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Importance of moderating and intervening variables on the relationship between independent and dependent variables

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Abstract

This paper has clarified the importance as well as roles of moderating variable and mediating (or intervening) variable in research studies, from the basic mathematical view point. The popular paper written by Baron and Kenny (1986) has been used as the main reference and other follow up models suggested by various authors are also discussed. Some corrective measures are put forward for the effective utilization of the roles of moderating and mediating variables in the model equations for the undertaken applied science studies.

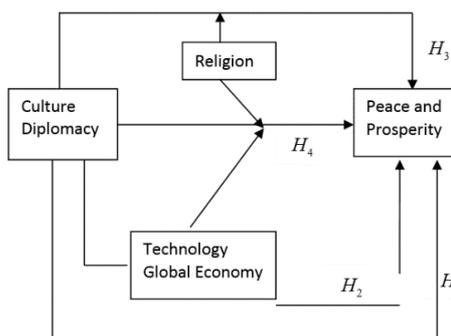
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1. Introduction

It is interesting to analyze the role and importance of moderating and intervening variables on the relationship between independent variable (The explanatory) and the dependent variable. In the applied studies the concept of moderation is internal and relatively soft in approach. On the other hand, the concept of mediating (or intervening) is external and relatively hard as well as harsh in approach. However, the use of these two concepts is mixed up and is often confusing. Baron and Kenny (1986) [1] referring to social psychological research indicated that, "moderators may involve either manipulations or assessments and either situational or personal variables. Moreover, mediators are in no way restricted to verbal reports or, for that matter, to individual-level variables"

In an undertaken study, a researcher identifies the independent (Or explanatory) variables, the moderating variables, the intervening (Mediating) variables and finally the dependent variable. The relationship between independent variable(s) and dependent variable is mostly the main focus of study. In majority of the studies this relationship is moderated and intervened by the corresponding variables, individually, as well as jointly.

In a study Pokhariyal (2015) [3]. Has investigated the relationship between culture and diplomacy with peace and prosperity, which is moderated by religion and intervened by technology and global economy. In this manner four hypothesis were formulated, as shown in the following conceptual framework.



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H₁: Culture and diplomacy has a significant relationship with peace and prosperity.

H₂: The relationship between culture and diplomacy and peace and prosperity is significantly intervened (mediated) by technology and global economy.

H₃: The relationship between culture and diplomacy and peace and prosperity is significantly moderated by religion.

H₄: The relationship between culture and diplomacy and peace and prosperity is jointly intervened and moderated by technology and global economy and religion, which is different than their individual effects.

In the set theory of algebra, basic concept of domain and range is introduced and the elements of these two sets have relationships. However, not all relationships can result into the functional relation between dependent variable and independent variables that can eventually expressed by equations. This fundamental rule is often ignored or misused in many applied studies, particularly when formulating some of the equations.

2. Moderating Variables

Researchers have curiosity to investigate the influence of the moderating variable on the relationship between predictor (independent) variable and the outcome (dependent) variable. Baron and Kenny (1986) ^[1] stated that, "in general terms, a moderator is qualitative (e.g., sex, race, class) or quantitative (e.g., level of reward) variable that affects the direction and/or strength of the relation between independent or predictor variable and a dependent or criterion variable".

It can be inferred from this statement that for a research study the relationship to be formulated and then investigated is between independent and dependent variables, which is influenced by the moderator variable. Such influence in general is motivational and is somewhat persuasive as well as soft in nature. However, the importance and roles of the variables need not be mixed. The statement like "moderator variables always function as independent variables", should be avoided, as it will in many cases not in conformity with the formulated conceptual framework of the undertaken study.

2.1 Testing the moderating effect

Let X denote independent variable, Z denote moderator and Y denote the dependent variable. The effect of moderator on the relationship between independent and dependent variables can be investigated in many ways mentioned as follows:-

The interaction of moderator with independent variables can lead to the following regression equations;

$$(a) Y_1 = \beta_{01} + \beta_{11}X + \beta_{21}Z + \varepsilon_1$$

This is a linear equation, showing the interaction between the independent variable X and moderator Z through addition. The extent of interaction would be determined by the corresponding coefficients of the model parameters from the data of the undertaken study.

$$(b) Y_2 = \beta_{02} + \beta_{12}X + \beta_{22}X.Z + \varepsilon_2$$

This is a non-linear equation, showing the interaction between the independent variable X and the moderating variable Z , through multiplication. The actual nature of such interaction is determined by the coefficient of the product term of the model from the data of the undertaken study.

The statement in Baron and Kenny (1986) ^[1], "Busemeyer and Jones (1983) ^[2] assumed that the moderation is linear and

so can be captured by an XZ product term" is in contradiction with the basic algebraic rules.

It can be noted that the popularly used interaction, even in the most of the recent studies, is of the form:

$$(C) Y_3 = \beta_{03} + \beta_{13}X + \beta_{23}Z + \beta_{33}X.Z + \varepsilon_3$$

This equation is obviously non-linear, but over uses the moderator variable Z , both through addition as well as multiplication. Such an equation may in some cases, increase the value of coefficient of determination R^2 , but cannot be considered appropriate from mathematical modeling view point. Therefore, alternatives a) and b) need to be investigated separately and then results can be compared which aspect of the intersection of moderator with independent variable either through addition or through multiplication provides better results for the undertaken study.

(d) In few cases the dependent variable Y has been regressed using $X, Y, X.Z, Z^2$ and XZ^2 for quadratic moderation, cited in Baron and Kenny, by Cohen and Cohen (1983)^[4], using hierarchical regression procedures. However, using the term XZ^2 which is of higher order (3) in the quadratic moderation seems improper. Thus, arbitrary mixing the terms without considering their dimensionality should be avoided and is unlikely, to yield proper results.

3. Mediating (or intervening) Variables

The mediating variables represent the aspects that are external to assigned variables of the undertaken study, but intervene in the relationship between independent and dependent variables. As such, organizations have no control over most of the mediating variables. However, in some case mediator clarifies the nature of relationship between independent and dependent variables, even through cause and effect.

For example, in a territorial dispute between two countries which is likely to cause war, the united nation or a third country, in most cases, will mediate or intervene between them in order to bring them together for talks or enforce ceasefire or deploy troops to maintain peace. In another example, the relationship between top management team characteristics and firm performance can be intervened by government policies, global economy and technology. In such situations one need not predict mediating variable through independent variable by a model equation, but correlation can be investigated.

3.1 Testing of intervening effect

Baron and Kenny (1986) ^[1] stated that, "A variable functions as a mediator when it meets the following conditions: a) variation in levels of independent variable significantly account for variations in the presumed mediator (i.e. path a), (b) variations in the mediator significantly account for variations in the dependent variable (i.e., path b) and (c) when paths a and b are controlled, a previously significant relation between the independent and dependent variables is no longer significant, with the strongest demonstration of mediation occurring when path C is zero."

Interpreting the above statement it can be seen that the condition a) in which the path connects the independent variable to the mediator, implies that independent variable is able to predict the mediator (the outcome). Some researchers keep on writing a regression equation to show such a relationship! The mediator (or intervening variable) is outsider (external) and can it be possible to explain its

variations with the variations of independent variables? Such misleading regressions should be avoided, as one cannot get the outcome (mediating/intervening variable) with independent variable as its predictor. However, one can investigate the relationship between mediator and dependent variable as well as independent variable in some special cases, but not through regression equation, as all relations need not be functions. The suggested path *C*, showing the direct relationship between independent and dependent variables is mostly investigated through the first hypothesis of the undertaken study.

Muller *et al.* (2005) [7], have suggested five possible models of moderation-mediation, which are equally mixed up and confusing from the basic mathematical view point. In a tutorial Hayes and Precher (2014) [5] have introduced the concepts of the relative indirect, direct and total effect and illustrated how they are estimated and interpreted. They used two linear models.

$$M = i_1 + aX + e_M \dots\dots (1) \text{ and } Y = i_2 + c'X + bM + e_Y \dots\dots\dots (2)$$

In the first model mediator variable has been proposed to be predicted with the help of independent variable!!
The total effect of *X* on *Y* has been shown by the model

$$Y = i_3 + cX + e_Y, \text{ with } c = c' + ab \dots\dots\dots(3)$$

The coefficient *c* seems to be mixed up and it is not clearly known what it could represent in real situation. Further, various mediation models with path diagrams have been shown to put forward corresponding arguments as the extension of Baron and Kenny path models.

Kang *et al.* (2015) [6], studied moderated-mediation effect by considering corporate social responsibility as independent variable and family hotels financial performances as dependent variable. The size of the company (hotel) as moderator and balance score card perspective customer satisfaction as mediator. However, the various paths are similar to that of Baron and Kenny (1986) [1], which are equally confusing and mathematically messed up, but suggested that logistic regression should be used.

Namazi and Namazi (2016) [8] emphasized on defining and analyzing potential impact of moderator(MO) and mediator(ME), their interaction and behaviors in business research. However, they mentioned that the most important differences between MO and ME are as follows: " A (MO) variable always acts like a new independent variable and is based upon the condition that: a) MO must be preceding Y, b) MO has no causal relation with X, but posit a causal relation with Y, and c) MO maintains a similar role just like X. However, a ME variable is based upon the condition that: a)X always recedes ME and Y occurs after ME and b) the role of ME is changing with respect to X, it acts as a "dependent variable" and in relation to Y, it has a role of the "independent variable". In either case, a causal relation between ME and X or Y exists. Such statements are made on the basis of mere intuition and very confusing and mixed up, with basic mathematical flaws. The causal relationships and correlation relationship need not be mixed up, as from the basic set theory of algebra, not every relation can be a function, to be expressed by equation.

The regression equation with *W*, as intervening variable in such a case can be formulated as follows:

$$Y_4 = \beta_{04} + \beta_{14}X + \beta_{24}W + \varepsilon_4$$

Finally, the joint effect of moderating and intervening variables on the relationship between independent variables and dependent variable can be expressed by the following regression equation.

$$Y_5 = \beta_{05} + \beta_{15}X + \beta_{25}Z + \beta_{35}W + \varepsilon_5$$

From this regression equation it can be shown whether the joint effect of the moderating and intervening variables on the relationship between independent variable (s) and dependent variable is different from their individual effects. This would be confirmed by comparing the coefficients of model parameters and their elasticity, from the respective equations.

4. Discussion

This article has shown clear distinction between moderating variable which is internal and mediating (or intervening) variable which is external to the organizations, in most cases of the undertaken studies. From basic concepts of algebra it is highlighted that all relations cannot be converted into functions and then expressed by an equation. However, some researchers still mix up the use of moderator and mediator, due to the nature of their studies, but with a bit of logic such things can be resolved at the formulation stage of the problem and then writing the adequate model equations. It is interesting to note that in the paper of Baron and Kenny (1986) [1], there is no mention of a equation which predicts the mediating variable by independent variable, but mentioned about studying the correlations between variables. Researchers Muller *et.al*, Hayes and Precher, Kang *etal*, Namazi and Namazi and many more start with main reference of Baron and Kenny and then through intuition or in an arbitrary manner introduce the model equation which estimate mediating variable by independent variable. Such approaches cannot be considered proper. However, through correlation analysis, the relationship between independent variable and mediating variable as well as between mediating variable and dependent variable can be studied, to show the influence and importance of the mediating variable in an undertaken study. Researchers currently conducting research by using moderating and intervening variables in their conceptual framework followed by the corresponding model equations are requested to use the concepts properly, so that basic mathematical discrepancies are avoided.

5. References

1. Baron RM, Kenny DA.: The moderator-mediator variable distinction in social psychological Research; conceptual, strategic and statistical considerations. Journal of personality and social psychology. 1986; 51(6):1173-1182.
2. Busemeyer JR, Jones LE.: Analysis of multiplicative combination rules when the causal variables are measured with error. Psychological Bulletin. 1983; 93:549-563.
3. Pokhariyal GP.: The influence of Religion, Technology and Economy on culture, Diplomacy and peace; International Journal on World Peace. 2015; 32(2):41-50.
4. Cohen, Cohen: Applied multiple regression/correlation analysis for the behavioral Sciences (2nd ed.), NJ: Erlbaum, 1983.
5. Andrew F Hayes, Kristopher J Preacher.: Statistical mediation analysis with multi-categorical independent variable. British Journal of Mathematical and Statistical Psychology. 2014; 67:451-470.

6. Kang JS, Chiang CF, Huangthanapan K, Dowing KS. Corporate Social Responsibility and Sustainability Balanced Scorecard. *International of Hospitality Management*. 2015; 48:124-134.
7. Muller D, JuddCM, Yzerbyt VY. When moderation is mediated and mediation is moderated. *Journal of Personality and Social Psychology*. 2005; 89(6):852-863.
8. Mpohammad Namazi, Navid-Reza Namazi. Conceptual Analysis of Moderator and Mediator Variables in Business Research. *Procedia Economics and Finance*. 2016; 36:540-554.