Factors Affecting Research Productivity of Faculty Members in Government Universities: Lisrel and Neural Network Analyses

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ABSTRACT

The purposes of this research were 1) to study researcher's characteristics, researchership, research competence and institutional support for research work as factors affecting research productivity, 2) to test for invariance of research productivity models across groups with size difference in Pedagogy Department, and 3) to compare the results of factors affecting research productivity using LISREL and Neural Network analyses. The sample consisted of 300 faculty members from 16 government universities. The research instruments were rating scales measuring research productivity, researchership, research competence and institutional supports for research work. The reliabilities of the instrument ranged from .76-.96. Data were analyzed through descriptive statistics, LISREL, and Neural Network Analyses.

The major findings were: 1) The average of each faculty member's research productivity was 0.40 research pieces per year; 2) Researchership and research competence were high in average, and institutional support for research work was moderate; 3) Research productivity model fitted well to empirical data (Chi-square=80.007, p=0.132 df=67, GFI=0.963, AGFI=0.942, RMR=0.161). The test of model invariance across 2 groups of departments with different size indicated that the two models were invariant in form, but varied in loading and other parameters. The causal relationship using LISREL and Neural Network analyses suggested consistently that researcher characteristic, research competence, institutional support for research work and researchership had direct effects on research productivity; 4) The comparison of analyses with LISREL and Neural Network indicated similar results.

Key words: Research productivity, researchership, Lisrel, Neural Network

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บทคัดย่อ

งานวิจัยครั้งนี้มีวัตถุประสงค์เพื่อ 1)ศึกษาปัจจัยด้านคุณลักษณะส่วนบุคคลปัจจัยด้านความเป็นนักวิจัย ปัจจัยด้านสมรรถภาพการวิจัย และปัจจัยด้านคุณลักษณะของสถานศึกษาที่เอื้อต่อการทำวิจัยที่ส่งผลต่อผลิตภาพการวิจัย 2) ตรวจสอบความไม่แปรเปลี่ยนของโมเดลผลิตภาพการวิจัยของอาจารย์สถาบันอุดมศึกษาของรัฐในคณะศึกษาศาสตร์/ครุศาสตร์ที่มีขนาดต่างกัน และ 3) เปรียบเทียบผลการวิเคราะห์ปัจจัยที่ส่งผลต่อผลิตภาพการวิจัยระหว่างการวิเคราะห์ด้วยโปรแกรมลิสเรลกับการวิเคราะห์ด้วยเครือข่ายใยประสาท กลุ่มตัวอย่างคืออาจารย์สังกัดคณะศึกษาศาสตร์/ครุศาสตร์ที่มีผลงานวิจัยในช่วงเวลา 3 ปีที่ผ่านมา จำนวน 300 คน จากมหาวิทยาลัยของรัฐ 16 แห่ง เครื่องมือการวิจัยเป็นแบบสอบถามผลิตภาพการวิจัยและแบบวัดความเป็นนักวิจัย สมรรถภาพการวิจัยและคุณลักษณะของสถานศึกษาที่เอื้อต่อการวิจัย มีช่วงพิสัยค่าความเที่ยงระหว่าง .76 - .96 วิเคราะห์ตรวจสอบความตรงและความไม่แปรเปลี่ยนของโมเดลด้วยโปรแกรม LISREL วิเคราะห์ปัจจัยที่ส่งผลต่อผลิตภาพการวิจัยด้วยเครือข่ายใยประสาทด้วยโปรแกรม Clementine

ผลการวิจัยสรุปได้ว่า 1) อาจารย์มีค่าเฉลี่ยผลิตภาพการวิจัยคิดเป็น 0.4 เรื่องต่อคนต่อปี 2) ปัจจัยด้านความเป็นนักวิจัยและสมรรถภาพการวิจัยมีค่าเฉลี่ยระดับสูง แต่มีค่าเฉลี่ยของคุณลักษณะของสถานศึกษาที่เอื้อต่อการทำวิจัยระดับปานกลาง 3) โมเดลผลิตภาพการวิจัยมีความสอดคล้องดีกับข้อมูลเชิงประจักษ์ (ไค-สแควร์ = 80.007, p = 0.132 ที่องศาอิสระ= 67, GFI = .963, AGFI = .942, RMR = 0.161) ผลการทดสอบความไม่แปรเปลี่ยนของโมเดลผลิตภาพการวิจัยระหว่างคณะขนาดใหญ่และขนาดเล็กพบว่าโมเดลไม่แปรเปลี่ยนด้านรูปแบบ แต่มีความแปรเปลี่ยนของพารามิเตอร์น้ำหนักองค์ประกอบและพารามิเตอร์อื่น ๆ ส่วนผลการวิเคราะห์ความสัมพันธ์เชิงสาเหตุในโมเดลจากการวิเคราะห์ด้วยลิสเรลและเครือข่ายใยประสาท พบสอดคล้องกันว่าคุณลักษณะส่วนบุคคล สมรรถภาพการวิจัย และคุณลักษณะของสถานศึกษาที่เอื้อต่อการทำวิจัยและความเป็นนักวิจัยมีอิทธิพลทางตรงต่อการมีผลิตภาพการวิจัย 4) การเปรียบเทียบผลการวิเคราะห์ปัจจัยที่ส่งผลต่อผลิตภาพการวิจัยวิเคราะห์ด้วยลิสเรลและเครือข่ายใยประสาท พบว่าให้ผลการวิเคราะห์สอดคล้องกัน

คำสำคัญ: ผลิตภาพการวิจัย ความเป็นนักวิจัย ลิสเรล เครือข่ายใยประสาท

INTRODUCTION

The quality and quantity of institution's research became one of the key benchmarks in academic achievement and excellence. In higher education, research productivity often served as a major role in attaining success in academics as it is related to promotion, tenure and salary (Bloedel, 2001; Kotrlik *et al*., 2002).

Jitpitak (1989) and Pabhapote (1996) and several researchers studied factors related to the faculty's research productivity and found that personal characteristics and environmental factors positively correlated with and could predict the faculty's research productivity. Although there were a large amount of research reports attempting to explain variation in research productivity, most of them focused on estimation of the effects of factors influencing research productivity. Recently there has been a rapid progress on research methodology pertaining to the analysis of causal relationships among variables displaying in the term of structural equation model. Among those techniques of analyses, LISREL model analysis apparently has been most popularly applied in behavioral research. LISREL analysis is considered to be a sophisticated tool relying on statistical technique. Hence, it is interesting to get a clearer picture of the causal relationship model of research productivity by LISREL technique.

Nowadays, data processing taken from computer engineering is introduced in the social sciences, the Neural Network Analyses (Tan *et al.*, 1996; Ader and Bramsen, 1998; Ragothaman, Davies and Moen, 1998; Sinha and McKim, 2000; Gonzalez and DesJardins, 2002) that scrutinizes the prediction efficiency and grouping of data. The Neural Network Analyses had no pre-agreement; still it delivered highly accurate results. However, this analytical technique has not been widely used among social scientists because it involves the calculation of several hidden node with activation functions. As a result, the weight value estimated by the program can find neither correlation nor comparison. Ader and Bremsen (1998) tested on analyzing the structural equation modeling of research productivity with the Neural Network Analyses. The results found was the consistency between the weight values derived from the Neural Network Analyses and the effect value of LISREL parameter of LISREL model. On the LISREL parameter, the high effect value earned high weight value in the Neural Network analysis as well.

This research focused on 2 major questions. The first question was on factors affecting the research productivity and how they affected the productivity model. The second question was how different the model developed by the researchers was when being analyzed with LISREL and the Neural Network Analysis, whether they were similar or different, and which variables or factors caused the productivity research model similarity or difference.

Objectives

The purposes of this research were 1) to study researcher's characteristics, researchership, research competence and institutional supports for research work as factors affecting research productivity, 2) to test for invariance of research productivity models across groups with size difference in pedagogy departments, and 3) to compare the results of factors affecting research productivity using LISREL and Neural Network analyses.

Theoretical framework

Definition and measurement of research productivity

Not many researchers provided the definition of research productivity. Williams (2003) noted that research productivity could be defined in terms of research product and research effort, to the extent of which a researcher produces. Most studies measured research productivity by calculating a composite indicator derived by summing up the number of finished research reports, number of published research reports, and number of utilized research report. The measurement of research productivity could be different depending on the weights given to each indicator. Bloedel (2001) recommended that indicator of getting published in leading journals should have higher weight than other indicators. Kotrlik *et al.* (2002) recommended a weight for published research based on status of the researcher as follows: a weight given to a sole author, co-author, and third author with 1.0, 0.5, and 0.33, respectively.

Practically, Jitpitak (1989), Pipatrojkamon (1994), Pabhapote (1996) and Changsrisang (2002) estimated research productivity score by calculating the ratio of research products and the period of conducting research. Sax *et al.* (2002) estimated research productivity as an average number of published research report in the last two years. This study used researcher's role, publications in journals, research fund and the procedure of research as a surrogate for research productivity.

Factors affecting research productivity

Several variables had been reported to be related to research productivity. In this study, we organized those variables into 4 groups: researchers' characteristics, researchership, research competence and institutional support for research work. In the first group, age and academic position had significant effects on research productivity. Panthupa (1997) observed that average research productivity seemed to drop as age increased. But Kotrlik *et al.* (2002) reported that there was no significant evidence that

age determined a drop in research productivity. Jitpitak (1989); Pabhapote (1996); Blackburn & Tien (1996); Dundar & Lewis (1998) and Sax *et al.* (2002) found that academic position was a significant predictor of research productivity. But Kotrlik *et al.* (2002) and Williams (2003) stated that there was no relationship between them. It was noticeable that age and academic position were significant factors affecting research productivity in Thai culture, but not in western culture.

In the second group, Jitpitak (1989), Pabhapote (1996) and Panthupa's (1997) model of research productivity indicated that the researchership had total effect and direct effect on research productivity. Researchership factors consisted of four indicators, namely 1) thinking factor 2) research mind 3) volition and control, and 4) meeting of international standard.

In the third group, Faculty members' confidence in their research abilities was found related to faculty research productivity. Pabhapote's (1996) model of faculty research productivity included research competence in one's research as an explanatory factor. Increased ability to do research was also correlated with increased research productivity according to the study conducted by Panthupa (1997). Research competence factors consisted of five indicators i.e. research skills and techniques, research fund, research management, communication skill, and networking and teamworking.

In the fourth group, perceived institutional supports for research work were the most important factors enhancing research productivity. Several studies had confirmed these significant effects on research productivity (Jitpitak, 1989; Panthupa, 1997; Changsrisang, 2002; Hughes, 1995 and Dundar & Lewis, 1998). Those research references employed several indicators measuring institutional and departmental supports for researchers. The most important indicators were institutional policy that encouraged instructors to do research, institutional library budget and computing facility. (Panthupa, 1997; Dundar & Lewis, 1998; Kotrlik *et al.*, 2002; Ratanit, 1993)

In summary, all indicators measuring the 4 groups of factors affecting research productivity had significant loadings, which consequently enhanced research productivity. The causal model displayed in LISREL model is shown in Figure 1.

It should be noted that there were no research evidences supporting associations among 4 exogenous latent variables in the model, and no research references on the mediator or moderator in the model. This causal model of research productivity, therefore, was simple enough to investigate by employing LISREL model analysis.

RESEARCH METHOD

Population and sample

The sample consisted of 300 faculty members randomly selected from the total 1,200 faculty members of Pedagogy Departments at Thai public universities.

Instrument

Tools used with the variables affecting research productivity was divided into 5 sections i.e. a questionnaire on personal data; researchership test, research competence test, a questionnaire on institutional research-promoting characteristics and a questionnaire on research productivity. The internal reliability was measured by Cronbach's Alpha with the range between .76-.96. The tool trial-out was carried out with the selected sample for structural validity of the confirmatory second-order factor analysis. Chi-square was found between 4.088-16.975 (df = 4-df = 23) in the study.

Data Collection and analysis

The data analysis was descriptive in which correlation analysis, validity test and invariance analysis of the research productivity model and the Neural Network Analysis were investigated.

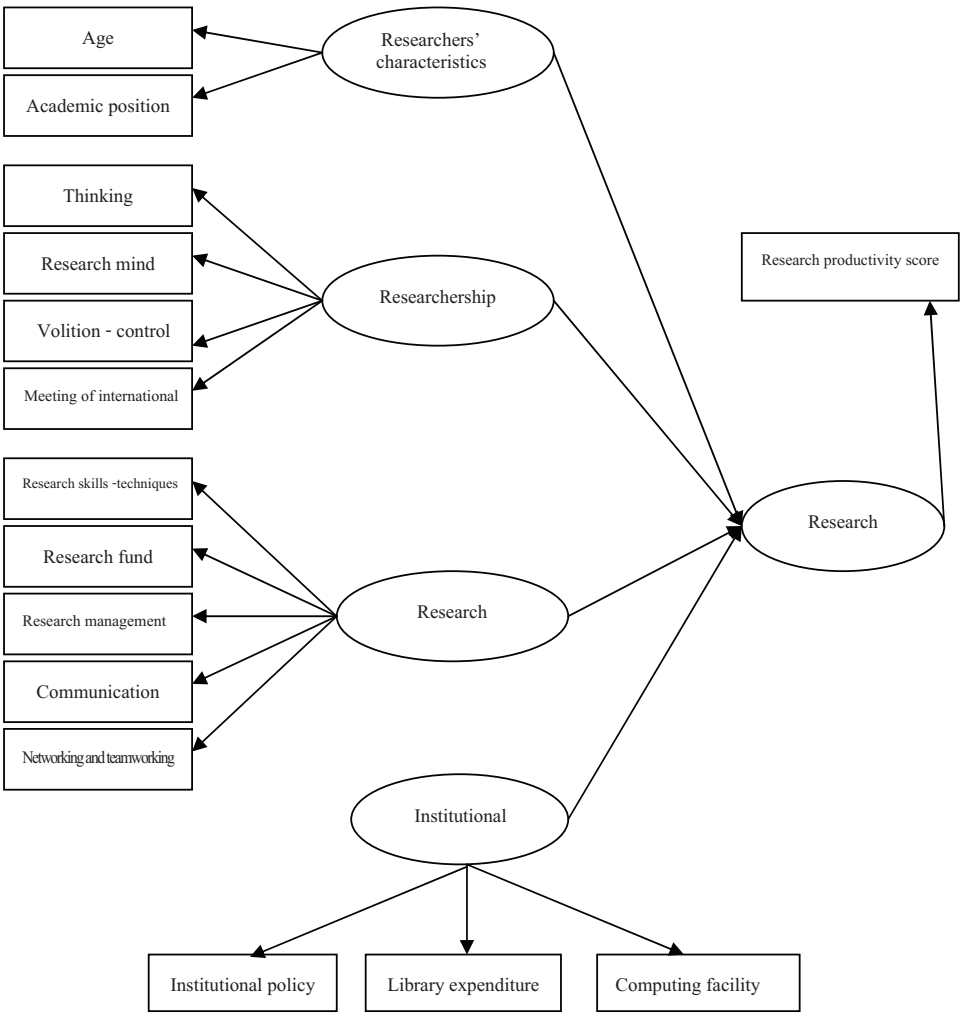

Figure 1 Structural Equation Modeling of Research Productivity

RESULTS

Among 300 selected respondents who conducted 863 research projects during 2002-2005, the sampled instructors of Pedagogy Departments conducted research at the average of 1-2 projects per person the most or 57.33 percent, and more than 3 projects at 42.67 percent. Most projects or 57.75 percent were group research. Most projects or 67.27 percent consumed 1 year and 11 months per project, whereas 13.61 percent were conducted in 2 years - 2 years 11 months. Projects with more than 4 years were the smallest group or 4.88 percent.

The instructors providing the data were mostly project leaders. The research budget with less than Baht 100,000 was found at 49.42 percent, and more than Baht 400,000 at 24.78 percent. With regard to research status, 60.60 percent of the respondents finished the projects and 69.68 percent of research were published in academic journals at the faculty, institutional, national and international levels.

The correlation results of the research productivity model of the respondents as shown in Figure 2 were found consistent with empirical data. (80.007 Chi-square, p = 0.132, df 67, GFI .963 and AGFI .942 and RMR were 0.161.)

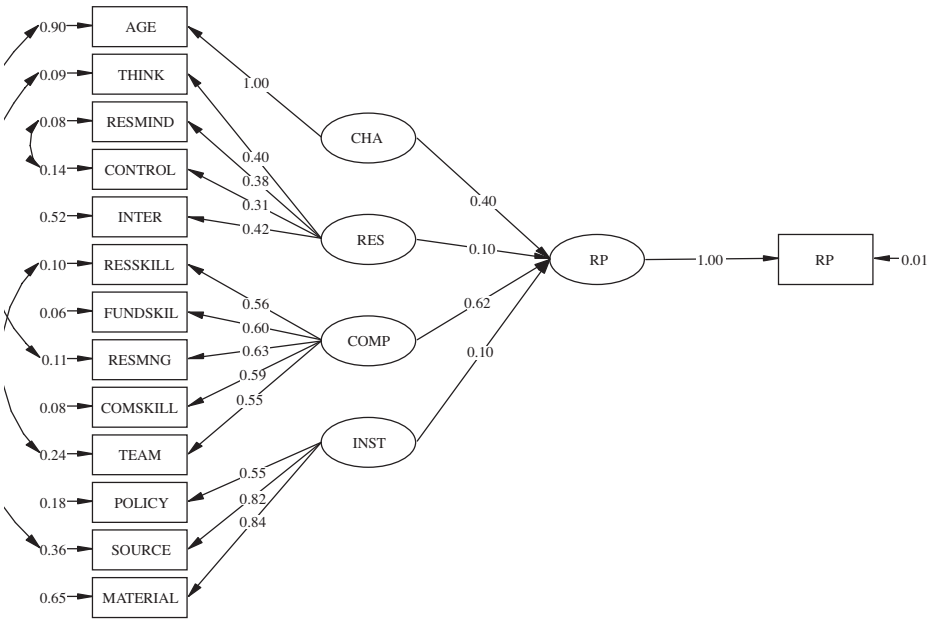

Figure 2 Causal model of research productivity

It was found that the highest validity of the observed variables was found .99; whereas the second highest, funding skills, was .85. The validity for communication skills and research management were .80 and .78, respectively.

Correlation coefficient value (R-square) of the research productivity variable was .936 which determined that the variables in the model were able to explain 93.60 percent of variance of the research productivity variables.

When considering research productivity variables, it was found that they were affected by direct correlation with the researchers' characteristics, researchership, research competence and institutional research-promoting characteristics at positive effect value 0.398, 0.100, 0.623 and 0.100, respectively. This implied that the instructors at the Pedagogy departments who were capable in research skills and technique, funding skills, research management and research communication skills and networking and teamworking would produce high research productivity. The higher the age reached, the higher the productivity became. Researchership such as thinking factor, research mind, volition and control and language ability are important requirements to achieve international standards and were found in this study as factors affecting high research productivity.

Under institutional support for research work, the perceived institutional characteristics such as research policy of the institution, data source and research conducting equipment were associated with research productivity. On the other hand, the instructors who perceived the lack of institutional research policy and the insufficiency of research sources and research equipment would deliver a fewer research projects.

Upon the invariance analysis of the research productivity model it was concluded that the model without forced conditions was associated with the empirical data showing that the model did not vary according to the size of the faculties at the .05 significance level. This implied that the research productivity model of the instructor population in the large and small pedagogy departments shared the same model parameter and model form. Upon the analysis of model with forced conditions (Hypothesis

model 2-5) inconsistency was found with the empirical data at the .05 significance level which represented the differences at the .05 significance level in the research productivity model of the instructors of the large and small faculties of matrix parameter LY, LX, TE, TD, GA, PH and PS. However, the models which were highly associated with the data were the hypothesis model of item 1, which was the model that did not have the forced conditions. The findings were determined by the lowest chi-square rate to the degree of freedom and the probability close to 1 when compared to other hypothesis models as shown on Table 1.

The factor analysis affecting the research productivity with Neural Network Analyses with the Quick mode Expert the learning rate derived was 0.9 and the momentum was 0.3. The findings were 90.84 percent accurate. Age was the most affecting factor whereas funding skills, research communication skills, research skills and technique and institution research policy had less effect. Researchership under thinking factor and research management were the least affecting factors as shown on Table 2.

Using the Neural Network Analyses, it was found that comparing the importance value with the weight value derived from LISREL must be conducted in the same manner. The researchers therefore reanalyzed the data stressing on variable association and analysis principles in to two manners. When comparing the findings of observed variables, it was analyzed with LISREL under the internally and externally observed variables for invariance. It was found that research skills and technique, funding skills, and research communication skills had the same effect values, which were at the top rankings. When comparing the importance value analysis findings of Neural Network Analyses, the association was found as shown on Table 3.

The second issue was the comparison between the findings in case that the variables were all hidden. The researchers rearranged 13 variables into 4 categories according to the research productivity analyzed by LISREL program such as characteristics, researchership, research competence and institutional support for research work. This was done for analyses with LISREL and Neural Network Analyses again. The findings from LISREL are shown on Table 4 and from the Neural Network Analyses on Table 5.

On Table 5, research competence was found having the highest importance value whereas institutional support for research work, researchership and characteristics were second highest. When comparing importance value found by Neural Network Analyses with effect value found by LISREL (Table 4), both values were consistent in all

Table 1 Findings of the invariance in the form and parameter hypothesis of the research productivity model among various instructor groups classified by faculty sizes

Hypothesis	Hypothesis Model	χ^2	df	χ^2/df	p	GFI	Difference χ^2	Difference df	χ^2 (.05)	from the table(.01)
1	Non-changeable form	154.79	131	1.18	0.07	0.91	-	-	-	-
2	Non-changeable LX LY and 1	172.88	143	1.21	0.04	0.90	18.08	12	21.03	26.22
3	Non-changeable TD TE and 2	190.35	159	1.19	0.04	0.89	17.48	16	26.30	32.00
4	Non-changeable GA and 3	195.22	161	1.21	0.03	0.89	4.87	2	5.99	9.21
5	Non-changeable PH PS and 4	204.82	169	1.21	0.03	0.88	9.59	8	15.51	20.09

Table 2 Preliminary data, data analysis findings and importance value of factors affecting research productivity analyzed with Neural Network Analyses

Preliminary data	
Input nodes: 13	Hidden layer 1 nodes: 20
Output nodes: 1	Algorithm: Back propagation
Training example rows: 150	Validating example rows: 150
Target error: below .01	Estimated accuracy: 90.845
Learning rate 0.9	Momentum 0.3
Input nodes	Importance value
Age	0.0663
Thinking factor	0.0042
Research mind	0.0107
Volition and Control	0.0116
Language ability	0.0213
Research skills and technique	0.0419
Funding skills	0.0637
Research Management	0.0016
Research communication skills	0.0432
Networking and teamworking	0.0082
Institutional research policy	0.0239
Data source	0.0170
Research equipments	0.0237

Table 3 Category weight and importance value comparison

Program	LISREL		Neural Network Analysis	
Variable/data	Effect value	Percentage/ Rank	Importance value	Percentage/ Rank
Age	0.043	1.80(13)	0.0663	19.94(1)
Thinking factor	0.100	4.19(6)	0.0042	1.21(12)
Research mind	0.200	8.39(4)	0.0107	3.02(10)
Volition and control	0.100	4.19(6)	0.0116	3.32(9)
Language ability	0.086	3.62(12)	0.0213	6.34(7)
Research skills and technique	0.400	16.77(2)	0.0419	12.34(4)
Funding skills	0.456	19.12(1)	0.0637	19.03(2)
Research management	0.100	4.19(6)	0.0016	0.30(13)
Research communication skills	0.400	16.77(2)	0.0432	12.99(3)
Networking and teamworking	0.100	4.19(6)	0.0082	2.42(11)
Institutional research policy	0.200	8.39(4)	0.0239	6.95(5)
Data source	0.100	4.19(6)	0.0170	5.14(8)
Research equipments	0.100	4.19(6)	0.0237	6.95(5)

categories. Research competence was the highest in effect value (1.334). Effect values of institutional support for research work, researchership and characteristics at .300, .200 and .044 were consistent with the importance value derived from the Neural Network Analyses at .114, .061, .057 and .056, respectively, as shown on Table 6.

DISCUSSION

In this paper we examined data from the faculty members of 16 pedagogy departments in Thai public universities in order to investigate the causal relationships between research productivity and researcher's characteristics, researchership, research

Table 4 Statistical value of research productivity model effect analysis (Latent variables)

Dependent Variables	Research Productivity		
Independent Variables	Total effect (TE)	Indirect effect (IE)	Direct effect (DE)
Characteristics	0.044*	-	0.044*
Researchership	0.200	-	0.200
Research Competence	1.334*	-	1.334*
Institutional support for research work	0.300	-	0.300
Chi-square = 11.129 df = 8, p = 0.194 GFI = .985 AGFI = .972 RMR = .182			
Structural variable equation	Research Productivity		
R-SQUARE	.07		

* $p < .05$

Table 5 Findings of Data Analysis, Effective factors' Importance Value analyzed by Neural Network Analyses (Latent Variables)

Preliminary node	
Input nodes: 4	Hidden layer 1 nodes: 3
Output nodes: 1	Algorithm: Backpropagation
Training example rows: 150	Validating example rows: 150
Target error: below .01	Estimated accuracy: 90.729
Learning rate 0.9	Momentum 0.3
Input nodes	Importance value
Characteristics	0.056
Researchership	0.057
Research competence	0.114
Institutional support for research work	0.061

Table 6 Effect value and importance value of the factors affecting research productivity

Variable/Node	Effect value (LISREL)	Importance value (Neural Network Analysis)
Characteristics	0.044	0.056
Researchership	0.200	0.057
Research competence	1.334	0.114
Institutional support for research work	0.300	0.061

competence and institutional characteristics that support research work. The findings from this study are important for Thai public universities for several reasons. Most importantly, we found consistent by with some previous studies that researcher's characteristics and research competence are closely associated with research productivity. The effects further suggest that research competence may have more influence than researcher's characteristics on individual productivity. Therefore, universities attempting to increase their research productivity should set up programs to increase of research abilities current faculty members. For example, a mentoring program could be developed to assist junior faculty members to enhance their research competence.

The number of research work per instructor at the pedagogy departments was found 0.4 project per year, which was very low. This implied that in the past research policy of the concerned organizations such as the Commission on Higher Education, The Office for National Educations and Quality (ONESQA), the Thailand Research Fund (TRF) and universities' policy did not stimulate enough research productivity. The enthusiasm of conducting research was caused by intrinsic or extrinsic motivation towards delivering academic research for instructor career's good prospects. At some university abroad, research publication is used for the employment evaluation and promotion. (Lombardi, 2001; Kotrlik *et al.*, 2002)

Most affecting factors of research productivity were under personal characteristics such as age; under research competence such as research skills and technique, funding skills, research management, research communication skills and networking and teamworking found by both LISREL and Neural Network Analyses; whereas institutional support for research work and researchership had the second large effects.

Comparing the analysis of research productivity using LISREL and the Neural Network Analyses revealed five observations. Firstly, the program was convenient in terms of data analysis duration. LISREL was basically applicable with Microsoft Window which is familiar to most researchers in the social sciences. The results of LISREL were presentable in both text and figure. The text results showed at the analysis command sentence in details; namely the empirical data estimation comparison of the programs. The researchers can specify the results needed to the program again for the analysis. Both results are shown on the model chart derived from the calculation and they can be saved as .wmf and .gif files.

The analysis duration of LISREL depends on the sophistication of the analysis. The more sophisticated the calculation, the longer time it takes. However, the researchers had to re-analyze the data or adjust the model again in order to get the best results. Some model took more than 20 times of calculation, involving over days or months for one model to complete. The analysis techniques used were many times, depending on the skills of each researcher and sophistication of model.

Clementine is the program developed by SPSS that has 3 steps of data analysis. The first step is to prepare the data where the .sav, .xls and .txt file types are applicable. The researcher has to determine the status of the variables for analysis such as incoming, outgoing, both incoming and outgoing and non-relevant data. The second step is the selection of the data analysis in which the Neural Network Analyses was one of the 12 methods of Clementine Program with the logo shown where the forms and the command line included. The final step is the analysis. The program will give the results of the analysis with the same logo. The researcher can see the results by clicking at the logo. The duration used each analysis is less than 1 minute. However there is no need for the researcher to adjust the model used in the Neural Network Analyses because the program will stop automatically when the analysis is complete. The Neural Network Analyses will not show any logo together with the results. It can be concluded that with the application of LISREL and

Neural Network Analyses under Clementine Program the researcher needs to know the commands and how to read the results for both programs. The Neural Network Analyses was consuming less processing time than LISREL.

Secondly, the methods of estimation according to LISREL program are made in 7 ways i.e. Instrumental Variables (IV), Two-Stage Least Squares (TSLS), Unweighted Least Squares (ULS), Generalized Least Squares (GLS), Maximum Likelihood (ML), Generally Weighted Least Squares (WLS) and Diagonally Weighted Least Squares (DWLS). With to Clementine, the methods of estimation are made in 5 ways i.e. Neural Networks, Rule Induction, Kohonen Network, Association Rules, Statistical Models and Clustering Models.

Thirdly, testing the model with LISREL the association between the model and empirical data were found in many ways such as SEs, t value, χ^2, Goodness of Fit Index (GFI), Adjusted Goodness of Fit Index (AGFI) and Root Mean Square Residual (RMR). The Neural Network Analyses gives the estimated accuracy equivalent to significance value (Willett, 2001) for the relative importance as input between 0.0 -1.0. Fourthly, the flexibility of the analysis of LISREL can be applied with a variety of research models because LISREL includes measuring models and structural models within the analysis. It is capable of doing multiple group analysis. LISREL also has PRELIS sub program which to analyze variable association with ranking measurement and censored variables as well as to find asymptotic covariance matrix for the WLS analysis.

Having hybrid analyzing principle between mathematics, science and domain expertise, the Neural Network Analyses is suitable and highly accurate for the prediction of the targeted models. Even though the Neural Network Analyses did not present the analyzing principles clearly, in many studies it was found that the Neural Network Analyses was associated with the conventional methods of statistical analysis such as regression, chi-square and structural equations. Additionally, the mathematics methods of the Neural Network Analyses produced regression value which is favorable for the estimation. (Luan, 2001)

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