



Trust Game and Behaviour Pattern of Public-Private Partnership Project Management Team Based on EEG

Jinglei Meng*, Guoyi Xiu

ABSTRACT

The Public-Private Partnership (PPP) project is currently one of the main ways for countries to get back from the economic downturn and realize entrepreneurial economy. If the management team wants to achieve long-term stable and vigorous development, it must establish a lasting and reliable trust relationship. The neuroscience research on game has provided new methods and ideas for the study of trust. Based on the game and ERP experiments, this paper constructs a model for the relationships between the factors of trust, individual risk preferences and partner's behaviours and the investment behaviours. At the same time, based on the EEG data with ERP components, this paper further analyzes the internal neural influencing mechanism of how various factors affect the cognitive process and decision-making attitude of trust, modifies, tests and re-modifies the experimental model through enterprise interviews and SEM; and finally obtains the model for the trust recognition mechanism and behaviour pattern among members of the PPP project management team, and proposes measures to keep long-term stable trust between members of the project management team, so as to promote the development and expansion of the PPP project management team

Key Words: EEG, PPP Project Management Team, Game, ERP, SEM

DOI Number: 10.14704/nq.2018.16.6.1660

NeuroQuantology 2018; 16(6):219-226

219

Introduction

The PPP project is the most important way for countries of the world to get back from the economic downturn and achieve entrepreneurial economy. However, many members of PPP project management teams focus more on exchanging tangible interests and greatly neglects the exchange of intangible trust. One of the most important reasons for partnership business failure is the breakdown of trust (Suh and Kwon, 2006; Lippincott *et al.*, 1993). Since the 1990s, many scholars have been studying trust. These research results allow us to have a more comprehensive understanding of trust. The trust cognition mechanism for the the two sides of a PPP project is

essentially a complex system (Clampit *et al.*, 2005; Grover *et al.*, 1996; Bailie *et al.*, 2010). In partnership entrepreneurial activities, trust is expressed as the behaviour pattern of entrepreneurs. This paper performs computer testing and trust game experiments to provide reliable physiological and behavioural data for discussion of trust decision-making and cognitive processes, and also enhances the theoretical foundations for the establishment of relation models (Moon *et al.*, 2017; Yeung *et al.*, 2013; Shi *et al.*, 2016).

Corresponding author: Jinglei Meng

Address: School of Economics and Management, Harbin University of Science and Technology, Harbin 150080, China

e-mail ✉ mengjinglei420@126.com

Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Received: 6 March 2018; **Accepted:** 25 April 2018



Table 1. Factor frequency statistics

Order	Consideration factors	Frequency of occurrence	Proportion
1	Economic environment	7	8.40%
2	Cultural background	11	10.54%
3	Reputation	9	9.42%
4	Professional ability	5	6.37%
5	Third-party authority	5	4.25%
6	Organizational atmosphere	7	8.38%
7	Team size	8	7.33%
8	Interpersonal relationships	7	6.35%
9	History	4	5.25%
10	Communication and sharing	9	9.49%
11	Legal contract	11	11.53%
12	Resource complementarity	5	5.32%
13	Other	7	7.37%
A combined		95	100%

Factors of trust in the establishment of business partnerships

Factors of trust

There are various factors that can influence trust, and many of them interact with each other or have fuzzy boundaries (Kanmogne and Eskridge, 2013; King *et al.*, 1984). The author comprehensively analysed 32 domestic and international articles on the influencing factors and then statistically summarized the factors that affect the investor’s trust in its partner in a PPP project, as shown in Table 1.

These factors are classified as follows: (1) external factors: 1, 2, 5 and 11; (2) trait factors: 3, 4, 6 and 7, which are the factors showing the traits; (3) relationship factors: 8, 9, 10, and 12, that is, the factors showing the interactions.

Modelling

The author collected the data mainly through questionnaire survey, and then sorted and analyzed these complex data using AMOS 17.0 and SPSS 16.0. At last, the author obtained the measurement dimensions of the index system and performed Cronbach’s α analysis, as shown in Fig. 1.

Then the author selected Data File to configure from the File under the path AMOS and found the File Name. The evaluation results of the model are shown in Tab. 2.

The high-order factor composite reliability is calculated as follows:

$$\rho_v = \frac{(\sum \lambda)^2}{[(\sum \lambda)^2 + \sum (\theta)]} \quad (1)$$

The average variance extraction quantity is a latent variable, mainly used to describe in detail the variation of an index variable. It is used

as a criterion to indicate convergence validity. As the value of this variable increases steadily, the measurement indices can more clearly show the potential traits of common factors.

Internal due to potential variables	External due to potential variables	Observation variable	Cronbach’s α
The trust between the PPT project team(1)	External factors (ξ 1)	economic environment (X1)	0.6721
		Cultural background(X2)	0.6335
		Third-party authority(X3)	0.6213
		Legal contract(X4)	0.6892
	The factors (ξ 2)	Organizational atmosphere(X5)	0.6551
		Reputation(X6)	0.7031
		Professional ability(X7)	0.6433
		Team size(X8)	0.6702
	Relationship factors (ξ 3)	Interpersonal relationships(X9)	0.7213
		History of cooperation(X10)	0.6954
		Communication and sharing(X11)	0.7134
		Resource complementarity(X12)	0.6491

(Cronbach’s $\alpha > 0.6$ Reliability acceptable, > 0.7 High reliability)

Figure 1. Index system measurement dimensions and Cronbach’s α analysis

$$\rho_v = \frac{(\sum \lambda^2)}{[(\sum \lambda)^2 + \sum (\theta)]} \quad (2)$$

Based on the results of software operation and relevant theories, the author obtained the path diagram for fully standardized coefficients of the optimal model, where each factor ξ has a positive effect on the factor η , and Fig. 2 shows the results of the optimal fitting model.



Table 2. Model evaluation results

Measurement	Factor loading	Reliability coefficient	Measurement error	Composite reliability	Mean variation
X1	0.812	0.662	0.334		
X2	0.767	0.591	0.415		
X3	0.725	0.547	0.462		
X4	0.673	0.463#	0.523		
				0.834	0.558
X5	0.750	0.554	0.435		
X6	0.872	0.755	0.245		
X7	0.782	0.612	0.392		
X8	0.718	0.511	0.485		
				0.862	0.611
X9	0.890	0.780	0.197		
X10	0.792	0.635	0.345		
X11	0.815	0.664	0.334		
X12	0.828	0.685	0.313		
				0.900	0.695
ξ1	0.720	0.552	0.470		
ξ2	0.855	0.726	0.270		
ξ3	0.905	0.816	0.186		
				0.868	0.689

Note: # indicates no minimum value; factor loading < .70; reliability coefficient < .50

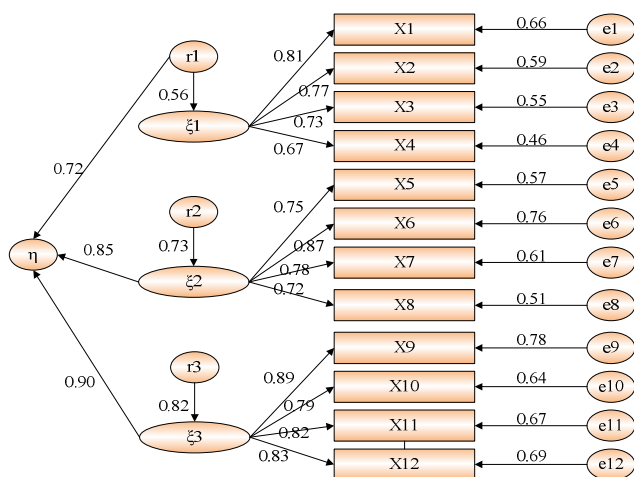


Figure 2. Optimal fitting model results

According to a comprehensive analysis of the output results of the structural equation model, there are three elements of the latent variables, namely, trait variables, relational variables and external variables. Their loads are 0.85, 0.90, and 0.72, respectively. This order fully shows that: the relational factors have much greater influence on the trust between partners than the trait factors. External factors have the least influence among the three. Economy has a load of up to 0.81, which is the highest among the external factors, showing that among all external factors, economy has the most obvious influence on the partnership trust; reputation has a load of up to 0.87, the highest among all trait factors, showing that reputation has the greatest influence on partnership trust among the trait factors; interpersonal relationship has a load of

up to 0.90, the highest among all the relational factors, showing that interpersonal relationship has the greatest influence on partnership trust in the relational factors.

Influencing mechanism for the trust cognition and decision-making behaviours based on game neuroscience

Theoretical basis for the experimental study

(1) Neuroscience analysis on gaming
 Through game experiments and application of the fMRI technology, we can, on one hand, better understand how trust and mutual benefit influence the investment decisions made by decision makers, and on the other hand, know the relationship between the activity level of the brain caudate nucleus and the trusting intention. In 2005, Shiv *et al.* from Stanford University combined neural experiments with cognitive neuroscience theories. From then on, a large number of scholars in management and economic fields at home and abroad began to pay attention to the game theory, and that was when the related potential technology (ERP) emerged. This technology, now widely used in the practical field, can detect the brain waves of the psychological activities of decision makers in milliseconds.

(2) ERP component analysis

N2 represents the core evaluation index in cognitive control and conflict detection. The amplitude of N2 reflects the level of cognitive conflict generated by risk information. After stimulation, the peak incubation period of the N2 component was up to 00-350ms. This result



shows that: the conscious processing of diversified information by the individual brain represents the level of influence that monitoring information has on decision-making conflict. A comprehensive analysis of the N2 component clearly reveals the individual's cognition of external information. P3 is the attitude formation index. After the conflict information is processed, there will be a decision-making attitude, with a peak latency of 300-600ms. The amplitude has an inverse relationship with the decision-making attitude; in other words, if the decision-maker shows too much disgust and avoidance, the amplitude of P3 will be reduced.

Experimental considerations

Stage 1: distinguish the risk preferences of the subjects per the *Risk Preference Scale*, analyse them in groups and focus on studying the role of risk preference in trust cognition and decision-making behaviours.

Stage 2: in the investment decision experiment, before the amount of investment is determined, give both positive and negative stimulating trust factors, let decision makers have a clear understanding of multiple factors before designing investment decisions and then provide feedbacks for them. Dynamically monitor the changes in the brain waves of investors to explore the influences of decision makers' different cooperative behaviours on their decision-making attitudes and trust cognition.

Experimental results of the influencing factors to cooperative decision-making behaviours

1. Trust factors only affect the trust cognition process and have no effect on the process of decision-making.

2. Risk preference simply influences the decision formation process, and the influencing factors do not include the trust information cognition process.

3. Partner's behaviours have influences on the formation process of both trust cognition and decision-making attitudes.

According to the EEG monitoring results and behavioural results, the author drew the relational diagram for the influences of various factors, as shown in Fig. 3.

Empirical analysis on the model for trust cognition mechanism and behaviour patterns

Interview of start-up partnership enterprises

This interview mainly targeted members of the PPP project management team. The interview was conducted in the form of an academic workshop. The topic was the subject of this research, and the specific interview results are as follows:

During the interview, the author found that when choosing business partners, entrepreneurs mainly took three kinds of factors into account - relational factors, external factors and trait factors. After careful analysis of these three kinds, the entrepreneurs would determine whether they could trust this partner and ultimately make a choice.

Each interviewee showed an emphasis on management during the interview. Each decision maker had differentiated management behaviours according to their trust in their partners and their own investment scales, which were mainly manifested in the corporate management participation and partner communication. The management has certain restrictions and influences on the monitoring level.

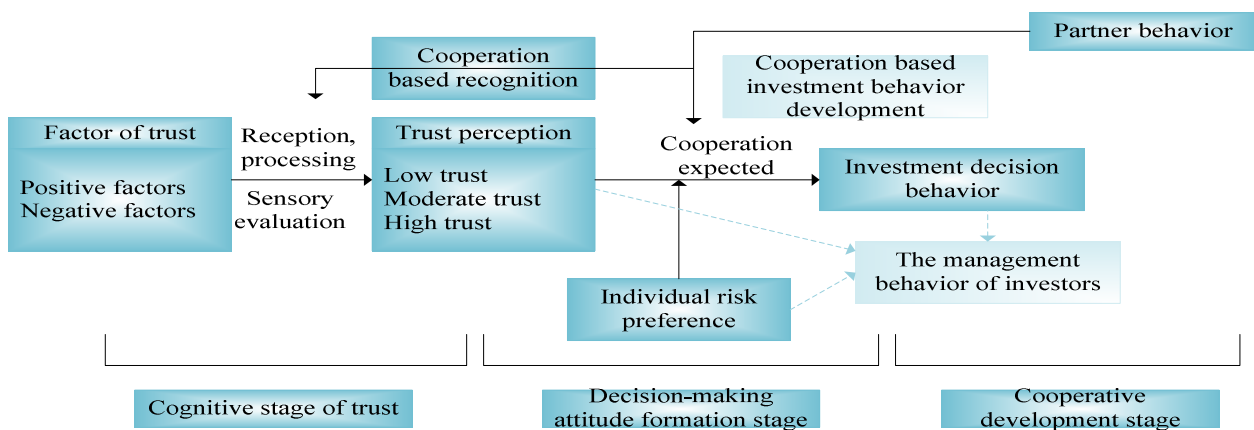


Figure 3. Influence diagram of entrepreneurial activity based on ERP analysis



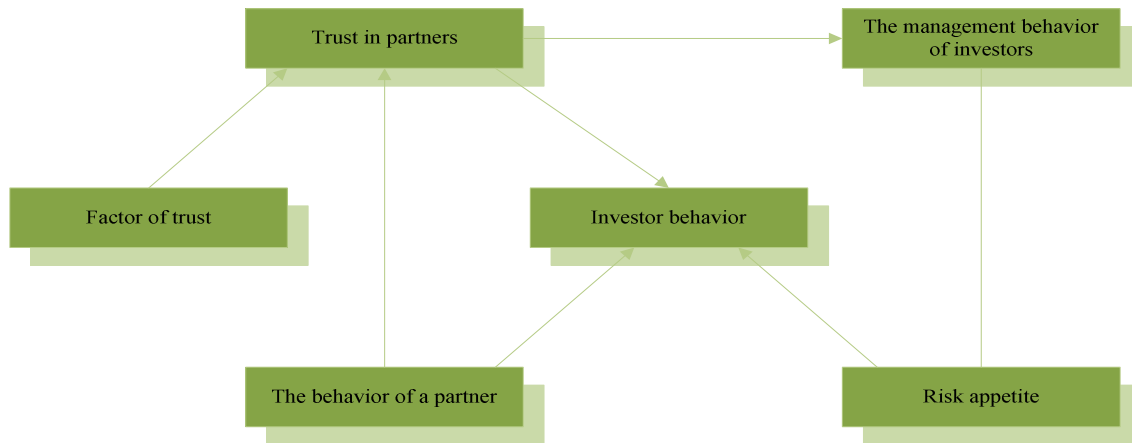


Figure 4. Modelling based on game experiment

From the perspective of the investment decision maker, whether the partner's involvement in management and the returns meet his/her expectations will directly affect his/her investment and management level in the next stage.

Modelling

Based on the interview results and the experimental results, the author corrected the currently used model. Fig. 4 shows the theoretical factor model.

In order to ensure a reasonable degree of differentiation, the model designs the questionnaire score using a 10-point scale. Tab.3 shows the measurement of the “degree of trust in partner”.

Table 3. Measurement of “degree of trust in partner”

Q: What is your attitude towards the protection measures in cooperation with partners (such as the terms of the contract, exit mode, etc.) 1 represents less importance, and 10 represents a great deal of importance. If you don't have complete protection, you refuse to cooperate.

Not too Seriously 1 2 3 4 5 6 7 8 9 10 Attaches great importance to

According to the setting of the initial model structure, there are altogether 9 observation indices of endogenous latent variables, i.e., $p=9$, and there are 9 observation indices of external latent variables, ie, $q=9$. Let t be the number of parameters to be estimated in the model. The pattern recognition condition is $t \leq (p+q)(p+q+1)/2$. In this study, $t=21$, $p=9$ and $q=9$, so $(p+q)(p+q+1)/2=171$. $t=21 < 171$, so it can be recognized by the model, with the degree of freedom being $DF=150$.

Initial model fitting

(1) Significance test

The model evaluation must first carefully analyze whether parameters estimated in the model results have statistical significance, and at the same time, perform significance experiments on two coefficients: (a) path coefficient, i.e. the regression coefficient between the latent variables; (b) load factor, i.e. the regression coefficient between the measurable variables and the latent variables, at last the specific results were obtained.

(2) Evaluation of model fitting

Multiple types of fit indices are absolute, relative, and complex when being used to evaluate the theoretical model. Amos provided multiple types of fit index to fully evaluate the model. The initial model fitting results are shown in Tab. 4.

Table 4. Fitting index calculation results

Index Name		Result	Evaluate
Absolute fitting index	χ^2	143.862	-----
	RMSEA	0.054*	Tolerableness
Comparative fit index	CFI	0.874 ≈ 0.9**	Tolerableness
Confidence Range	AIC	217.862	-----

Model correction

After combining the relevant theoretical results with the significance test results of the model parameters, the author found that: the path coefficient of the influence that “risk preference” has on “management behaviour” is trending to zero. This shows that for these complex data, there is no interaction between the two latent



variables, so this path can be deleted when the initial model is modified.

The specific operation results of the modified model are listed in the table. After comprehensive analysis of various data, it is found that there are no obvious differences between the fitting indices and the initial model. When the free parameters are released, both the χ^2 value and the AIC value are increased, but the model will remove the insignificant hypothetical paths, which will make the study more practical.

Table 5. Fitting index of the modified model

Index Name	Result	Evaluate
Absolute fitting index	χ^2	145.799
	RMSEA	0.054*
Comparative fit index	CFI	0.872 \approx 0.9**
Confidence Range	AIC	247.799

See Tab. 5 for the parameter significance test results of the modified model. Each loading coefficient and path coefficient show statistical significance at the confidence level of 90%. The table below reflects the covariance estimation results of the modified model.

Model interpretation

The author modified, tested and re-modified the selected model and took the results as the basis for the influence relation model under the support of psychology and neurology. Based on the empirical test results, the influences of various factors can be accurately determined.

1. Cooperative behaviour and factors of trust affect the degree of trust. The effect

coefficients of partner’s behaviour and factors of trust on the degree of trust are 0.462 and 0.218, respectively, which fully demonstrates that partner’s behaviour has a greater influence on trust than the factors of trust.

2. The direct effect coefficients of risk preference, partner’s behaviour, and trust degree on the investment behaviour are 0.583, 0.607, and 0.883, respectively. The effect coefficient of partner’s behaviour on investment behaviour is 1.015, which fully shows that among the three factors affecting investment behaviour, the most influential one is the partner’s behaviour. The effect coefficient of risk preference on investment behaviour is 0.583, which indicates that risk preference does not have too much influence on investment behaviour. In the game experiments, risk preference only causes investment differences in the first investment decision and will have no significant influence after other factors exert their influences.

3. The effect coefficients of trust degree, risk preference, partner’s behaviour, and investment decision-making behaviour on management are: -0.447, 0.296, -0.105, and 0.509, respectively. From these data, it can be found that the degree of trust has a significant negative effect on management behaviour. When the degree of trust is low, the management behaviour will be increased. Risk preference indirectly influences management behaviour based on investment behaviour, and the indirect effect coefficient is at a low level. This fully shows that risk preference has a great influence on investment decisions and can lead to more rational corporate management.

Coefficient evaluation result					
Regression Weights:(Group number 1-Default model)					
		Estimate	S.E.	C.R.	P
trust	-- considerations	0.485	0.381	1.274	0.102
Manage behavior	-- Investment behavior	0.473	0.211	2.240	0.025
Manage behavior	-- Risk appetite	0.373	0.334	1.119	0.129
Investment behavior	-- Risk appetite	0.384	0.210	1.828	0.048
X4 feedback	-- Partner behavior	1.000			
		1.444	0.314	4.601	***
		0.931	0.218	4.269	***
		1.000			
		0.803	0.160	5.008	***
		1.138	0.209	5.439	***
		1.000			
		0.805	0.118	6.807	***
		0.988	0.142	6.940	***
		1.000			
		0.932	0.250	3.724	***
		0.275	0.160	1.716	0.086
		1.000			
		1.940	0.692	2.805	0.005
		0.735	0.371	1.980	0.048
		1.000			
		0.632	0.446	1.417	0.113
		0.578	0.392	1.475	0.106
		1.414	0.797	1.774	0.076
		0.704	0.162	4.351	***
		0.408	0.180	2.265	0.024
		-1.035	0.310	-3.338	***

Revised coefficient estimation results					
Regression Weights:(Group number 1-Default model)					
		Estimate	S.E.	C.R.	P
trust	-- considerations	0.503	0.382	1.316	0.089
Manage behavior	-- Risk appetite	0.552	0.193	2.864	0.004
Investment behavior	-- Risk appetite	0.716	0.150	4.763	***
X4 feedback	-- Partner behavior	1.000			
X5 input	-- Partner behavior	1.421	0.306	4.646	***
X6 share	-- Partner behavior	0.920	0.212	4.338	***
X7 participation	-- Manage behavior	1.000			
X8 monitor degree	-- Manage behavior	0.842	0.167	5.031	***
X9 communicate degree	-- Manage behavior	1.139	0.241	5.321	***
Y4 money	-- Investment behavior	1.000			
Y5 Material resources	-- Investment behavior	0.798	0.118	6.735	***
Y6 Immaterial resources	-- Investment behavior	0.994	0.143	6.954	***
X1 difficulty	-- Risk appetite	1.000			
X2 number	-- Risk appetite	0.805	0.223	3.608	***
X3 deviation	-- Risk appetite	0.277	0.153	1.813	0.037
Y1 aspiration	-- trust	1.000			
Y2 expectation	-- trust	1.928	0.684	2.819	0.005
Y3 self-protection	-- trust	0.707	0.358	1.976	0.025
X7 external factor	-- considerations	1.000			
X8 trait factor	-- considerations	0.606	0.451	1.344	0.129
X9 relational factors	-- considerations	0.588	0.404	1.455	0.109
Investment behavior	-- trust	1.245	0.678	1.837	0.032
Investment behavior	-- Partner behavior	0.698	0.157	4.434	***
trust	-- Partner behavior	0.388	0.173	2.236	0.017
Manage behavior	-- trust	-0.901	0.252	-3.575	***

Figure 5. Parameter significance test results of the modified model



Measures to promote the stable development of the trust relationship in a PPP project management team

Individual-based measures to improve the trust relationship in a PPP project management team

(1) Take various factors into account when choosing a partner

When selecting a partner, each venture investor should stay rational and actively consider the traits and external factors of partners. With such rational and comprehensive consideration, the investor can build a more stable trust relationship so as to promote the robust development of the PPP project.

(2) Rationalize return expectations

The venture investor needs to perform comprehensive and rational analysis of the cooperation project and the partner and be prepared for long-term cooperation and risk sharing.

(3) Have clear self-knowledge

During the start-up of partnership, everyone should have clear understanding of themselves and utilize each other's advantages in cooperation. They need to build a positive partnership and also resolve various conflicts during the partnership, so as not to break down the relationship.

(4) Make appropriate investments

At the initial stage of cooperation, investors should rationally divide the investment stages, make targeted investment decisions for each stage and adjust their management behaviours in a timely manner in accordance with the implementation of each stage.

Organization-based measures to improve the PPP project management team activities

(1) Routinize communication

Build a systematic and comprehensive communication network, which not only maintains stable partnerships among various members of the PPP project, but also ensures that members of the organization can achieve information sharing and free communication.

(2) Adopt scientific management models

With the help of cooperative office system functions, gradually push the enterprise towards the paperless office stage. Regulate various management behaviour and adhere to the

philosophy of conservation-oriented management.

(3) Contractually contributions and benefits

Monitor the involvement of the partner in different stages, make reasonable and scientific assessment of the partner's contributions, and revise the cooperation contract after effective communication with the partner to ensure that the benefits are distributed in an open and fair manner.

Conclusions

(1) Based on neural experiments and game experiments, this paper integrates the ERP method in neuroscience to detect and determine the ERP factors that are related to the formation of decision-making attitude and trust cognition, and scientifically analyzes the entire process of how trust is built.

(2) This paper reasonably uses the SEM empirical analysis and interview methods to modify, test, and re-modify the model based on the experimental results and obtains a more reliable model.

(3) Based on the behaviour data analysis results obtained through the ERP component, SEM model and game experiment, this paper puts forward suggestions for promoting the development of stable trust relationships among PPP project members and helping PPP project management teams achieve higher cohesion.

References

- Bailie R, Si D, Shannon C, Semmens J, Rowley K, Scrimgeour DJ. Study protocol: national research partnership to improve primary health care performance and outcomes for indigenous peoples. *BMC Health Services Research* 2010; 10(1): 1-11.
- Clampit J, Kedia B, Fabian F, Gaffney N. Offshoring satisfaction: the role of partnership credibility and cultural complementarity. *Journal of World Business* 2005; 50(1): 79-93.
- Dickinson H, Peck E, Davidson D. Opportunity seized or missed? a case study of leadership and organizational change in the creation of a care trust. *Journal of Interprofessional Care* 2007; 21(5): 503.
- Grover V, Cheon MJ, Teng JTC. The effect of service quality and partnership on the outsourcing of information systems functions. *Journal of Management Information Systems* 1996; 12(4): 89-116.
- Kanmogne M, Eskridge KM. Identifying some major determinants of entrepreneurial partnership, using a confounded factorial conjoint choice experiment. *Quality & Quantity* 2013; 47(2): 943-60.
- King JC, LaGrone RP, Miller SF. The Patient and Physician in Partnership. *Southern Medical Journal* 1984;77(3):360-66.



- Lippincott RC, Wilson WH, Godard SL, Cutler DL, Angell RH. Disseminating the partnership: the pew memorial trust state-university collaboration project. *Administration and Policy in Mental Health and Mental Health Services Research* 1993; 20(6): 471-79.
- Moon SG, Jeong S, Choi Y. Moderating effects of trust on environmentally significant behavior in Korea. *Sustainability* 2017; 9(3): 415.
- O'Neill P, Whatmore S, Henry N, Pollard J. The business of place: networks of property, partnership and produce. *Geoforum* 2000; 31(2): 121-36.
- Shi S, Chong HY, Liu L, Ye X. Examining the interrelationship among critical success factors of public private partnership infrastructure projects. *Sustainability* 2016; 8(12): 1313.
- Suh T, Kwon IWG. Matter over mind: when specific asset investment affects calculative trust in supply chain partnership. *Industrial Marketing Management* 2006; 35(2): 191-201.
- Wilson AD, Mouzas S, Henneberg S, Naudé P. Trust and reliance in business relationships. *European Journal of Marketing* 2007; 41(9): 1016-32.
- Yeung K, Lee PKC, Yeung ACL, Cheng TCE. Supplier partnership and cost performance: the moderating roles of specific investments and environmental uncertainty. *International Journal of Production Economics* 2013; 144(2): 546-59.