	1	4	4	4	4	4	4
2	1	1	1	1	1	1	2	2	1	1	2	2	1	1	1
3	1	1	4	4	5	6	6	4	5	5	5	4	4	4	4
4	3	4	1	4	5	1	5	5	1	1	5	4	5	6	6
5	2	2	3	3	3	6	4	4	4	4	3	6	5	5	5
6	1	2	2	1	5	1	3	1	1	1	4	3	2	2	2
7	5	6	3	2	3	6	6	6	3	6	6	6	5	5	6
8	6	6	4	6	6	5	4	5	5	5	3	5	4	5	4
9	4	5	4	3	4	5	3	2	2	2	6	6	6	6	6
10	4	6	2	2	2	4	4	3	3	3	5	5	5	4	3
11	3	3	3	3	3	4	4	4	1	4	4	3	3	3	3
12	2	2	2	2	2	2	2	2	2	2	5	5	4	4	4
13	3	2	2	1	1	1	1	1	1	1	1	2	1	4	6
14	4	3	3	3	3	3	4	4	3	3	3	4	3	4	3
15	5	5	5	5	5	5	5	5	5	6	4	4	4	4	4
16	2	3	4	4	4	3	3	3	3	3	3	3	3	3	4
17	3	3	5	6	4	5	4	2	4	5	5	6	6	5	5
18	2	1	2	2	2	3	3	2	2	1	3	3	3	3	4
19	6	5	4	6	5	5	3	4	2	5	5	5	5	5	5

[44] The data have been sorted randomly and anonymously represent online or paper respondent.

20	4	4	5	2	4	3	6	6	1	5	7	7	7	7	7
21	4	5	5	5	5	5	5	5	5	5	5	5	7	5	5
22	3	1	3	3	3	3	4	3	4	4	3	3	3	3	3
23	1	1	1	1	1	3	2	2	1	4	2	3	3	3	4
24	1	1	1	2	2	3	5	3	3	3	3	3	6	6	5
25	1	1	2	2	2	2	2	3	1	1	2	2	2	1	3
26	2	2	2	3	1	3	3	1	2	3	3	3	3	3	3
27	1	2	1	1	1	1	6	1	1	6	7	4	7	7	7
28	3	3	3	3	3	3	4	3	4	4	2	2	3	3	3
29	2	2	2	3	1	2	3	1	1	3	2	2	1	1	2
30	1	1	1	1	3	4	4	4	4	4	5	5	6	6	6
31	1	1	1	1	1	6	5	2	2	2	2	2	2	2	2
32	3	3	2	2	2	2	4	3	2	2	2	2	2	2	2
33	1	1	3	7	7	7	7	7	1	7	6	7	7	7	7
34	1	1	1	1	2	1	7	2	5	4	4	4	4	4	3
35	4	7	4	2	4	6	7	3	4	7	7	6	3	4	5
36	2	2	2	2	2	7	7	7	7	7	7	7	7	7	7
37	1	1	1	3	1	7	7	3	1	6	7	7	7	6	7
38	5	4	5	5	6	4	5	4	4	5	4	5	5	5	6
39	2	3	2	4	4	5	5	4	4	5	5	6	5	4	4
40	3	5	3	1	1	1	1	1	2	1	4	4	3	3	3
41	2	2	3	5	5	3	4	5	5	4	5	6	6	6	7
42	4	4	4	4	4	4	4	4	3	4	4	5	4	4	4
43	1	1	2	3	3	4	4	4	4	3	3	3	3	4	4
44	1	1	1	1	1	1	3	2	2	2	2	2	2	2	2
45	4	5	6	3	4	6	5	5	6	5	4	6	6	6	5
46	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
47	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

48	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
49	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
50	2	2	2	2	2	2	4	2	2	3	1	1	2	1	1
51	3	3	5	5	4	3	6	2	2	3	5	4	6	5	6
52	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
53	1	1	1	3	3	3	1	1	2	1	1	1	4	4	3
54	2	2	2	2	2	3	2	6	6	6	3	3	6	6	6
55	1	1	1	1	1	1	1	1	1	1	7	7	7	7	7
56	5	1	5	5	2	5	6	4	5	5	7	7	7	7	7
57	4	6	6	4	5	7	7	7	7	7	7	7	7	7	7
58	1	1	1	1	1	1	1	4	1	2	4	3	2	1	2
59	3	3	3	4	2	2	4	2	3	3	1	1	1	1	1
60	2	3	2	2	2	2	1	1	1	3	3	2	2	4	4
61	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1
62	1	1	1	1	1	3	4	3	4	2	4	4	5	5	6
63	5	4	5	5	6	4	5	5	6	6	6	6	6	5	6
64	1	1	1	2	1	3	5	4	3	5	6	6	6	6	3
65	1	1	1	1	1	2	1	1	1	1	3	3	4	4	1
66	1	1	1	2	2	1	1	1	1	1	3	3	3	3	3
67	2	3	4	2	2	1	3	5	2	3	5	4	5	5	4
68	2	2	2	5	2	2	2	2	2	2	2	2	2	3	2
69	1	1	1	2	1	5	4	2	1	1	1	1	1	1	1
70	1	1	1	1	1	2	3	2	2	4	2	4	3	3	3
71	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
72	2	2	4	4	3	2	4	3	4	4	6	6	5	4	5
73	1	1	1	1	2	3	3	1	1	1	5	5	6	5	6
74	3	2	3	3	4	5	6	5	3	4	6	6	6	6	6
75	3	4	4	4	5	2	2	2	4	4	6	5	6	6	6

76	4	5	4	6	4	6	6	5	6	5	6	6	6	3	6
77	5	3	2	5	2	1	3	1	4	1	3	3	1	1	2
78	1	1	2	2	2	2	3	2	2	3	4	4	3	3	4
79	2	1	1	1	1	3	1	1	1	1	6	6	7	5	7
80	2	2	5	5	3	1	1	2	1	2	3	3	2	6	2

Appendix C1. Correlation Matrix Inter-Item Level from Combined Dataset (n=80)[45], Blackboard Case Study, Hafidz 2011

Correlation Matrix at item level for Blackboard Survey – 80 Respondent Data (all data combined)

	POAM1	POAM2	POAM3	POAM4	POAM5	PORC1	PORC2	PORC3	PORC4	PORC5	OKSB1	OKSB2	OKSB3	OKSB4	OKSB5
POAM1	**1**														
POAM2	**0,8251**	**1**													
POAM3	**0,7282**	**0,6806**	**1**												
POAM4	**0,6011**	**0,4758**	**0,7109**	**1**											
POAM5	**0,5713**	**0,5817**	**0,7276**	**0,7603**	**1**										
PORC1	0,3923	0,3938	0,4652	0,4665	0,4981	**1**									
PORC2	0,3453	0,3533	0,4225	0,4060	0,4855	**0,7039**	**1**								
PORC3	0,4410	0,4258	0,5154	0,4634	0,6024	**0,6547**	**0,6619**	**1**							
PORC4	0,4732	0,4316	0,5570	0,4697	0,4994	**0,5443**	**0,5520**	**0,6110**	**1**						
PORC5	0,4340	0,4531	0,5528	0,4841	0,5359	**0,7129**	**0,7667**	**0,7386**	**0,6461**	**1**					
OKSB1	0,3310	0,3847	0,4251	0,3085	0,4322	0,4918	0,6027	0,5187	0,3741	0,6106	**1**				
OKSB2	0,4052	0,4038	0,4883	0,3940	0,4927	0,6157	0,5997	0,6016	0,4769	0,6535	**0,9142**	**1**			
OKSB3	0,2655	0,2740	0,3875	0,3400	0,4440	0,5468	0,5662	0,5708	0,4553	0,6106	**0,8517**	**0,8647**	**1**		
OKSB4	0,2786	0,2766	0,4109	0,3348	0,4524	0,4734	0,4998	0,5536	0,3964	0,5859	**0,7843**	**0,8050**	**0,8994**	**1**	
OKSB5	0,3199	0,2943	0,3974	0,3296	0,4568	0,5139	0,5246	0,5374	0,4046	0,5779	**0,8081**	**0,8202**	**0,8751**	**0,8663**	**1**

[45] This correlation matrix is produced using TETRAD 4, version tetrad-4.3.10-4.jnlp. The newest version from TETRAD is updated by its developer at http://www.phil.cmu.edu/projects/tetrad_download/launchers/.

Appendix C2. Correlation Matrix Inter-Item Level from Online Dataset (n=51)[46], Blackboard Case Study, Hafidz 2011

Correlation Matrix at item level for Blackboard Survey – 51 Respondent Data (Online Dataset)

	POAM1	POAM2	POAM3	POAM4	POAM5	PORC1	PORC2	PORC3	PORC4	PORC5	OKSB1	OKSB2	OKSB3	OKSB4	OKSB5
POAM1	1														
POAM2	0,877135	1													
POAM3	0,719108	0,656997	1												
POAM4	0,507931	0,379711	0,677748	1											
POAM5	0,523504	0,482767	0,709409	0,810823	1										
PORC1	0,336109	0,329447	0,466741	0,515061	0,464079	1									
PORC2	0,177035	0,230159	0,29946	0,361527	0,440508	0,62653	1								
PORC3	0,417606	0,345704	0,433179	0,527931	0,638885	0,661729	0,616543	1							
PORC4	0,329445	0,31832	0,478353	0,372057	0,436213	0,51525	0,459233	0,510131	1						
PORC5	0,354116	0,349844	0,457084	0,494445	0,472046	0,750562	0,7846	0,659519	0,536095	1					
OKSB1	0,291603	0,424675	0,366659	0,34001	0,452637	0,556412	0,717812	0,531104	0,284579	0,686751	1				
OKSB2	0,410219	0,465723	0,495427	0,48597	0,549928	0,712516	0,645933	0,672541	0,450631	0,724504	0,87578	1			
OKSB3	0,271865	0,305812	0,408153	0,482304	0,492683	0,589458	0,696644	0,620633	0,404663	0,683019	0,837283	0,855765	1		
OKSB4	0,327999	0,32686	0,38243	0,441185	0,506337	0,550065	0,666228	0,642796	0,398038	0,658254	0,809543	0,848377	0,930769	1	
OKSB5	0,288376	0,278707	0,379444	0,428917	0,466786	0,523022	0,602312	0,582017	0,283946	0,620267	0,784887	0,804658	0,855523	0,933035	1

[46] This correlation matrix used 51 respondent data from online dataset gathered from Google Spreadsheet and calculated using Add-Ins from Microsoft Excel 2007: *Analysis Toolpak*, which provides data analysis tools for statistic and engineering. From our observation, the correlation matrix resulted from TETRAD 4 and Microsoft Excel (2007) is indifference.

Appendix C3. Correlation Matrix Inter-Item Level from Paper Dataset (n=29)[47], Blackboard Case Study, Hafidz 2011

Correlation Matrix at item level for Blackboard Survey – 29 Respondent Data (Paper Dataset)

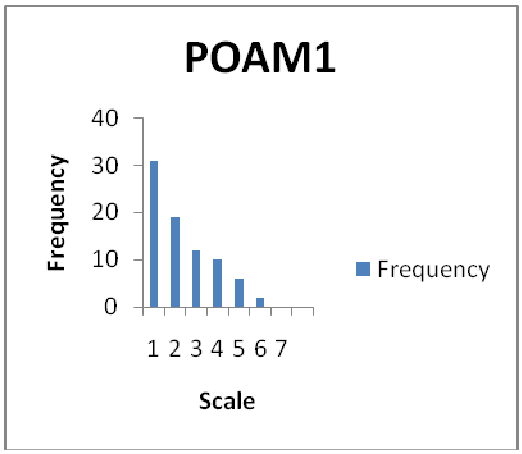
	POAM1	POAM2	POAM3	POAM4	POAM5	PORC1	PORC2	PORC3	PORC4	PORC5	OKSB1	OKSB2	OKSB3	OKSB4	OKSB5
POAM1	1														
POAM2	0,6967748	1													
POAM3	0,7449525	0,7488452	1												
POAM4	0,7871626	0,6541763	0,7680606	1											
POAM5	0,6525462	0,7837193	0,7814501	0,6961036	1										
PORC1	0,4679459	0,4631803	0,4521775	0,3888659	0,500131339	1									
PORC2	0,5914596	0,5028758	0,5870159	0,5063333	0,494111167	0,8070447	1								
PORC3	0,4589033	0,5568196	0,6225169	0,3622595	0,514378261	0,6270176	0,713427794	1							
PORC4	0,7288477	0,6941166	0,6701596	0,6217793	0,661280766	0,6460785	0,738825987	0,7660345	1						
PORC5	0,5514619	0,6257051	0,6922449	0,4755875	0,621533802	0,6082953	0,718363943	0,8504252	0,8407705	1					
OKSB1	0,4189906	0,3678826	0,5156795	0,265769	0,455287043	0,4464839	0,529795412	0,5249198	0,4908857	0,5405988	1				
OKSB2	0,4038764	0,3112417	0,4783382	0,2531379	0,419616764	0,4878401	0,582530178	0,5083628	0,5120205	0,5654567	0,9680546	1			
OKSB3	0,2730261	0,255483	0,3680005	0,1255746	0,411161302	0,5392392	0,461504921	0,5232137	0,5225561	0,5412921	0,8703995	0,8790241	1		
OKSB4	0,2079215	0,2124937	0,4581316	0,1702726	0,400094628	0,3868453	0,323965331	0,4431809	0,3945082	0,5068707	0,7508513	0,7471269	0,8568762	1	
OKSB5	0,3734274	0,3371533	0,4190098	0,1840624	0,466121364	0,5297706	0,451760907	0,4799015	0,558599	0,5298527	0,8417242	0,8404243	0,9042416	0,78175	1

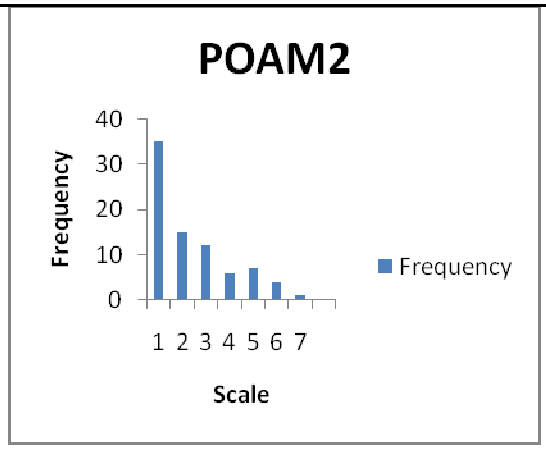
[47] This correlation matrix used 29 respondent data from paper dataset. The correlation matrix is also calculated using Add-Ins from Microsoft Excel 2007: *Analysis Toolpak*.

Appendix D1. Histogram for Inter- Item Level for Combined Dataset (n=80), Blackboard Case Study, Hafidz - 2011

There are three table presented in Appendix E4: the Histogram for POAM, PORC and OKSB Item Level is presented at Table B, Table C and Table D respectively.

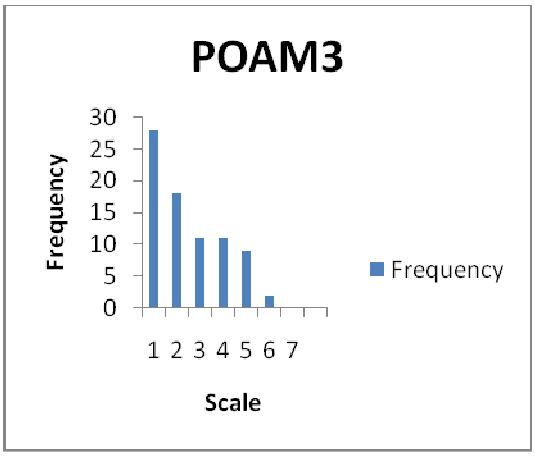
Table B. Histogram for POAM Item Level for Combined Dataset (n=80)

Histogram	**Frequency-Scale table**
POAM1: If I feel unhappy or kind of depressed in learning (course), I usually try to be around other members using the "Blackboard" to make me feel better. 	*Scale* / *Frequency* 1 — 31 2 — 19 3 — 12 4 — 10 5 — 6 6 — 2 7 — 0
POAM 2: I usually have the greatest need to have other members using the "Blackboard" around me when I feel upset in learning (course).	*Scale* / *Frequency* 1 — 35 2 — 15 3 — 12 4 — 6 5 — 7 6 — 4 7 — 1



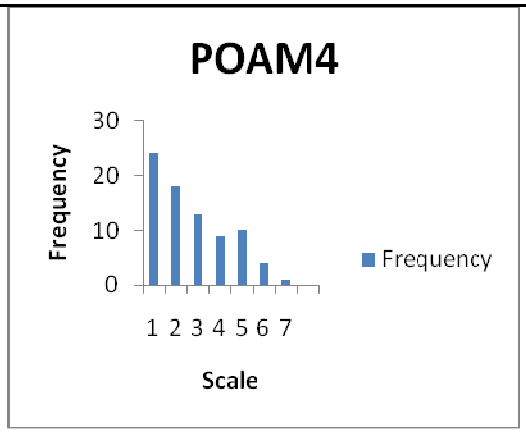
POAM3:
I often have a strong need to be around other "Blackboard" users who are impressed with what I am like and what I do in (course).

Scale	*Frequency*
1	28
2	18
3	11
4	11
5	9
6	2
7	0



POAM4:
I mainly like to be around other "Blackboard" users who think I am an important, exciting person in learning (course) together.

Scale	*Frequency*
1	24
2	18
3	13
4	9
5	10
6	4
7	1



POAM5:
I often have a strong desire to get other "Blackboard" users around to notice me and appreciate what I am like in learning (course) together.

Scale	*Frequency*
1	25
2	19
3	11
4	11
5	9
6	3
7	1

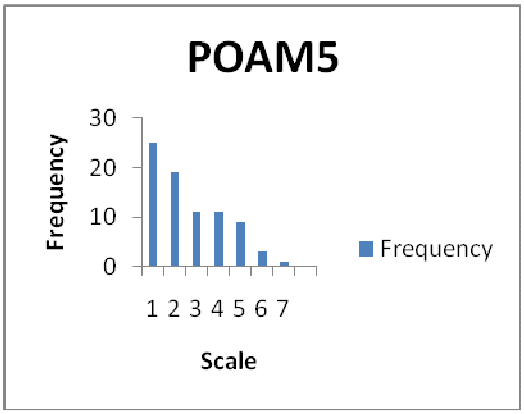
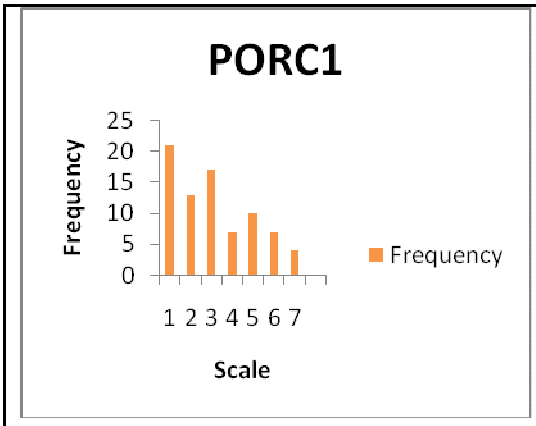


Table C. Histogram for PORC Item Level for Combined Dataset (n=80)

Histogram	**Frequency-Scale table**

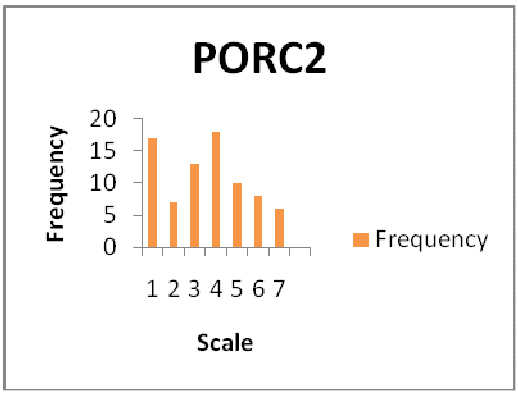
PORC1:
I am committed to maintaining my relationship with other members using the "Blackboard" to learn (course).

Scale	*Frequency*
1	21
2	13
3	17
4	7
5	10
6	7
7	4



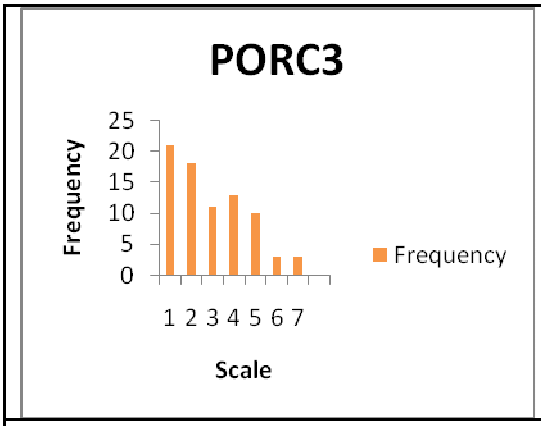
PORC2:
I want my relationships with other members using the "Blackboard" to learn (course) to last for a very long time.

Scale	*Frequency*
1	17
2	7
3	13
4	18
5	10
6	8
7	6



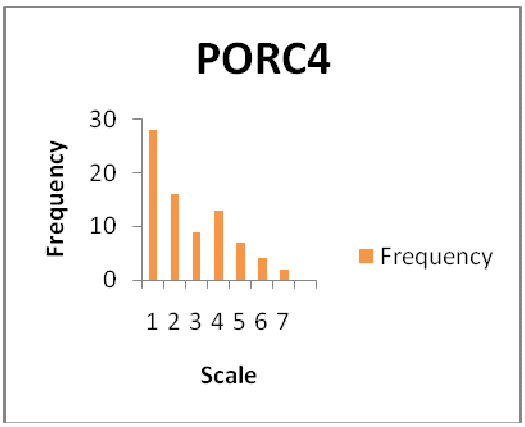
PORC3:
I feel very strongly linked to my relationship with other members using the "Blackboard" to learn (course).

Scale	*Frequency*
1	21
2	18
3	11
4	13
5	10
6	3
7	3



PORC4:
I would feel very upset if my relationship with other members using the "Blackboard" to learn (course) were to end.

Scale	*Frequency*
1	28
2	16
3	9
4	13
5	7
6	4
7	2



PORC5:
I seek the long-term future of my relationship with other members using the "Blackboard" to learn (course).

Scale	*Frequency*
1	22
2	9
3	13
4	13
5	12
6	6
7	4

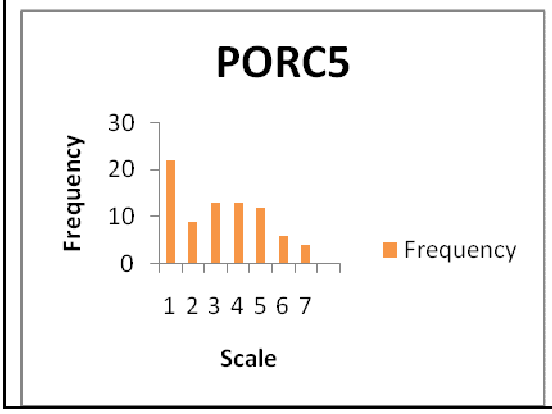
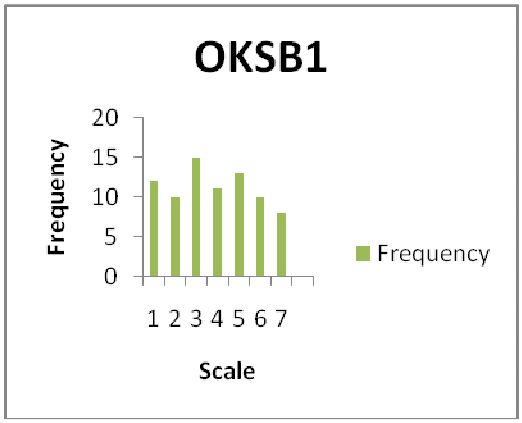


Table D. Histogram for OKSB Item Level for Combined Dataset (n=80)

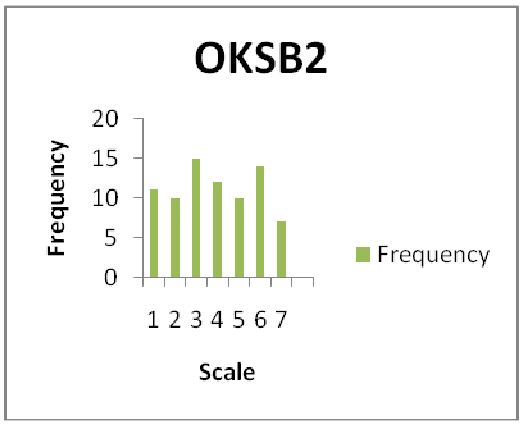
Histogram	Frequency Scale-table

OKSB1:
The advice I receive from other members using the "Blackboard" has increased my understanding of (course).



Scale	*Frequency*
1	12
2	10
3	15
4	11
5	13
6	10
7	8

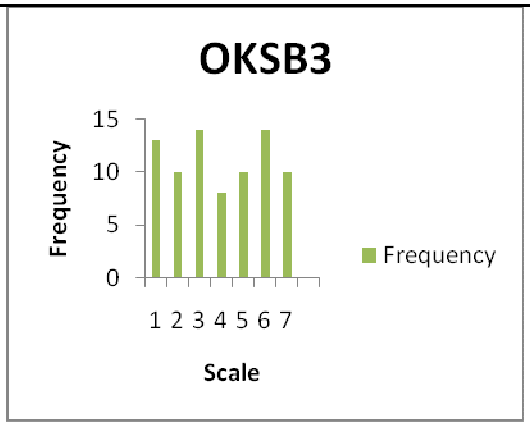
OKSB2:
The advice I receive from other members using the "Blackboard" has increased my knowledge of (course).



Scale	*Frequency*
1	11
2	10
3	15
4	12
5	10
6	14
7	7

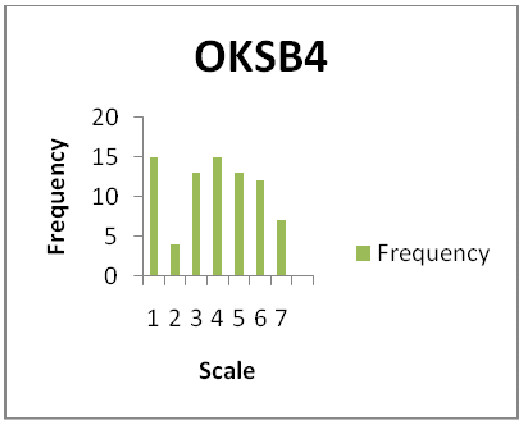
OKSB3:
The advice I receive from other members using the "Blackboard" allows me to complete similar tasks in (course) more efficiently.

Scale	*Frequency*
1	13
2	10
3	14
4	8
5	10
6	14
7	10



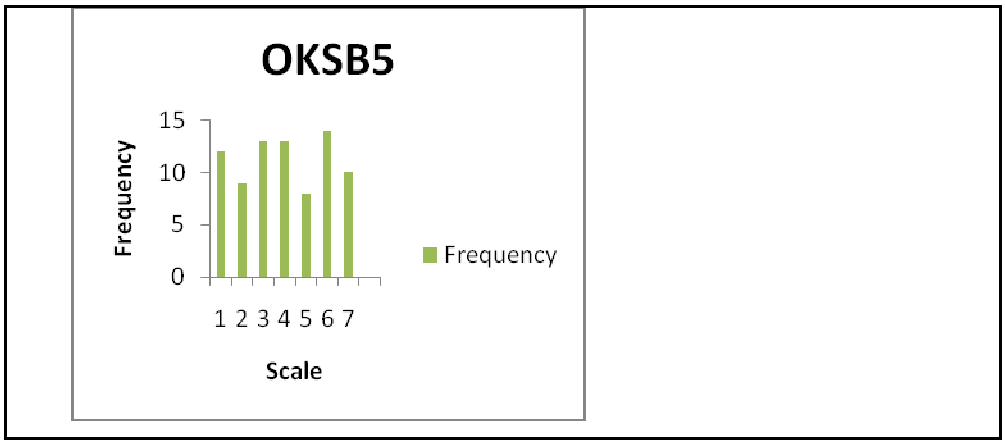
OKSB4:
The advice I receive from other members using the "Blackboard" allows me to improve the quality of similar work in (course).

Scale	*Frequency*
1	15
2	4
3	13
4	15
5	13
6	12
7	7

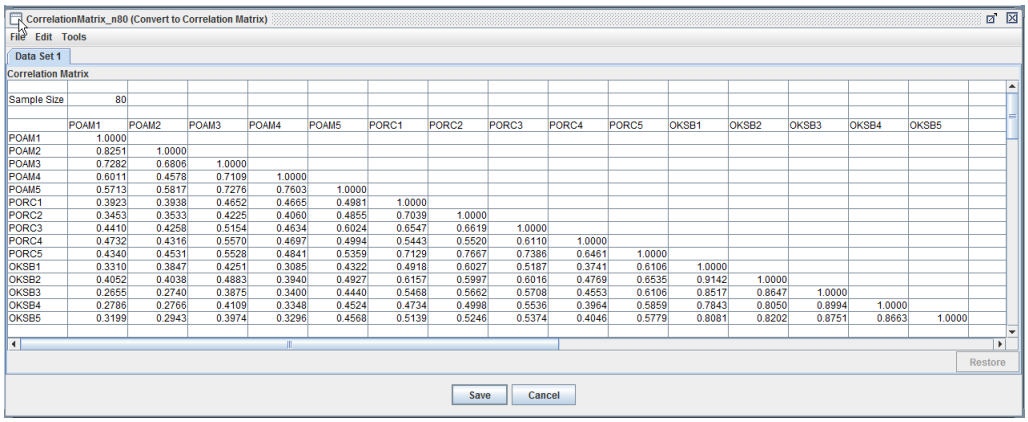


OKSB5
The advice I receive from other members using the "Blackboard" allows me to conduct similar (course) tasks with greater independence.

Scale	*Frequency*
1	12
2	9
3	13
4	13
5	8
6	14
7	10

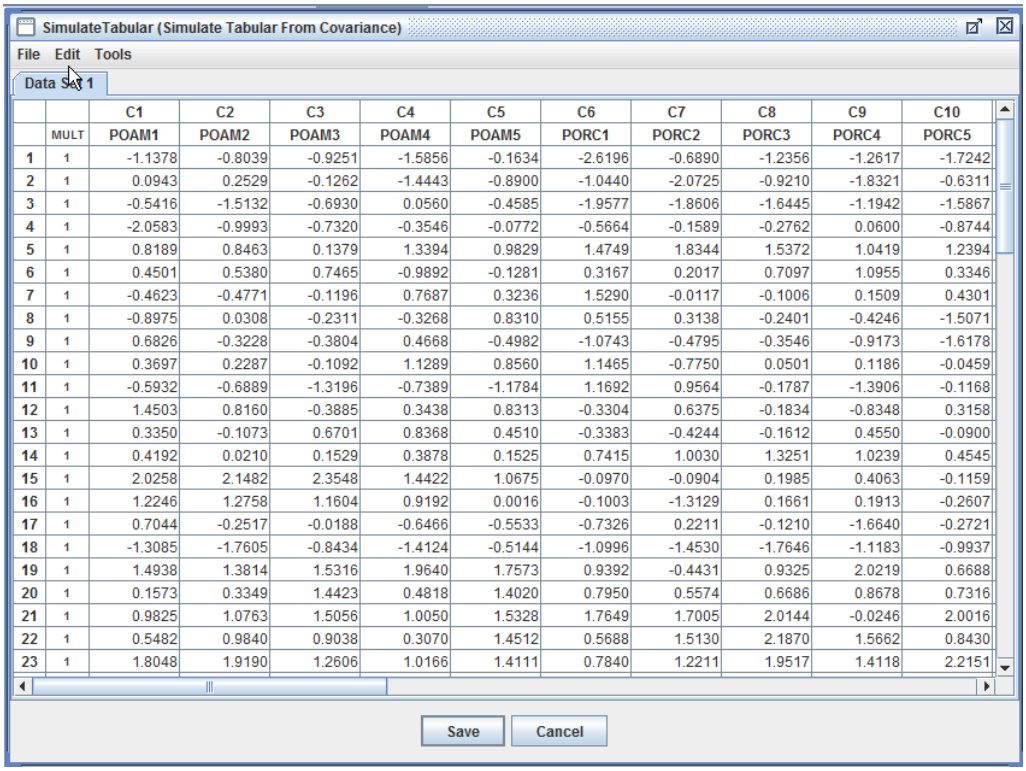

OKSB5
15
10
5
0
Frequency
1 2 3 4 5 6 7
Scale
Frequency

Appendix D2. Correlation Matrix, Simulate Tabular from Correlation Matrix in TETRAD IV, Blackboard Survey, Hafidz - 2011



	POAM1	POAM2	POAM3	POAM4	POAM5	PORC1	PORC2	PORC3	PORC4	PORC5	OKSB1	OKSB2	OKSB3	OKSB4	OKSB5
POAM1	1.0000														
POAM2	0.8251	1.0000													
POAM3	0.7282	0.6806	1.0000												
POAM4	0.6011	0.4578	0.7109	1.0000											
POAM5	0.5713	0.5817	0.7276	0.7603	1.0000										
PORC1	0.3923	0.3938	0.4652	0.4665	0.4981	1.0000									
PORC2	0.3453	0.3533	0.4225	0.4060	0.4855	0.7039	1.0000								
PORC3	0.4410	0.4258	0.5154	0.4634	0.6024	0.6547	0.6619	1.0000							
PORC4	0.4732	0.4316	0.5570	0.4697	0.4994	0.5443	0.5520	0.6110	1.0000						
PORC5	0.4340	0.4531	0.5528	0.4841	0.5359	0.7129	0.7667	0.7386	0.6461	1.0000					
OKSB1	0.3310	0.3847	0.4251	0.3085	0.4322	0.4918	0.6027	0.5187	0.3741	0.6106	1.0000				
OKSB2	0.4052	0.4038	0.4883	0.3940	0.4927	0.6157	0.5997	0.6016	0.4769	0.6535	0.9142	1.0000			
OKSB3	0.2655	0.2740	0.3875	0.3400	0.4440	0.5468	0.5662	0.5708	0.4553	0.6106	0.8517	0.8647	1.0000		
OKSB4	0.2786	0.2766	0.4109	0.3348	0.4524	0.4734	0.4998	0.5536	0.3964	0.5859	0.7843	0.8050	0.8994	1.0000	
OKSB5	0.3199	0.2943	0.3974	0.3296	0.4568	0.5139	0.5246	0.5374	0.4046	0.5779	0.8081	0.8202	0.8751	0.8663	1.0000

Correlation matrix shown in TETRAD (n=80), Blackboard Survey, Hafidz - 2011



		C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
	MULT	POAM1	POAM2	POAM3	POAM4	POAM5	PORC1	PORC2	PORC3	PORC4	PORC5
1	1	-1.1378	-0.8039	-0.9251	-1.5856	-0.1634	-2.6196	-0.6890	-1.2356	-1.2617	-1.7242
2	1	0.0943	0.2529	-0.1262	-1.4443	-0.8900	-1.0440	-2.0725	-0.9210	-1.8321	-0.6311
3	1	-0.5416	-1.5132	-0.6930	0.0560	-0.4585	-1.9577	-1.8606	-1.6445	-1.1942	-1.5867
4	1	-2.0583	-0.9993	-0.7320	-0.3546	-0.0772	-0.5664	-0.1589	-0.2762	0.0600	-0.8744
5	1	0.8189	0.8463	0.1379	1.3394	0.9829	1.4749	1.8344	1.5372	1.0419	1.2394
6	1	0.4501	0.5380	0.7465	-0.9892	-0.1281	0.3167	0.2017	0.7097	1.0955	0.3346
7	1	-0.4623	-0.4771	-0.1196	0.7687	0.3236	1.5290	-0.0117	-0.1006	0.1509	0.4301
8	1	-0.8975	0.0308	-0.2311	-0.3268	0.8310	0.5155	0.3138	-0.2401	-0.4246	-1.5071
9	1	0.6826	-0.3228	-0.3804	0.4668	-0.4982	-1.0743	-0.4795	-0.3546	-0.9173	-1.6178
10	1	0.3697	0.2287	-0.1092	1.1289	0.8560	1.1465	-0.7750	0.0501	0.1186	-0.0459
11	1	-0.5932	-0.6889	-1.3196	-0.7389	-1.1784	1.1692	0.9564	-0.1787	-1.3906	-0.1168
12	1	1.4503	0.8160	-0.3885	0.3438	0.8313	-0.3304	0.6375	-0.1834	-0.8348	0.3158
13	1	0.3350	-0.1073	0.6701	0.8368	0.4510	-0.3383	-0.4244	-0.1612	0.4550	-0.0900
14	1	0.4192	0.0210	0.1529	0.3878	0.1525	0.7415	1.0030	1.3251	1.0239	0.4545
15	1	2.0258	2.1482	2.3548	1.4422	1.0675	-0.0970	-0.0904	0.1985	0.4063	-0.1159
16	1	1.2246	1.2758	1.1604	0.9192	0.0016	-0.1003	-1.3129	0.1661	0.1913	-0.2607
17	1	0.7044	-0.2517	-0.0188	-0.6466	-0.5533	-0.7326	0.2211	-0.1210	-1.6640	-0.2721
18	1	-1.3085	-1.7605	-0.8434	-1.4124	-0.5144	-1.0996	-1.4530	-1.7646	-1.1183	-0.9937
19	1	1.4938	1.3814	1.5316	1.9640	1.7573	0.9392	-0.4431	0.9325	2.0219	0.6688
20	1	0.1573	0.3349	1.4423	0.4818	1.4020	0.7950	0.5574	0.6686	0.8678	0.7316
21	1	0.9825	1.0763	1.5056	1.0050	1.5328	1.7649	1.7005	2.0144	-0.0246	2.0016
22	1	0.5482	0.9840	0.9038	0.3070	1.4512	0.5688	1.5130	2.1870	1.5662	0.8430
23	1	1.8048	1.9190	1.2606	1.0166	1.4111	0.7840	1.2211	1.9517	1.4118	2.2151

Simulate Tabular from Correlation Matrix (n=80), shown in TETRAD IV workspace, Blackboard Survey, Hafidz – 2011

Appendix D3. Simulate Tabular for Correlation Matrix Inter-Item Level for Combined Dataset (Ma and Yuen 2011)

Pearson Correlation Matrix from Ma and Yuen (2011)

POAM1	POAM2	POAM3	POAM4	POAM5	PORC1	PORC2	PORC3	PORC4	PORC5	OKSB1	OKSB2	OKSB3	OKSB4	OKSB5
-0.4752	0.2614	0.7839	-11.414	0.5570	0.6241	10.810	0.5958	0.3507	0.4647	24.553	18.721	17.800	12.264	15.732
0.4147	0.1341	11.348	21.550	29.725	17.566	28.965	12.887	0.8159	0.8139	10.778	15.282	11.504	0.8599	15.384
0.6352	0.7358	-0.3123	-12.413	-16.207	-15.871	-12.213	-15.468	-0.3946	-0.8829	13.228	0.6948	-0.2202	0.9336	-0.0468
0.4469	-0.0551	0.9274	0.5518	-0.4823	0.5467	0.5586	0.2229	16.560	13.942	0.9841	13.720	15.677	16.512	14.150
-0.0804	-0.0216	-0.9934	-10.291	-0.6157	-0.5609	-0.2121	0.7441	-11.647	-0.9895	-0.5798	-0.1068	-11.342	-0.9693	-10.810
-12.592	-12.519	-12.989	-0.9246	-15.998	-27.020	-14.364	-15.927	-12.094	-19.812	-14.610	-20.852	-15.567	-16.243	-21.744
0.0487	0.2732	-12.343	-14.012	-0.9185	-0.2412	-0.9471	-11.614	-16.228	-20.058	-0.6315	-0.5600	-0.5585	-0.3207	-0.0849
15.194	0.9026	0.6039	13.631	-0.7266	-0.0469	-0.2204	-0.5997	0.1512	-0.9786	-17.869	-17.049	-20.417	-16.940	-22.525
-21.079	-16.211	-13.933	0.1915	0.4898	-0.1919	0.0307	-0.5933	-0.2839	-14.217	-0.8378	-0.0902	-0.2616	-0.2247	-0.3172
0.0451	-0.6501	0.5029	0.2372	-0.4486	-0.5755	-10.886	-0.9620	-15.464	-0.4160	-0.4711	-0.6042	-0.5164	0.3838	-0.5816
-0.1760	-13.064	0.0086	13.489	0.4031	-0.3650	-0.7093	0.2049	0.3209	0.1022	0.2589	0.2715	0.2877	0.2325	0.1621
-0.9552	0.0980	-0.8708	-0.9238	-0.2775	-0.3614	-0.7346	-10.094	0.5132	-0.7089	-10.090	-12.685	-0.8260	-0.0692	-10.467
0.1306	-12.263	0.0744	0.8659	10.417	-0.7945	0.6453	0.5782	0.1361	0.1714	0.6654	0.5657	14.782	11.584	14.431
-12.986	-15.519	-12.645	-0.6665	0.2031	-0.2149	-0.3507	-0.6271	-0.3192	-0.1168	0.2374	-0.5245	-0.6045	-0.2956	0.2629
-0.5805	-0.0721	-0.3247	0.0942	0.5437	-10.948	0.2191	-10.570	-10.302	-0.4984	0.1276	-0.0235	-0.3747	-0.2787	-0.4401
-11.013	-0.2113	-0.0836	-0.1724	0.4620	0.8378	0.6779	0.8725	13.264	-0.3742	-0.1151	0.3599	10.035	0.7712	0.8715

-0.3344	-0.2940	-0.6359	-16.435	-16.226	-0.3731	0.4296	-0.6743	-0.4915	-0.2524	-0.2032	-0.3621	-0.8103	-0.3133	-0.9601
0.5518	14.720	0.1654	-12.267	-0.0366	-0.1373	0.5069	-0.1622	0.8350	-0.5306	0.3578	0.2298	-0.4773	-0.2207	-0.9928
-0.2595	-0.2505	-0.2453	-11.851	-0.8200	-0.3435	-0.0714	-0.2866	0.3009	-0.8186	-0.0270	-0.3239	-0.5728	-0.1025	-0.1086
-0.6777	-0.9027	0.2993	-0.0026	0.4157	-0.1565	-0.1269	-0.2463	-0.3889	-0.4649	0.3215	0.0675	0.5061	0.5875	0.7506
-15.275	-0.3925	-0.0245	-0.7246	-0.1068	-0.5368	0.9099	0.1402	-0.5510	-0.5442	0.7982	0.1202	0.3440	0.3401	0.6761
-0.3519	-0.3929	23.604	0.8896	17.961	0.6656	15.293	12.960	12.676	13.772	16.564	13.872	10.133	0.6084	11.644
0.2154	-0.4848	-0.7957	0.9628	14.646	0.4650	0.3702	-0.3933	-0.0017	-0.1042	-0.4467	-0.9882	-0.2969	-0.5742	0.0176
0.9406	-0.0066	0.8462	-0.4628	-0.0334	0.3258	-0.4678	0.0922	-0.7644	-0.7978	0.4216	0.5949	-0.4168	-0.0992	0.1057
-0.1800	-0.2701	-0.1204	0.9721	20.873	-0.8333	-0.3540	0.9619	14.681	0.1140	-12.777	-12.260	-0.2546	-0.0114	-0.1140
-12.698	-18.551	-11.184	-0.4796	-14.697	-0.8690	-0.8671	-13.049	-0.2187	-11.704	-19.849	-16.593	-13.756	-13.928	-12.954
-20.780	-21.144	-0.3483	0.2082	0.2920	-0.6964	-12.154	-0.7766	-11.482	-0.9492	-18.238	-13.707	-0.4062	-0.6874	-0.7195
-0.1317	-0.1744	-0.2896	-0.8100	-0.1350	0.8941	0.5243	0.4879	-0.2888	0.6168	0.6617	0.1040	10.579	0.7336	0.6923
-0.4544	0.2520	11.384	0.7985	11.971	0.6964	16.024	0.6145	20.204	10.776	18.708	12.353	24.525	17.693	11.401
13.535	11.543	11.816	-0.0208	0.9677	0.1433	-0.4002	13.086	0.2879	-0.3220	14.946	21.022	16.886	24.580	15.403
-0.1504	0.1448	0.0622	0.1949	-0.0271	-0.2569	-0.1621	-0.7538	0.7214	-11.718	-0.2581	-10.095	-0.2615	-0.5136	-0.5647
-0.3300	0.6018	-0.3038	-0.4048	-0.7134	-10.019	-15.144	-0.6974	-12.484	-10.400	-0.7290	-11.046	-11.781	-18.751	-14.726
-0.1953	0.1570	0.7662	11.391	0.1666	0.4444	12.814	-11.055	-10.458	-0.3417	13.929	13.682	0.5732	0.5538	12.041
-0.2954	0.9933	0.1131	-12.152	-0.1999	-0.4272	-12.570	-0.4545	-0.6917	-0.5718	0.3153	-0.2862	10.514	0.5308	-0.0227
0.5118	-0.2934	0.6630	0.0027	-0.7755	-11.198	-10.495	-0.1176	-0.4630	-0.5200	-0.0146	-0.4198	-0.6993	-0.4813	-0.2778
11.228	0.5569	17.366	15.791	15.726	0.2026	12.919	0.7177	0.2855	0.2304	13.946	10.064	0.2625	0.2298	-0.0121
0.1265	0.9792	14.175	16.729	26.668	0.5659	0.3918	0.0446	0.4586	0.6827	0.1502	-0.1448	0.0731	-0.1145	0.2152
15.191	13.966	10.994	-0.0351	0.2552	25.581	22.808	12.477	33.451	18.724	0.3262	0.7826	0.6598	0.5329	-0.2529
0.0361	-0.3654	0.4605	-0.4407	-0.1817	-13.077	-14.138	11.127	-0.0560	-0.2792	-0.6745	0.0113	-0.6173	-0.2833	-0.8028

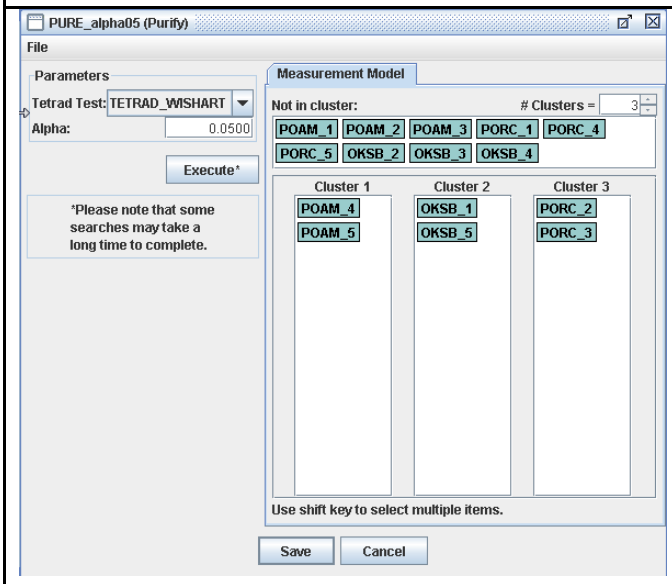
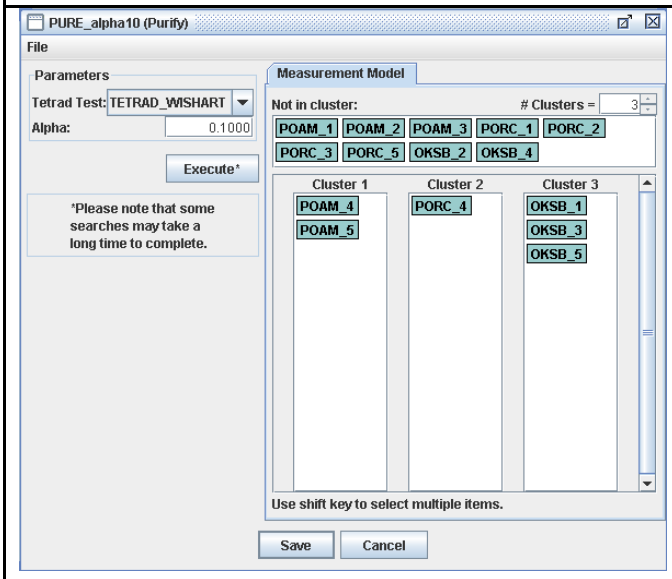
-0.6412	0.0748	-0.0897	0.0443	-0.2224	0.3819	-0.3322	0.5505	-0.5183	-0.4474	0.0662	-0.3622	-0.4016	-0.3720	-0.1375
-0.0246	-0.6072	0.6296	-0.2107	-0.7472	0.3779	0.7663	-0.8708	0.0297	-0.2425	-0.0202	-0.0173	-0.2006	-0.0657	0.0930
11.510	0.7363	17.128	16.779	10.014	13.081	13.657	0.0147	0.5034	0.1429	0.2589	-0.0648	0.1102	-0.7874	0.1071
-0.9724	-0.6499	-0.9871	-10.942	-11.542	-0.3327	-10.262	-13.323	0.0278	-0.6351	-0.1199	0.0281	0.2801	0.2174	0.3309
-0.9413	-16.843	-10.895	-0.0062	0.1923	-14.418	-10.668	-0.6594	-14.919	-0.6403	-13.746	-12.844	-0.9720	-11.205	-10.548
-0.7952	0.0811	-0.0472	0.5351	-0.4719	-0.3871	-0.9386	-0.5657	-0.6894	-0.1550	-0.3459	-0.3715	-0.9174	-12.596	-0.7951
0.6570	0.3290	0.4061	0.9039	0.1701	-0.0037	0.8741	0.3346	0.4954	12.275	0.6631	0.5475	0.0821	-0.6265	0.1010
0.3361	-0.1530	0.2422	0.3477	-0.1982	-0.6478	-0.1760	0.2679	-19.262	0.2622	0.4414	0.2060	-0.7023	-0.4069	-0.8706
0.8654	13.636	-0.0154	-0.6772	-0.6104	-0.6670	0.4325	0.5966	0.6777	0.8905	-0.7876	-11.128	-17.912	-15.432	-18.442
-10.583	-0.2918	-15.327	-0.8063	-11.254	-0.4471	-0.8769	-13.979	-15.915	-17.046	-15.809	-15.904	-23.571	-27.708	-21.625
17.495	15.685	11.073	18.271	0.5532	-0.9655	-0.4963	-0.5189	-0.3935	0.1498	-0.6173	-0.1945	-10.129	-10.569	-0.6628
0.9516	10.281	-0.3664	0.2034	0.5681	0.6406	10.344	12.821	23.274	0.1202	-0.3390	-0.0122	-0.3168	-0.6766	-11.884
-0.4480	0.5168	0.0103	-0.0900	0.4497	13.952	13.946	0.7998	0.7238	0.9441	10.053	11.781	0.9682	0.9593	0.4887
-15.455	-17.410	-12.305	-11.165	-12.921	-15.659	-10.859	-0.8049	-0.7049	-15.587	-13.465	-0.7427	-0.6656	-0.3144	-0.8395
-0.0466	0.2713	0.0008	0.2191	-0.2589	0.6957	-0.1304	0.2361	-0.9529	11.511	-0.7604	-0.8345	-11.294	-0.4118	0.0629
11.282	24.639	0.8563	0.2212	11.982	-0.2731	0.8678	0.2570	0.8820	0.6454	-0.2671	-0.3446	-0.0681	0.4323	-0.2711
-22.045	-17.875	-18.900	-16.978	-10.288	-15.203	-11.887	-17.361	-0.9884	-0.4532	-0.9925	-11.434	-0.7365	-0.7358	-15.411
-0.4343	0.1218	-10.549	-19.994	-0.3427	-15.634	-22.857	-0.2206	-10.933	-10.539	-0.4517	-0.7176	-0.1750	0.0563	-0.0768
-0.4770	-0.3243	-0.3616	-0.7390	-0.4440	-0.9368	0.5028	0.5914	-0.4072	-0.4284	-0.1455	-0.7840	-0.6205	-0.7750	-14.570
0.3908	0.2274	0.5755	15.153	0.4296	0.1121	0.1534	-0.7515	-0.1080	-0.6533	0.2052	0.3001	12.912	13.753	0.8733
0.4317	0.8603	15.870	11.101	17.401	0.7700	0.4843	-0.3510	19.638	19.936	0.0695	0.5898	0.5698	-0.1042	0.4979
-20.420	-17.174	-0.5160	-0.1993	0.3330	12.242	14.177	0.1873	0.1552	0.1223	-0.8708	-0.6235	0.3414	0.5397	-0.1079
0.8098	11.449	0.5155	0.5813	0.6836	-0.6199	-0.9404	-0.1120	0.2470	-0.5702	-0.9666	-0.7635	-11.414	-0.4057	-11.163

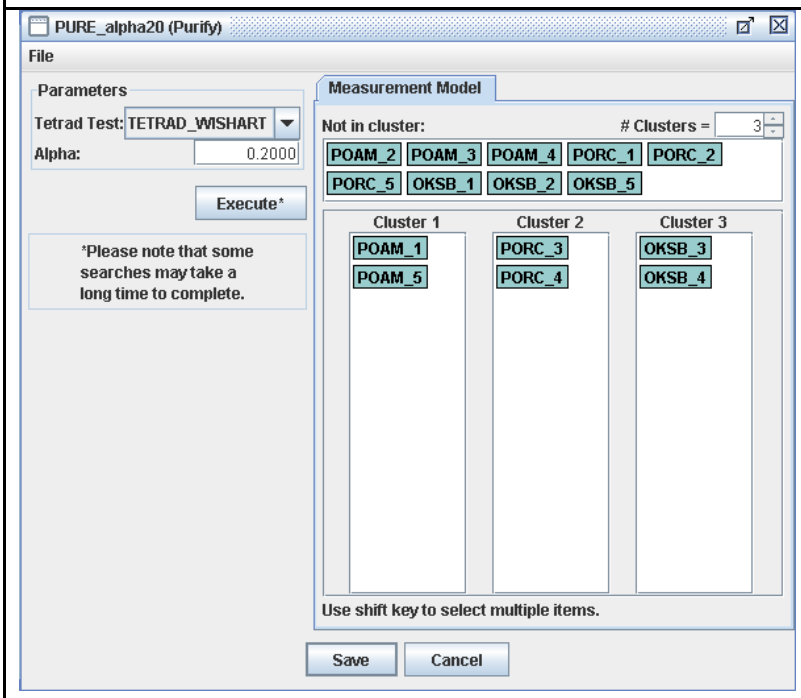
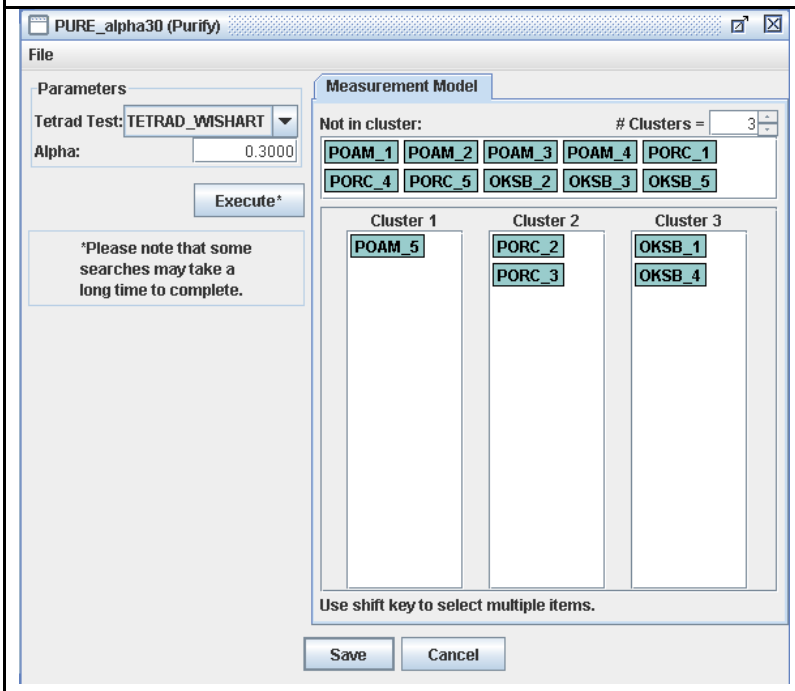
0.0918	-0.1292	-0.3244	0.3149	0.6030	-0.6614	-0.3495	0.2735	0.8490	-0.7035	-0.7060	-0.6150	0.2382	0.1952	0.2835
15.701	12.840	0.8576	0.2330	0.0091	0.1852	0.5136	0.6631	16.648	11.769	-0.5996	-0.5006	-0.6244	-11.683	-0.9606
22.119	23.226	18.955	0.8739	24.653	18.449	13.108	0.5615	20.082	15.995	25.969	31.123	29.632	26.533	21.815
0.7635	11.896	0.2543	0.8859	19.721	14.130	14.158	15.765	0.2372	18.602	16.518	16.436	12.764	10.147	15.663
-10.522	-0.2754	-0.0251	0.2424	0.4968	-0.3115	-0.0051	-0.1753	0.0259	-0.3286	-29.814	-28.626	-22.602	-22.973	-26.586
29.326	31.501	34.538	18.018	20.372	16.689	14.778	18.702	16.070	25.475	26.081	27.444	19.115	20.582	19.612
-15.605	-10.213	-22.462	-0.6552	-14.579	-14.720	0.0679	-12.232	-16.307	-0.1373	-0.0004	-0.4116	-0.5532	-0.9385	-12.203
0.4864	16.200	0.3440	0.0801	0.2572	10.927	0.6217	-0.0747	0.2818	0.3587	0.1326	0.2683	0.1849	-0.8279	0.2853
-0.6311	-0.7311	0.0260	-0.4768	-0.5597	0.2451	-11.832	0.5677	-0.1792	-13.925	-16.099	-13.989	-20.249	-24.693	-26.955
-0.2570	0.7284	0.4858	-0.8104	-0.5010	-0.3736	0.1117	-0.2632	-0.5193	0.3636	0.5754	0.4779	-0.0000	0.8535	0.8469
-0.7117	-21.009	-0.5672	0.0389	-0.1003	-0.5959	-10.848	-0.4722	0.0700	-0.4468	-0.1793	0.8416	0.3806	-0.0040	-0.1783
-0.2488	-0.3499	-0.6799	0.4363	-0.0786	0.8766	0.6558	0.4098	-0.1770	0.6596	0.0613	0.4440	13.091	10.264	11.674
0.5612	0.2896	0.1514	0.4358	-0.2321	0.7793	-0.0158	0.5674	15.282	17.124	0.8686	16.766	16.419	19.109	18.147
0.2880	12.920	-18.348	-11.753	-0.8377	0.5287	10.221	-0.7544	-19.752	-0.2352	10.459	0.9435	0.8366	0.3485	0.6437
0.9476	0.6689	0.4093	0.4375	0.7541	-23.560	-0.9849	-0.0748	-10.571	-11.079	15.439	11.015	0.3669	0.6467	0.6573
-0.0148	0.9928	0.2979	-0.5097	-0.6077	-0.9281	0.6572	0.7669	-11.447	0.9515	-0.0554	-0.2826	0.1131	0.6536	-0.4262
11.103	20.104	0.8646	0.6016	0.4477	0.8265	12.136	0.7082	-0.2285	0.2490	-10.262	-0.9368	-13.752	-0.7984	-11.431
-0.2004	-0.2909	-0.8893	-0.9456	-0.5465	-0.1196	-15.459	-12.859	10.197	-0.8403	-18.477	-17.194	-17.065	-18.069	-12.470

Appendix D4. Case Study 1: TETRAD IV Result from PURIFY

The table presented in this section provide the results from TETRAD IV by using alpha 0.05, 0.10, 0.20 and 0.30.

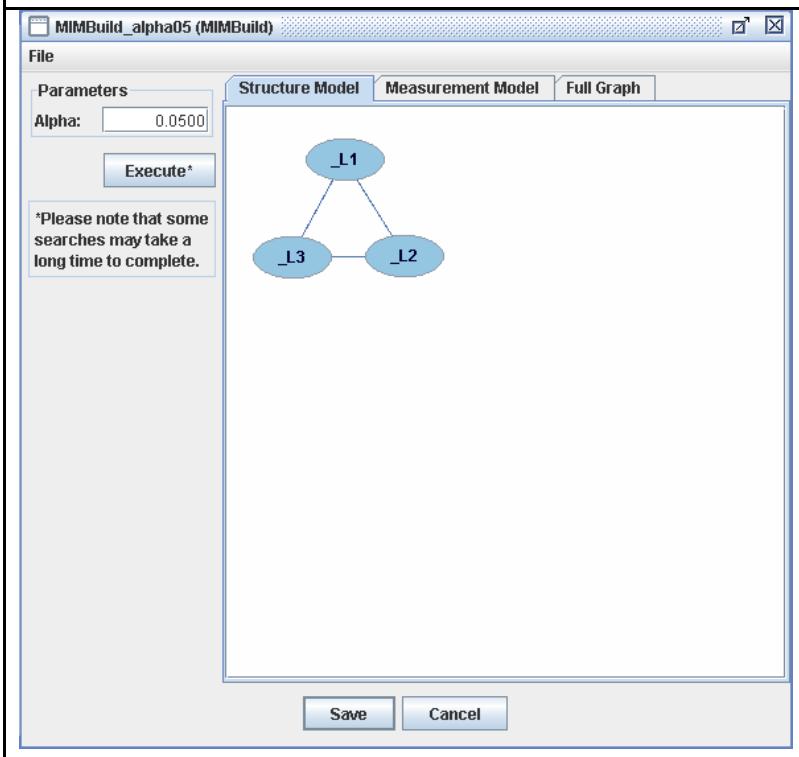
CASE STUDY 1: TETRAD Result from PURIFY (all alpha)

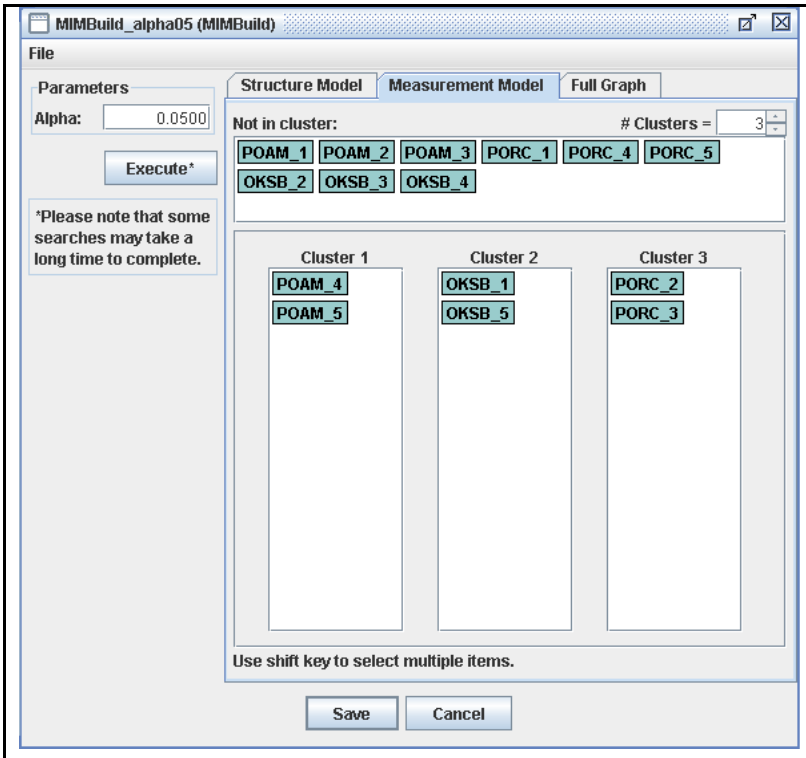
Alpha	Note
Alpha 0.05	
	TETRAD IV - PURIFY: Blackboard Case Study, Measurement Model Alpha 0.05 Item pruned (not in cluster) – 7 items: • POAM1 • POAM2 • POAM3 • PORC1 • PORC4 • PORC5 • OKSB2 • OKSB3 • OKSB4
Alpha 0.10	
	TETRAD IV - PURIFY: Blackboard Case Study, Measurement Model Alpha 0.10 Item pruned (not in cluster) – 8 items: • POAM1 • POAM2 • POAM3 • PORC1 • PORC2 • PORC3 • PORC5 • OKSB2 • OKSB4

Alpha 0.20	
	TETRAD IV - PURIFY: Blackboard Case Study, Measurement Model Alpha 0.20 Item pruned (not in cluster) – 8 items: • POAM2 • POAM3 • POAM4 • PORC1 • PORC2 • PORC5 • OKSB1 • OKSB2 • OKSB5
Alpha 0.30	
	TETRAD IV - PURIFY: Blackboard Case Study, Measurement Model Alpha 0.30 Item pruned (not in cluster) – 9 items: • POAM1 • POAM2 • POAM3 • POAM4 • PORC1 • PORC4 • PORC5 • OKSB2 • OKSB3 • OKSB5

Appendix D5. Case Study 2: TETRAD IV Result from MIMBuild

There are four tables presented in this section, which provide the results from TETRAD IV by using alpha 0.05, 0.10, 0.20 and 0.30 respectively.

Alpha	Note
Alpha 0.05	
	TETRAD IV - MIM Build: Blackboard Case Study, Structural Model with Alpha 0.05 Paths listed: OKSB – PORC OKSB – POAM POAM – PORC

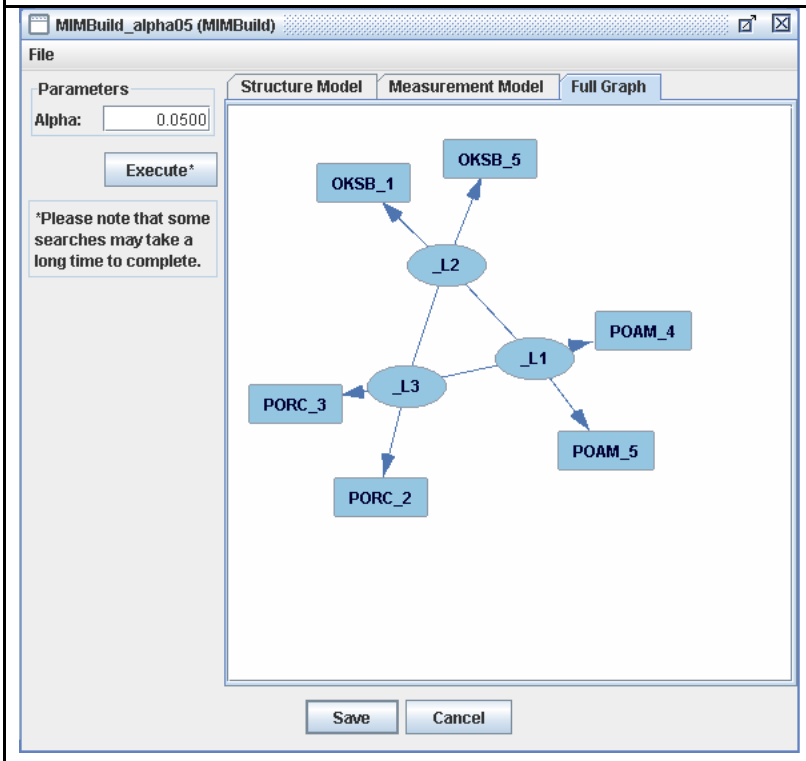


TETRAD IV - MIM Build: Blackboard Case Study,

Measurement Model with Alpha 0.05

Item pruned (not in cluster) – 7 items:

- POAM1
- POAM2
- POAM3
- PORC1
- PORC4
- PORC5
- OKSB2
- OKSB3
- OKSB4

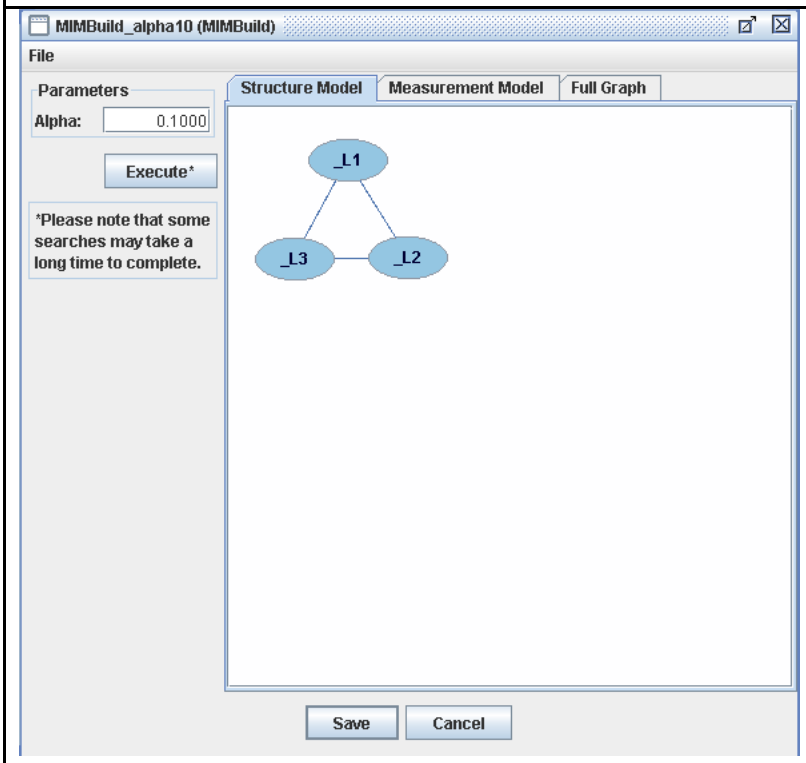


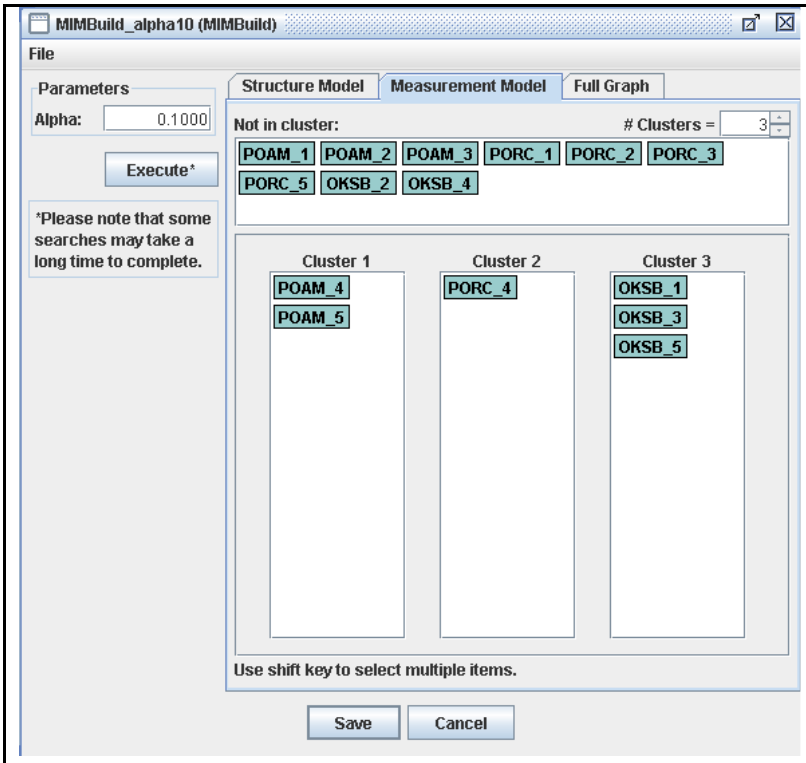
TETRAD IV - MIM Build: Blackboard Case Study,

Full Graph with Alpha 0.05

Paths listed:

OKSB – PORC
OKSB – POAM
POAM – PORC
OKSB →OKSB1
OKSB →OKSB5
PORC →PORC2
PORC →PORC3
POAM →POAM4
POAM →POAM5

Alpha	Note
Alpha 0.10	
	TETRAD IV - MIM Build: Blackboard Case Study, Structural Model with Alpha 0.10 Paths listed: OKSB – PORC POAM – PORC POAM – OKSB

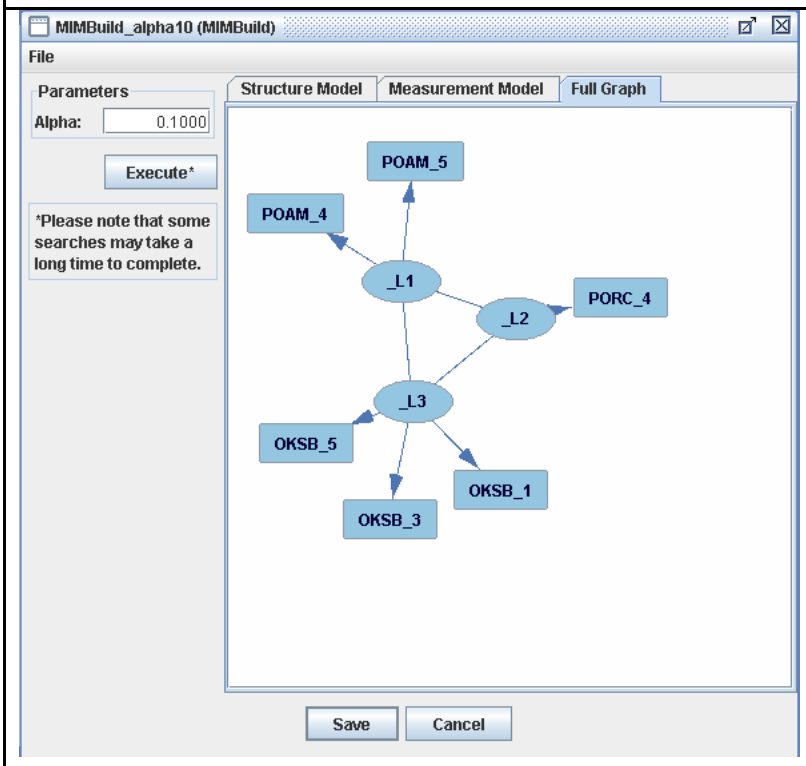


TETRAD IV - MIM Build: Blackboard Case Study,

Measurement Model with Alpha 0.10

Item pruned (not in cluster) – 8 items:

- POAM1
- POAM2
- POAM3
- PORC1
- PORC2
- PORC3
- PORC5
- OKSB2
- OKSB4

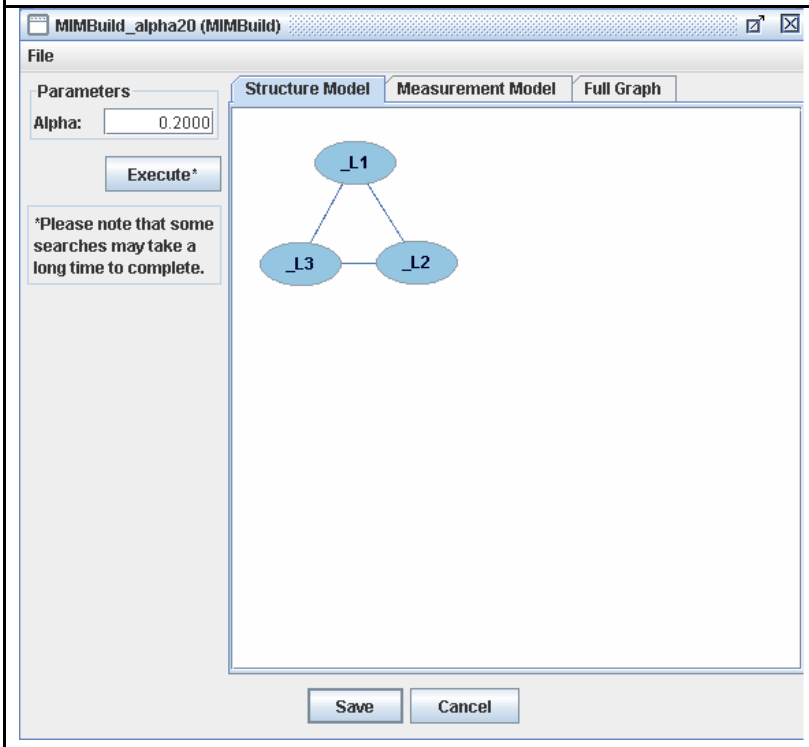
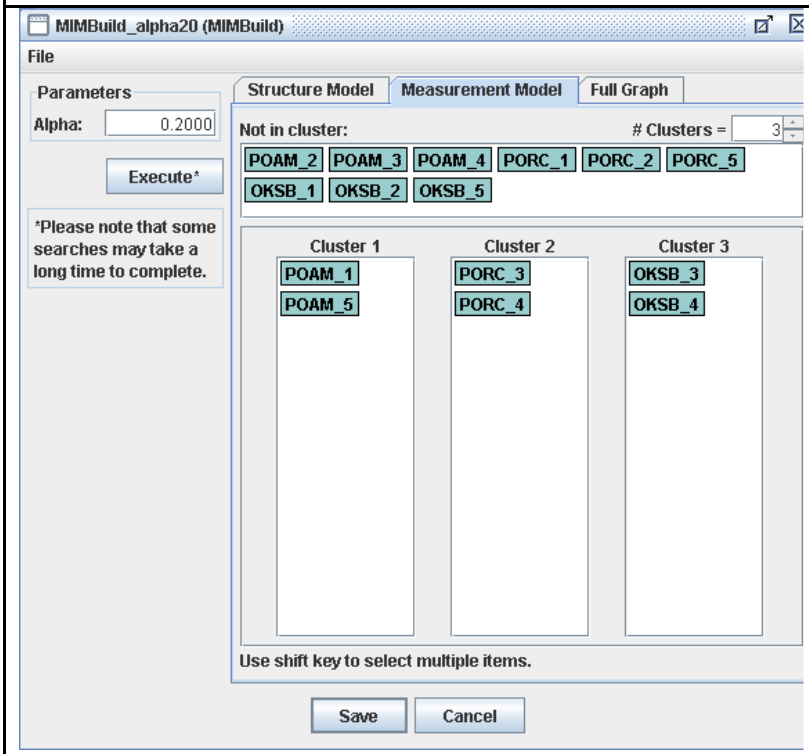


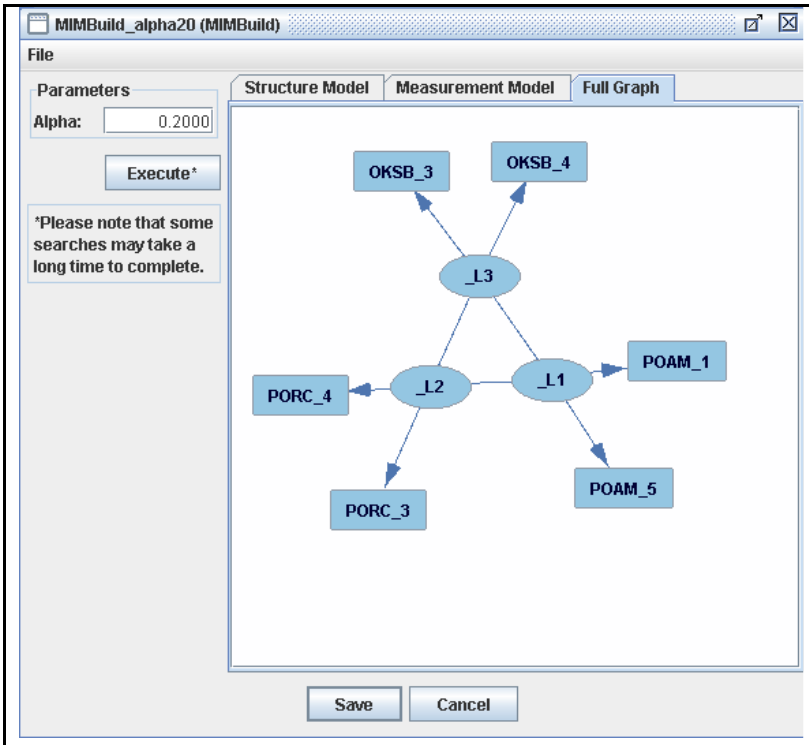
TETRAD IV - MIM Build: Blackboard Case Study,

Full Graph with Alpha 0.10

Paths listed:

OKSB – PORC
POAM – PORC
POAM – OKSB
OKSB →OKSB1
OKSB →OKSB3
OKSB →OKSB5
PORC →PORC4
POAM →POAM4
POAM →POAM5

Alpha	Note
Alpha 0.20	
	TETRAD IV - MIM Build: Blackboard Case Study, Structural Model with Alpha 0.20 Paths listed: OKSB – PORC OKSB – POAM POAM – PORC
	TETRAD IV - MIM Build: Blackboard Case Study, Measurement Model with Alpha 0.20 Item pruned (not in cluster) – 8 items: • POAM2 • POAM3 • POAM4 • PORC1 • PORC2 • PORC5 • OKSB1 • OKSB2 • OKSB5



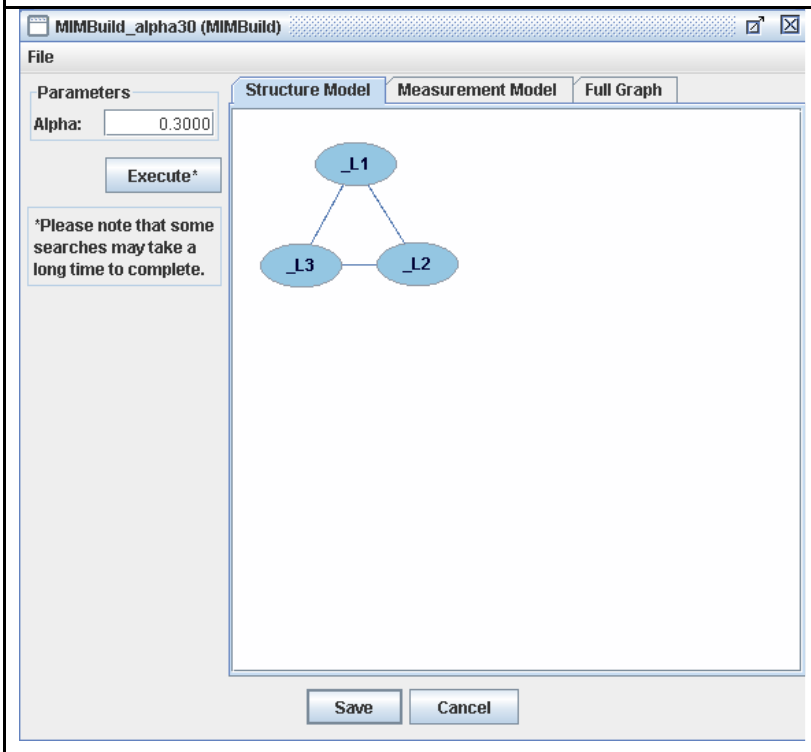
TETRAD IV - MIM Build: Blackboard Case Study,

Full Graph with Alpha 0.20

Paths listed:

OKSB – PORC
OKSB – POAM
POAM – PORC
OKSB →OKSB3
OKSB →OKSB4
PORC →PORC3
PORC →PORC4
POAM →POAM1
POAM →POAM5

Alpha	Note
Alpha 0.30	

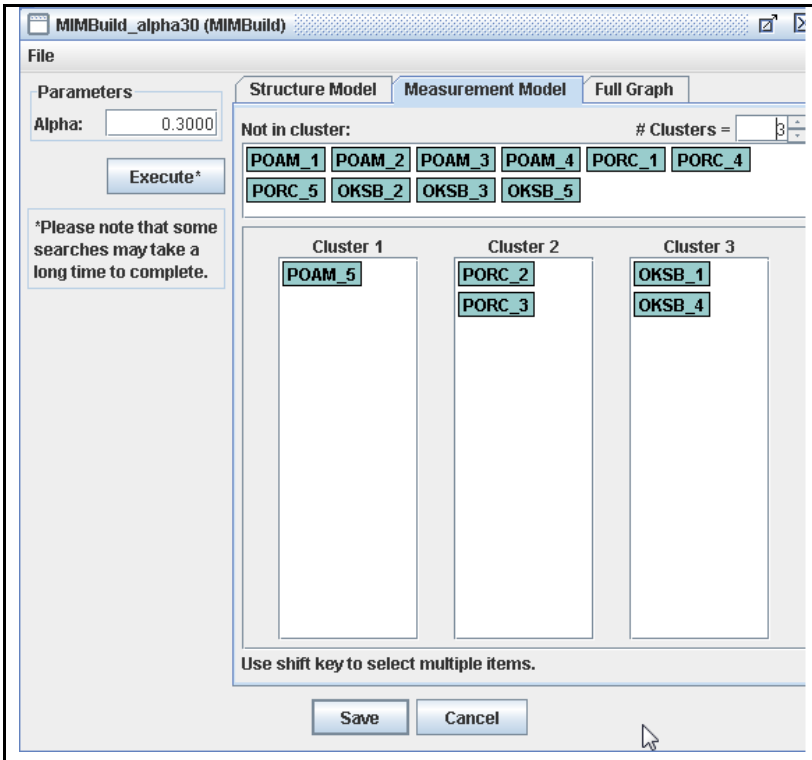


TETRAD IV - MIM Build: Blackboard Case Study,

Structural Model with Alpha 0.30

Paths listed:

OKSB – POAM
POAM – PORC
OKSB – PORC

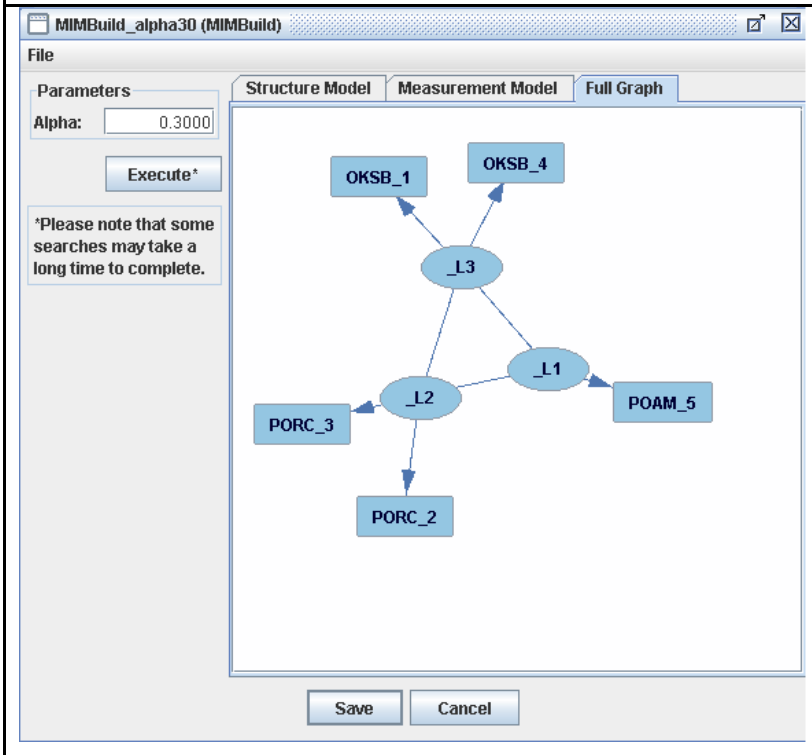


TETRAD IV - MIM Build: Blackboard Case Study,

Measurement Model with Alpha 0.30

Item pruned (not in cluster) – 8 items:

- POAM1
- POAM4
- PORC1
- PORC2
- PORC3
- OKSB1
- OKSB2
- OKSB3



TETRAD IV - MIM Build: Blackboard Case Study,

Full Graph with Alpha 0.30

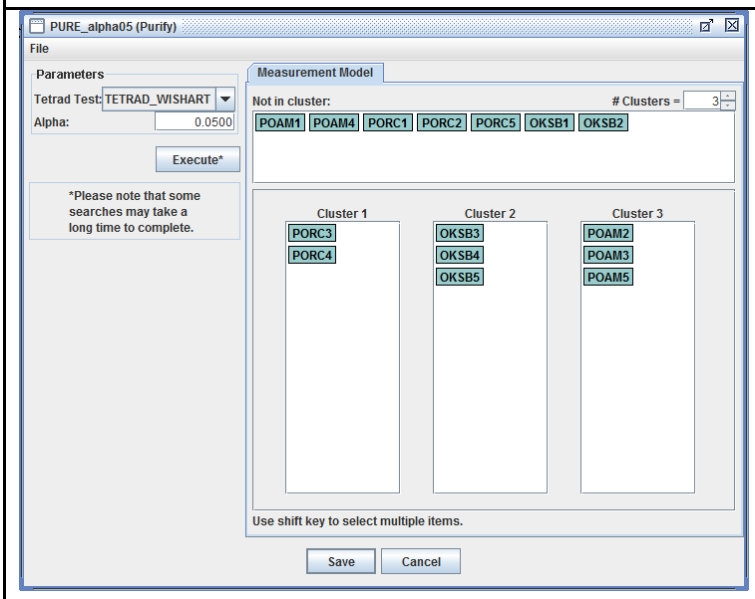
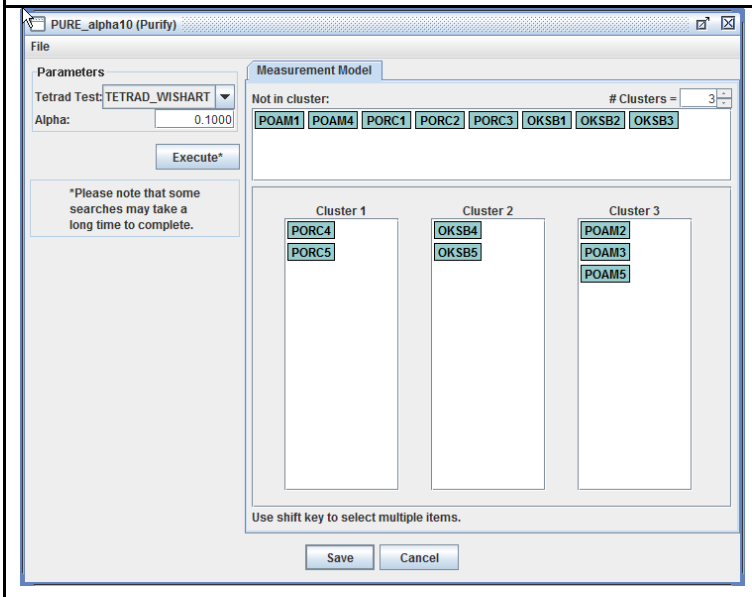
Paths listed:

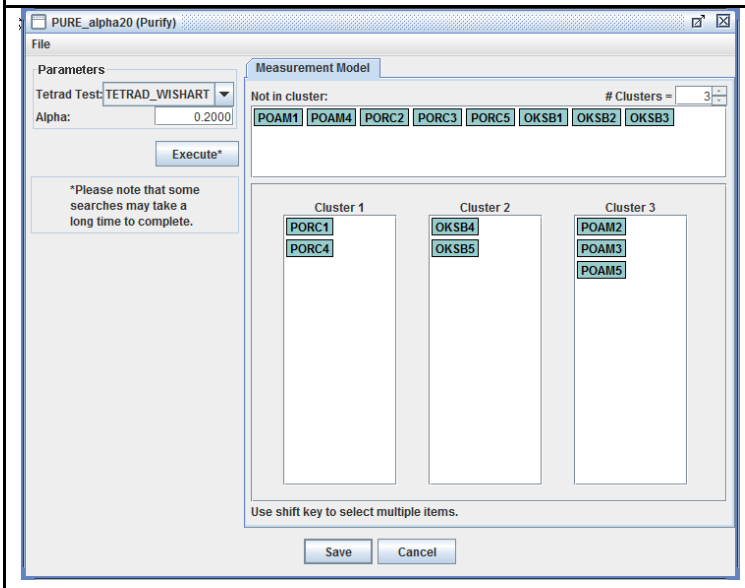
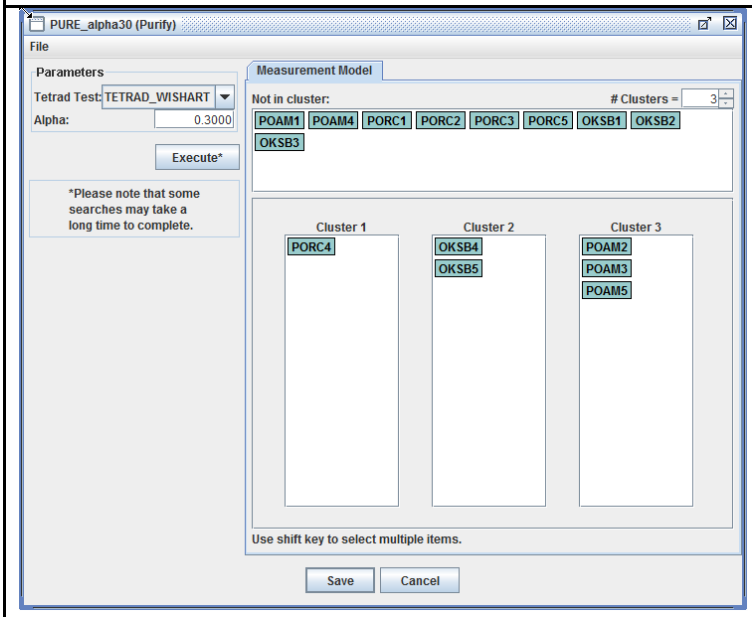
OKSB – PORC
OKSB – POAM
POAM – PORC
OKSB →OKSB1
OKSB →OKSB4
PORC →PORC2
PORC →PORC3
POAM →POAM5

Appendix D6. Case Study 2: TETRAD IV Result from PURIFY

The table presented in this section provide the results from TETRAD IV by using alpha 0.05, 0.10, 0.20 and 0.30.

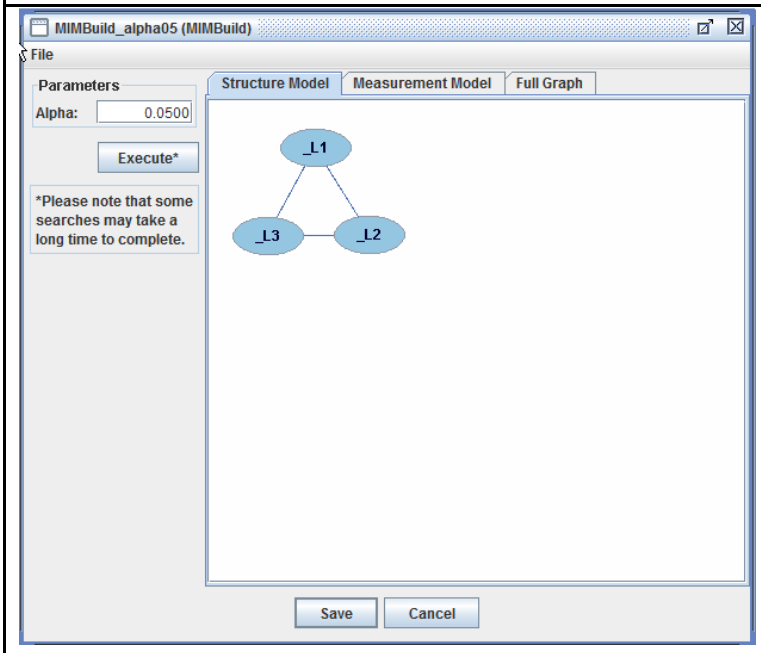
CASE STUDY 2: TETRAD Result from PURIFY (all alpha)

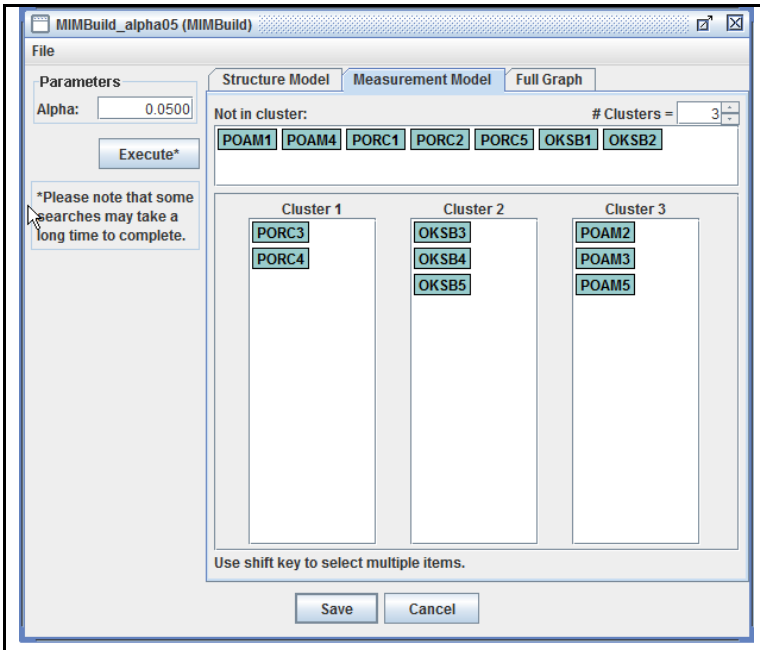
Alpha	Note
Alpha 0.05	
	TETRAD IV - PURIFY: Blackboard Case Study, Measurement Model Alpha 0.05 Item pruned (not in cluster) – 7 items: • POAM1 • POAM4 • PORC1 • PORC2 • PORC5 • OKSB1 • OKSB2
Alpha 0.10	
	TETRAD IV - PURIFY: Blackboard Case Study, Measurement Model Alpha 0.10 Item pruned (not in cluster) – 8 items: • POAM1 • POAM4 • PORC1 • PORC2 • PORC3 • OKSB1 • OKSB2 • OKSB3

Alpha 0.20	
	TETRAD IV - PURIFY: Blackboard Case Study, Measurement Model Alpha 0.20 Item pruned (not in cluster) – 8 items: • POAM1 • POAM4 • PORC2 • PORC3 • PORC5 • OKSB1 • OKSB2 • OKSB3
Alpha 0.30	
	TETRAD IV - PURIFY: Blackboard Case Study, Measurement Model Alpha 0.30 Item pruned (not in cluster) – 9 items: • POAM1 • POAM4 • PORC1 • PORC2 • PORC3 • PORC5 • OKSB1 • OKSB2 • OKSB3

Appendix D7. Case Study 2: TETRAD IV Result from MIMBuild

There four tables presented in this section, which provide the results from TETRAD IV by using alpha 0.05, 0.10, 0.20 and 0.30 respectively.

Alpha	Note
Alpha 0.05	
	TETRAD IV - MIM Build: Blackboard Case Study, Structural Model with Alpha 0.05 Paths listed: OKSB – PORC OKSB – POAM POAM – PORC

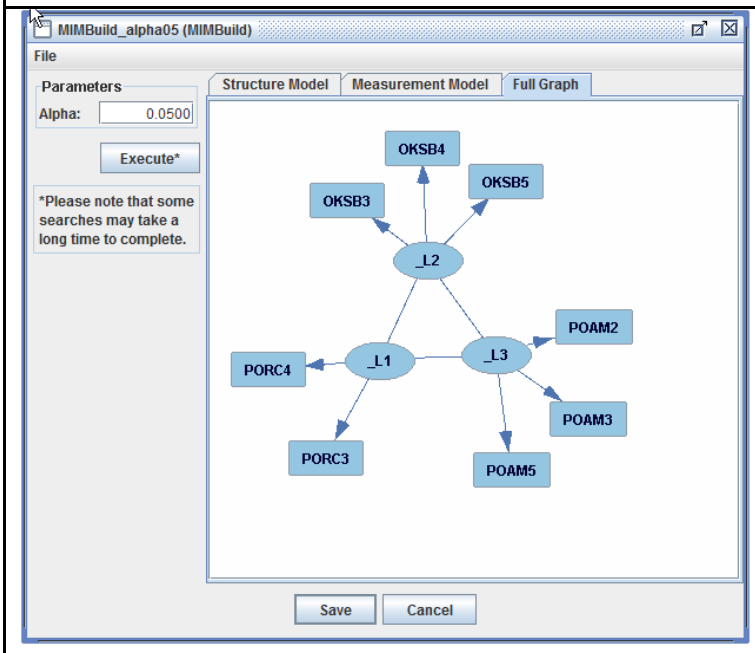


TETRAD IV - MIM Build: Blackboard Case Study,

Measurement Model with Alpha 0.05

Item pruned (not in cluster) – 7 items:

- POAM1
- POAM4
- PORC1
- PORC2
- PORC5
- OKSB1
- OKSB2

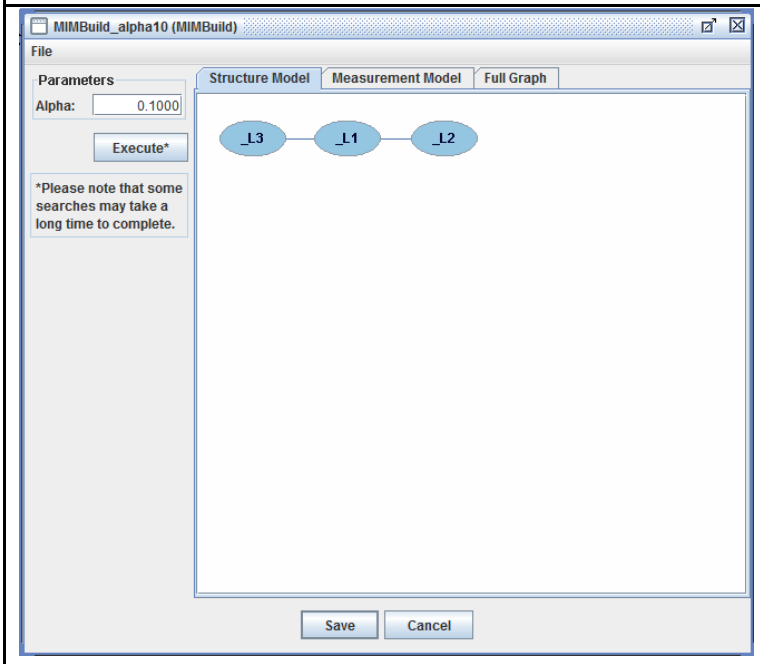
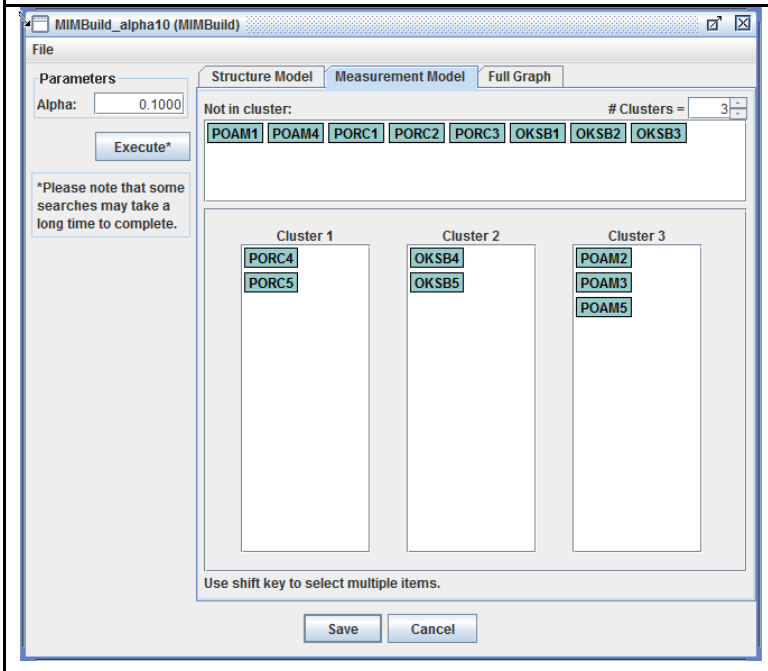


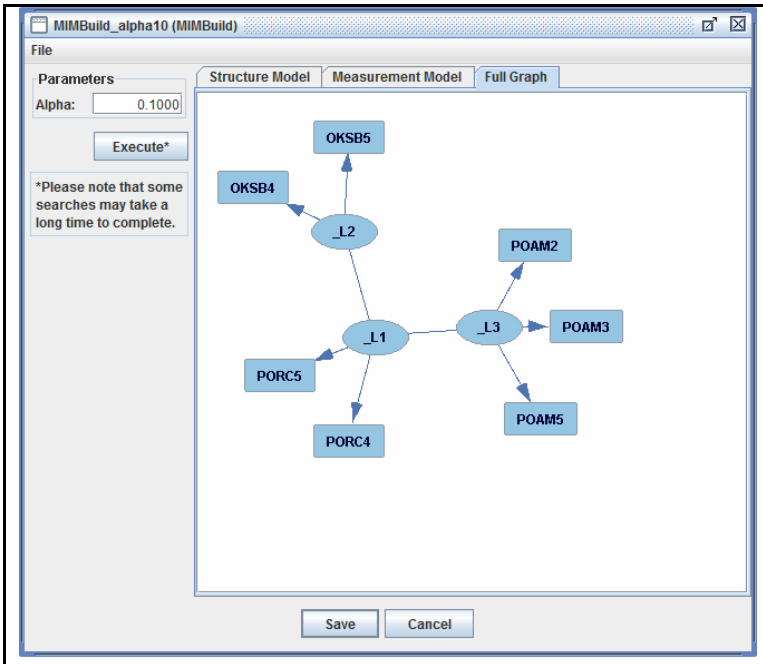
TETRAD IV - MIM Build: Blackboard Case Study,

Full Graph with Alpha 0.05

Paths listed:

OKSB – PORC
OKSB – POAM
POAM – PORC
OKSB →OKSB3
OKSB →OKSB4
OKSB →OKSB5
PORC →PORC3
PORC →PORC4
POAM →POAM2
POAM →POAM3
POAM →POAM5

Alpha	Note
Alpha 0.10	
	TETRAD IV - MIM Build: Blackboard Case Study, Structural Model with Alpha 0.10 Paths listed: OKSB – PORC POAM – PORC
	TETRAD IV - MIM Build: Blackboard Case Study, Measurement Model with Alpha 0.10 Item pruned (not in cluster) – 8 items: • POAM1 • POAM4 • PORC1 • PORC2 • PORC3 • OKSB1 • OKSB2 • OKSB3

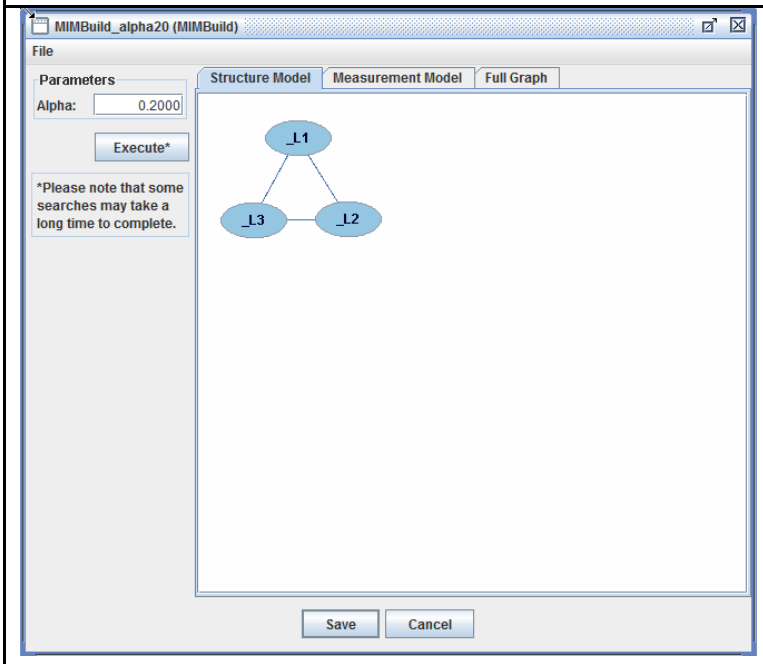
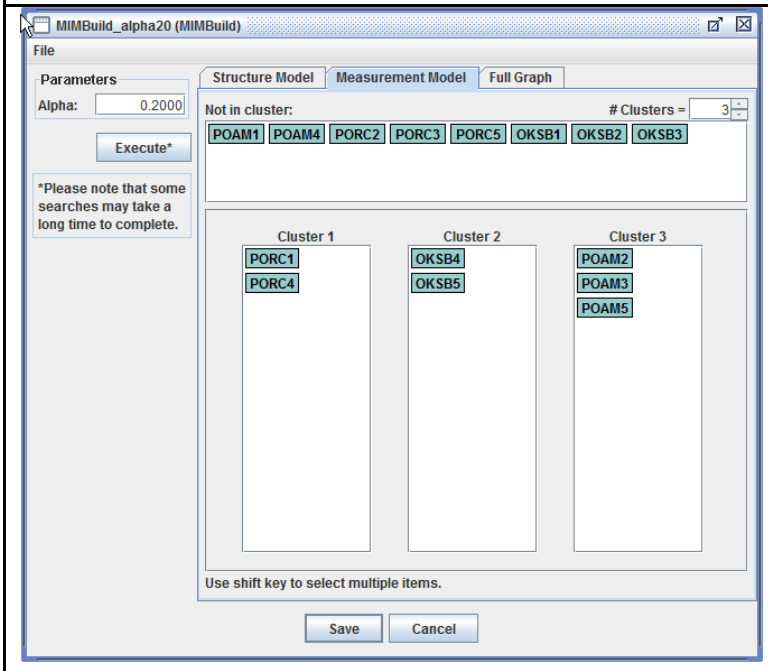


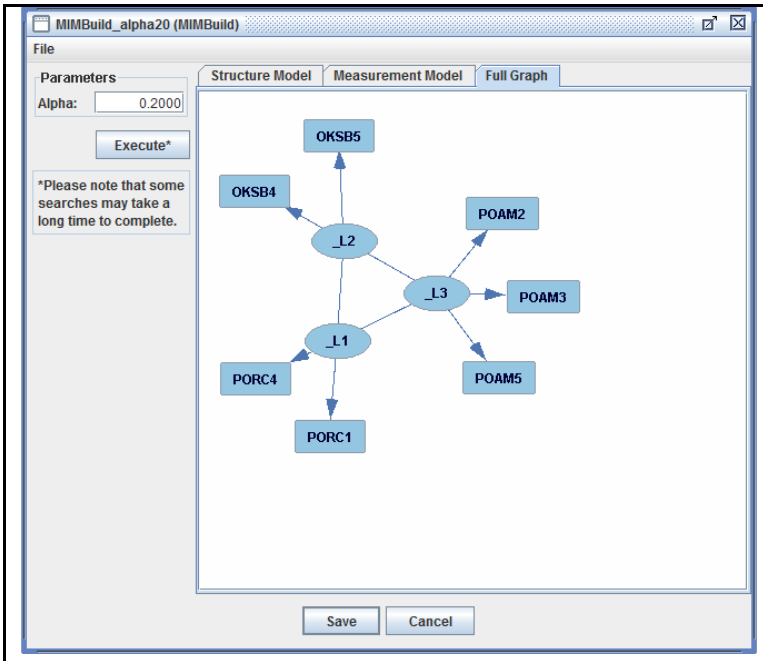
TETRAD IV - MIM Build: Blackboard Case Study,

Full Graph with Alpha 0.10

Paths listed:

OKSB – PORC
POAM – PORC
OKSB →OKSB4
OKSB →OKSB5
PORC →PORC4
PORC →PORC5
POAM →POAM2
POAM →POAM3
POAM →POAM5

Alpha	Note
Alpha 0.20	
	TETRAD IV - MIM Build: Blackboard Case Study, Structural Model with Alpha 0.20 Paths listed: OKSB – PORC OKSB – POAM POAM – PORC
	TETRAD IV - MIM Build: Blackboard Case Study, Measurement Model with Alpha 0.20 Item pruned (not in cluster) – 8 items: • POAM1 • POAM4 • PORC2 • PORC3 • PORC5 • OKSB1 • OKSB2 • OKSB3



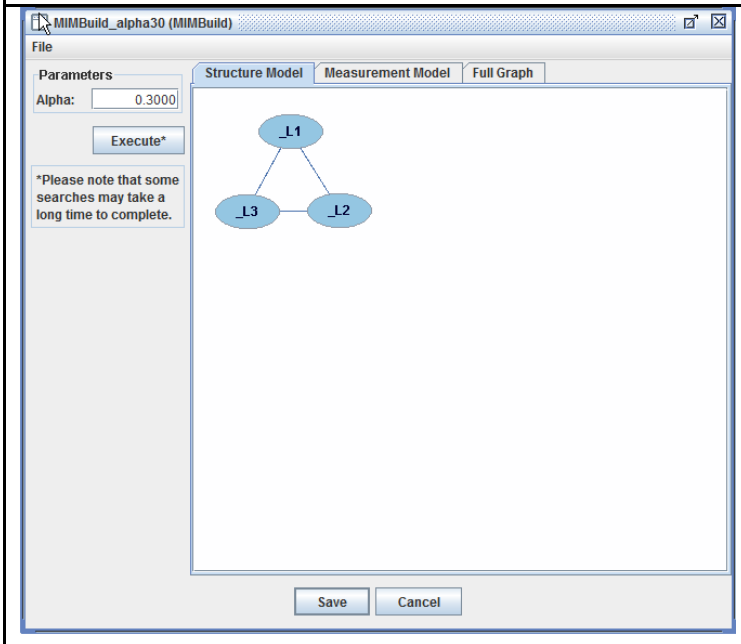
TETRAD IV - MIM Build: Blackboard Case Study,

Full Graph with Alpha 0.20

Paths listed:

OKSB – PORC
OKSB – POAM
POAM – PORC
OKSB →OKSB4
OKSB →OKSB5
PORC →PORC1
PORC →PORC4
POAM →POAM2
POAM →POAM3
POAM →POAM5

Alpha	Note
Alpha 0.30	

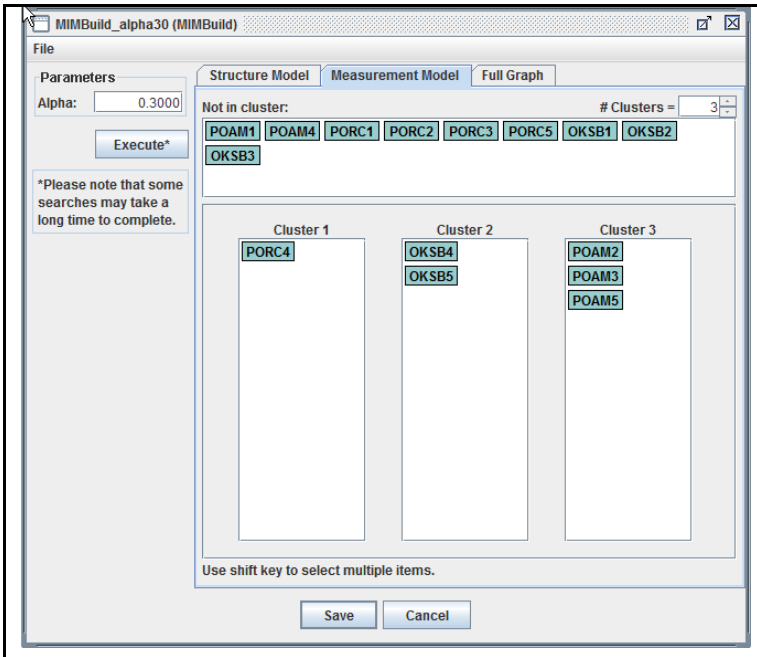


TETRAD IV - MIM Build: Blackboard Case Study,

Structural Model with Alpha 0.30

Paths listed:

OKSB – POAM
POAM – PORC

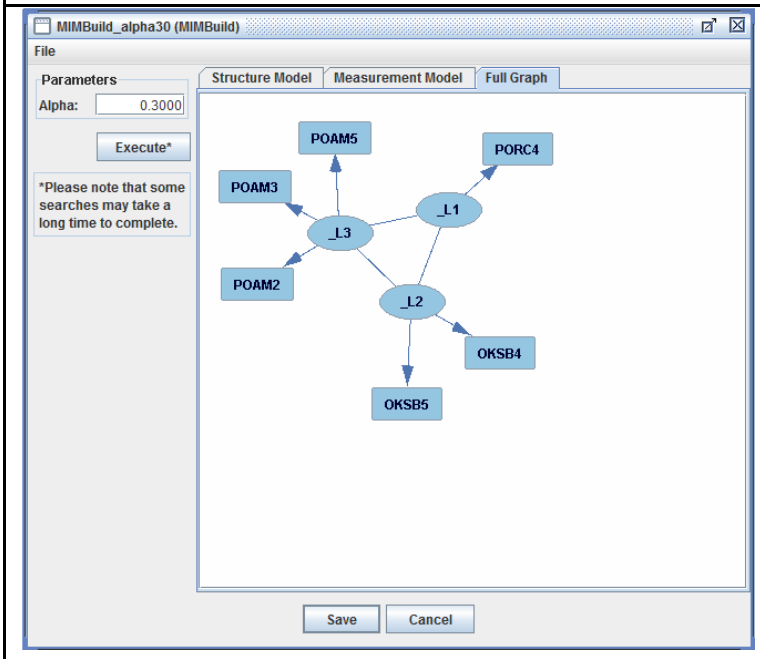


TETRAD IV - MIM Build: Blackboard Case Study,

Measurement Model with Alpha 0.30

Item pruned (not in cluster) – 8 items:

- POAM1
- POAM4
- PORC1
- PORC2
- PORC3
- OKSB1
- OKSB2
- OKSB3



TETRAD IV - MIM Build: Blackboard Case Study,

Full Graph with Alpha 0.30

Paths listed:

OKSB – PORC
OKSB – POAM
POAM – PORC
OKSB →OKSB4
OKSB →OKSB5
PORC →PORC4
PORC →PORC5
POAM →POAM2
POAM →POAM3
POAM →POAM5

Appendix D8. Case Study 1: CFA using LISREL 8.8 (The chosen model, Input from MIMBuild using alpha = 0.05)

DATE: 8/30/2011
TIME: 1:17

LISREL 8.80 (STUDENT EDITION)

BY

Karl G. Jöreskog & Dag Sörbom

The following lines were read from file D:\=master thesis bismillah\1st experiment - CASE 3_Yuen\LISREL MIMBuild\MIMBuild_with alpha_05.spl:

"Ma and Yuen (2011) -- Confirmatory Factor Analysis of 15 variables and 3 factors -- From TETRAD: MIMBuild with alpha .05"
Observed variables
POAM1 POAM2 POAM3 POAM4 POAM5 PORC1 PORC2 PORC3 PORC4 PORC5 OKSB1 OKSB2 OKSB3 OKSB4 OKSB5
Correlation Matrix
1.0
.60 1.0
.56 .58 1.0
.57 .60 .72 1.0
.52 .53 .59 .66 1.0
.46 .49 .49 .51 .42 1.0
.43 .43 .49 .49 .45 .63 1.0
.49 .49 .52 .52 .51 .56 .55 1.0
.60 .54 .62 .55 .51 .49 .49 .45 1.0
.31 .33 .37 .36 .36 .47 .52 .40 .34 1.0
.47 .53 .55 .56 .52 .49 .48 .51 .49 .33 1.0
.52 .50 .61 .62 .60 .50 .52 .53 .56 .39 .67 1.0
.52 .51 .61 .63 .60 .50 .49 .53 .53 .35 .65 .80 1.0
.48 .52 .59 .63 .57 .49 .51 .50 .54 .34 .69 .84 .77 1.0

.54 .58 .60 .62 .58 .50 .50 .52 .52 .36 .58 .66 .67 .66 1.0
Sample Size 581
Latent variables : POAM PORC OKSB
Relationships :
POAM4 POAM5 = POAM
PORC2 PORC3 = PORC
OKSB1 OKSB5 = OKSB
OKSB = POAM
POAM = PORC
OKSB = PORC
Path Diagram
End of Problem

Sample Size = 581

"Ma and Yuen (2011) -- Confirmatory Factor Analysis of 15 variables and 3 facto

Correlation Matrix

	POAM4	POAM5	OKSB1	OKSB5	PORC2	PORC3
POAM4	1.00					
POAM5	0.66	1.00				
OKSB1	0.56	0.52	1.00			
OKSB5	0.62	0.58	0.58	1.00		
PORC2	0.49	0.45	0.48	0.50	1.00	
PORC3	0.52	0.51	0.51	0.52	0.55	1.00

"Ma and Yuen (2011) -- Confirmatory Factor Analysis of 15 variables and 3 facto

Number of Iterations = 10

LISREL Estimates (Maximum Likelihood)

Measurement Equations

POAM4 = 0.84*POAM, Errorvar.= 0.30 , R^2 = 0.70
(0.031)
9.74

POAM5 = 0.79*POAM, Errorvar.= 0.38 , R^2 = 0.62
(0.040) (0.031)
19.57 12.10

OKSB1 = 0.73*OKSB, Errorvar.= 0.46 , R^2 = 0.54
(0.035)
13.31

OKSB5 = 0.79*OKSB, Errorvar.= 0.37 , R^2 = 0.63

(0.045) (0.033)
17.53 11.17

PORC2 = 0.72*PORC, Errorvar.= 0.48 , R^2 = 0.52
(0.040) (0.039)
17.83 12.45

PORC3 = 0.77*PORC, Errorvar.= 0.41 , R^2 = 0.59
(0.040) (0.039)
19.10 10.66

Structural Equations

POAM = 0.82*PORC, Errorvar.= 0.33 , R^2 = 0.67
(0.050) (0.058)
16.43 5.79

OKSB = 0.60*POAM + 0.39*PORC, Errorvar.= 0.097 , R^2 = 0.90
(0.10) (0.098) (0.042)
5.97 4.02 2.29

Reduced Form Equations

POAM = 0.82*PORC, Errorvar.= 0.33, R^2 = 0.67
(0.050)
16.43

OKSB = 0.88*PORC, Errorvar.= 0.22, R^2 = 0.78
(0.056)
15.71

Correlation Matrix of Independent Variables

PORC
1.00

Covariance Matrix of Latent Variables

	POAM	OKSB	PORC
POAM	1.00		
OKSB	0.92	1.00	
PORC	0.82	0.88	1.00

Goodness of Fit Statistics

Degrees of Freedom = 6
Minimum Fit Function Chi-Square = 3.64 (P = 0.72)
Normal Theory Weighted Least Squares Chi-Square = 3.63 (P = 0.73)
Estimated Non-centrality Parameter (NCP) = 0.0
90 Percent Confidence Interval for NCP = (0.0 ; 5.43)

Minimum Fit Function Value = 0.0063
Population Discrepancy Function Value (F0) = 0.0
90 Percent Confidence Interval for F0 = (0.0 ; 0.0094)
Root Mean Square Error of Approximation (RMSEA) = 0.0
90 Percent Confidence Interval for RMSEA = (0.0 ; 0.039)
P-Value for Test of Close Fit (RMSEA < 0.05) = 0.98

Expected Cross-Validation Index (ECVI) = 0.062
90 Percent Confidence Interval for ECVI = (0.062 ; 0.071)
ECVI for Saturated Model = 0.072
ECVI for Independence Model = 4.38

Chi-Square for Independence Model with 15 Degrees of Freedom = 2530.71
Independence AIC = 2542.71
Model AIC = 33.63
Saturated AIC = 42.00
Independence CAIC = 2574.90
Model CAIC = 114.10
Saturated CAIC = 154.66

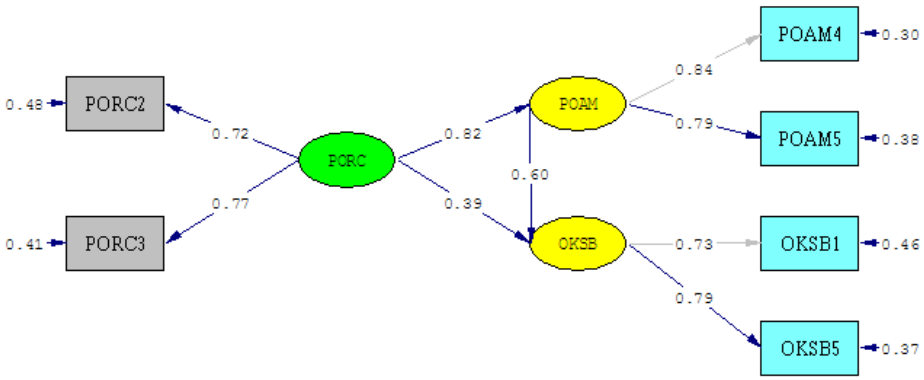
Normed Fit Index (NFI) = 1.00
Non-Normed Fit Index (NNFI) = 1.00
Parsimony Normed Fit Index (PNFI) = 0.40
Comparative Fit Index (CFI) = 1.00
Incremental Fit Index (IFI) = 1.00
Relative Fit Index (RFI) = 1.00

Critical N (CN) = 2678.18

Root Mean Square Residual (RMR) = 0.0082
Standardized RMR = 0.0082
Goodness of Fit Index (GFI) = 1.00
Adjusted Goodness of Fit Index (AGFI) = 0.99
Parsimony Goodness of Fit Index (PGFI) = 0.29

Time used: 0.031 Seconds

Path Diagram for case Study 1 resulted form LISREL 8.8, Input from MIMBuild alpha = 0.05



Appendix D9. Case Study 2: CFA using LISREL 8.8 (The chosen model, Input from MIMBuild using alpha =0 .20)

```
DATE:  8/29/2011
TIME: 15:02

LISREL 8.80 (STUDENT EDITION)

BY

Karl G. Jöreskog & Dag Sörbom

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The following lines were read from file D:\=master thesis bismillah\2nd experiment -
Blackboard\MIMBuild lisrel\29agtMIMBuild lisrel_alpha20.SPJ:

"Confirmatory Factor Analysis of 8 variables and 3 factors -- Blackboard Survey -- Hafidz
2011 -- Sub-model resulted from TETRAD: PURIFY with alpha .20"
Raw Data from file: 'D:\=master thesis bismillah\2nd experiment - Blackboard\27 agt
Purify_CFA lisrel_data__B\purify_blackboard.psf'
Sample Size = 80
Latent variables :  POAM PORC OKSB
Relationshps :
POAM2 = POAM
POAM3 = POAM
POAM5 = POAM
PORC1 = PORC
PORC4 = PORC
OKSB4 = OKSB
OKSB5 = OKSB
POAM = PORC
OKSB = PORC
OKSB = POAM
Path Diagram
End of Problem

Sample Size =    80
```

"Confirmatory Factor Analysis of 8 variables and 3 factors -- Blackboard Survey

Covariance Matrix

	POAM2	POAM3	POAM5	OKSB4	OKSB5	PORC1
POAM2	2.67					
POAM3	1.67	2.25				
POAM5	1.52	1.75	2.56			
OKSB4	0.86	1.18	1.38	3.64		
OKSB5	0.95	1.18	1.45	3.28	3.94	
PORC1	1.19	1.29	1.48	1.67	1.89	3.43
PORC4	1.21	1.43	1.37	1.29	1.38	1.73

Covariance Matrix

	PORC4
PORC4	2.94

"Confirmatory Factor Analysis of 8 variables and 3 factors -- Blackboard Survey

Number of Iterations = 12

LISREL Estimates (Maximum Likelihood)

Measurement Equations

POAM2 = 1.20*POAM, Errorvar.= 1.22 , R^2 = 0.54
(0.23)
5.29

POAM3 = 1.35*POAM, Errorvar.= 0.44 , R^2 = 0.81
(0.18) (0.15)
7.45 2.86

POAM5 = 1.31*POAM, Errorvar.= 0.86 , R^2 = 0.67
(0.19) (0.19)
7.02 4.48

OKSB4 = 1.74*OKSB, Errorvar.= 0.60 , R^2 = 0.84
(0.29)
2.04

OKSB5 = 1.88*OKSB, Errorvar.= 0.40 , R^2 = 0.90
(0.21) (0.33)
9.15 1.22

PORC1 = 1.37*PORC, Errorvar.= 1.55 , R^2 = 0.55
(0.20) (0.36)
6.76 4.28

PORC4 = 1.26*PORC, Errorvar.= 1.34 , R^2 = 0.54
(0.19) (0.31)
6.73 4.32

Structural Equations

POAM = 0.78*PORC, Errorvar.= 0.38 , R^2 = 0.62
(0.15) (0.15)
5.36 2.52

OKSB = - 0.029*POAM + 0.68*PORC, Errorvar.= 0.57 , R^2 = 0.43
(0.26) (0.28) (0.15)
-0.11 2.43 3.82

Reduced Form Equations

POAM = 0.78*PORC, Errorvar.= 0.38, R^2 = 0.62
(0.15)
5.36

OKSB = 0.65*PORC, Errorvar.= 0.57, R^2 = 0.43
(0.13)
4.97

Correlation Matrix of Independent Variables

	PORC
PORC	1.00

Covariance Matrix of Latent Variables

	POAM	OKSB	PORC
POAM	1.00		
OKSB	0.50	1.00	
PORC	0.78	0.65	1.00

Goodness of Fit Statistics

Degrees of Freedom = 11

Minimum Fit Function Chi-Square = 7.35 (P = 0.77)
Normal Theory Weighted Least Squares Chi-Square = 7.78 (P = 0.73)
Estimated Non-centrality Parameter (NCP) = 0.0
90 Percent Confidence Interval for NCP = (0.0 ; 6.59)

Minimum Fit Function Value = 0.093
Population Discrepancy Function Value (F0) = 0.0
90 Percent Confidence Interval for F0 = (0.0 ; 0.083)
Root Mean Square Error of Approximation (RMSEA) = 0.0
90 Percent Confidence Interval for RMSEA = (0.0 ; 0.087)
P-Value for Test of Close Fit (RMSEA < 0.05) = 0.84

Expected Cross-Validation Index (ECVI) = 0.57
90 Percent Confidence Interval for ECVI = (0.57 ; 0.65)
ECVI for Saturated Model = 0.71
ECVI for Independence Model = 5.63

Chi-Square for Independence Model with 21 Degrees of Freedom = 430.99
Independence AIC = 444.99
Model AIC = 41.78
Saturated AIC = 56.00
Independence CAIC = 468.67
Model CAIC = 99.28
Saturated CAIC = 150.70

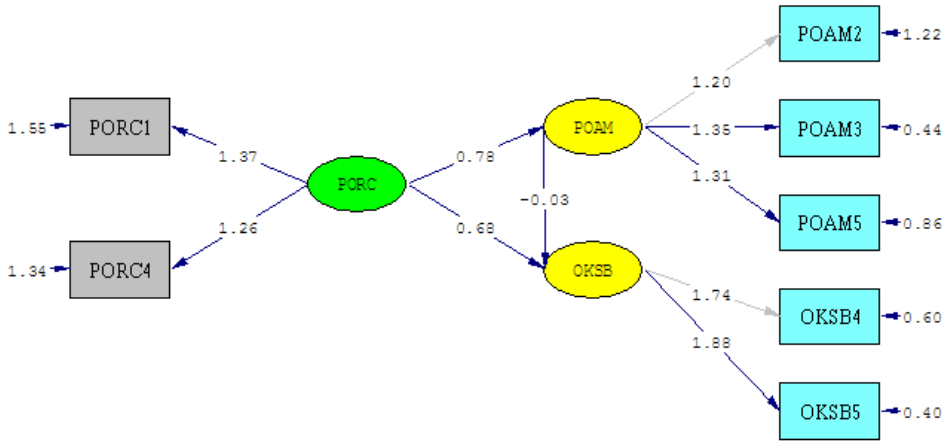
Normed Fit Index (NFI) = 0.98
Non-Normed Fit Index (NNFI) = 1.02
Parsimony Normed Fit Index (PNFI) = 0.51
Comparative Fit Index (CFI) = 1.00
Incremental Fit Index (IFI) = 1.01
Relative Fit Index (RFI) = 0.97

Critical N (CN) = 266.74

Root Mean Square Residual (RMR) = 0.11
Standardized RMR = 0.035
Goodness of Fit Index (GFI) = 0.97
Adjusted Goodness of Fit Index (AGFI) = 0.93
Parsimony Goodness of Fit Index (PGFI) = 0.38

Time used: 0.031 Seconds

Path Diagram for Case Study 2 resulted form LISREL 8.8, Input from MIMBuild alpha = 0.20



Chi-Square=7.78, df=11, P-value=0.73258, RMSEA=0.000