

Path analysis and determining the distribution of indirect effects via simulation

Öznur İşçi Güneri, Atilla Göktaş & Uğur Kayalı

To cite this article: Öznur İşçi Güneri, Atilla Göktaş & Uğur Kayalı (2017) Path analysis and determining the distribution of indirect effects via simulation, Journal of Applied Statistics, 44:7, 1181-1210, DOI: [10.1080/02664763.2016.1201793](https://doi.org/10.1080/02664763.2016.1201793)

To link to this article: <https://doi.org/10.1080/02664763.2016.1201793>



Published online: 28 Jun 2016.



Submit your article to this journal [↗](#)



Article views: 205



View related articles [↗](#)



View Crossmark data [↗](#)



Citing articles: 1 View citing articles [↗](#)

Path analysis and determining the distribution of indirect effects via simulation

Öznur İşçi Güneri, Atilla Göktaş and Uğur Kayalı

Department of Statistics, Muğla Sıtkı Kocman University, Muğla, Turkey

ABSTRACT

The difference between a path analysis and the other multivariate analyses is that the path analysis has the ability to compute the indirect effects apart from the direct effects. The aim of this study is to investigate the distribution of indirect effects that is one of the components of path analysis via generated data. To realize this, a simulation study has been conducted with four different sample sizes, three different numbers of explanatory variables and with three different correlation matrices. A replication of 1000 has been applied for every single combination. According to the results obtained, it is found that irrespective of the sample size path coefficients tend to be stable. Moreover, path coefficients are not affected by correlation types either. Since the replication number is 1000, which is fairly large, the indirect effects from the path models have been treated as normal and their confidence intervals have been presented as well. It is also found that the path analysis should not be used with three explanatory variables. We think that this study would help scientists who are working in both natural and social sciences to determine sample size and different number of variables in the path analysis.

ARTICLE HISTORY

Received 27 March 2015

Accepted 12 June 2016

KEYWORDS

Path analysis; path diagram; path coefficients; direct and indirect effect; path data simulation

1. Introduction

The path analysis technique was first developed in a series of samples in 1921 by Sewall Wright [10,11]. The purpose of path analysis is to predict the importance of the hypothetical causal correlations between the variables and to make policy implications. In the cause and effect correlations between two variables an important aspect is deciding which variable or variables is/are the cause variable/s and which variable or variables is/are the effect variable/s; hence this correlation should be determined by the investigator and the analysis should be performed according to this decision. The path analysis method developed by Wright is only applied to the sequence of correlations between the cause and effect variables.

Revealing the path analysis and mathematical structure of this analysis, Wright has asserted that the correlations between the variables should be linear and only the error terms should have no correlation with all the cause variables and the variables can be standardized and the interpretation problems that may arise from unit differences can be

encountered. The path analysis technique consists of more than one mathematical correlation and it analyzes the correlation coefficient according to its components as per the path diagram given in [12].

The path analysis is presented in the form of a research in social sciences [1,4]. A path diagram for numerical analysis, although not required, to demonstrate the direct and indirect relations between the variables is very useful in terms of [8]. Smith, Brown and Valour argued that the use of path analysis has pointed out the hidden pitfalls that may be encountered [9].

The most important difference that distinguishes the path analysis from other multivariate methods is that it determines not only the direct effects but also the indirect effects, unanalyzed effects and artificial effects. The studies performed till now are only oriented toward the application of the method. In this study, it is aimed to calculate the path coefficients by generating data via simulation according to different samples and number of variables and to investigate their distributions.

2. Path analysis

A path analysis has two components: path coefficients and a path diagram. Path coefficients represent the mathematical part of the analysis and the path diagram represents the visual part of the analysis. The part where all the variables for the analysis are present is called the path model. It is a multivariate technique that enables interpretation of the causal correlations between the variables of the model on the path analysis and to estimate the indirect effects [7]. The inter-variable correlations on the path analysis are presented numerically. This case provides an easy understanding of the correlation system and also visualizes the logical flow in the interpretation of the results [6].

Under the assumptions considered in the multiple regression analysis, when a dependent variable is being analyzed over all the independent variables every dependent variable in the path analysis is analyzed on every independent variable, that is, more than one regression analysis can be done. The path analysis considers a unilateral cause and effect correlation and presumes that the measurements are done in a quantitative structure and obtained without any errors [2].

2.1. Path coefficients

In a model with a causal correlation path coefficients are used in the determination of the effects of the independent variables on the dependent variables. In case the path coefficient between the dependent and independent variables is within the limits of the independent variable observed and when all the other variables in the model (thus the effects of this variable) are kept stable, the path coefficient is determined as the ratio of the change in the standard deviation value of the dependent variable to the change in the standard deviation value of the dependent variable when all the independent variables are all effective in the model. The path coefficients shown in the path diagram are calculated as follows [3,5]:

$$P_{YX} = b \frac{S_X}{S_Y}. \quad (1)$$

where P_{YX} is the path coefficient showing the direct effect of X independent variable on the Y dependent variable and b is the partial regression coefficient. In Equation (2), S_X is the standard deviation of the X variable and S_Y is the standard deviation of the Y variable.

$$S_X = \sqrt{\left[\sum (X - \bar{X})^2 \times \frac{1}{n} \right]} = \sqrt{\left(\sum X^2 \right) \frac{(\sum X)^2}{n} \times \frac{1}{n}} = \sqrt{S_{XX}} \tag{2}$$

$$S_Y = \sqrt{\left[\sum (Y - \bar{Y})^2 \times \frac{1}{n} \right]} = \sqrt{\left(\sum Y^2 \right) \frac{(\sum Y)^2}{n} \times \frac{1}{n}} = \sqrt{S_{YY}}$$

Other than the linear correlations there are also nonlinear correlations between the variables. As the analyses of the nonlinear correlations are hard and also the interpretation of the system is hard, it is assumed that all the correlation systems are linear and the principles of the path analysis technique are tried to be explained according to this assumption. When the correlations are not linear they are tried to be converted to a linear form by a specified conversion [12].

The most difficult and most important part of the path analysis is to create a path diagram. Although a path diagram is not necessary for the numerical analyses, it is very useful to find the direct and indirect correlations between the variables [8]. In the path diagram, if there is a path coefficient bigger than 1, then this indicates that there is a balancing mechanism (negative effect) in the system. When considered from this point of view, the path coefficients greater than 1 are not significant unilaterally [5]. When the path coefficients are being calculated, standardized variables are used. The difference of the average values of the variables from every observed value is calculated and these calculated differences are compared to the standard deviation of the variable. Thus the variable is standardized.

2.2. Calculation of the path coefficients

It is required to generate a path diagram and to calculate the path coefficients showing the causal correlations between the dependent and independent variables. An independent variable can have indirect effects on a dependent or another independent variable besides its direct effects. Correlation coefficient between these two variables is equal to the total of indirect effects of other variables plus the direct effect of the effective variable [12]. Thus the correlations between the independent variables can be written as:

$$\begin{aligned}
 P_{yx_1} + r_{x_1x_2}P_{yx_2} + \dots + r_{x_1x_k}P_{yx_k} &= r_{yx_1} \\
 r_{x_2x_1}P_{yx_1} + P_{yx_2} + \dots + r_{x_2x_k}P_{yx_k} &= r_{yx_2} \\
 &\vdots \\
 r_{x_2x_1}P_{yx_1} + P_{yx_2} + \dots + r_{x_2x_k}P_{yx_k} &= r_{yx_2}
 \end{aligned}
 \tag{3}$$

Here, P_{yx_1} is the direct effect of the first independent variable (x_1) on the dependent variable (y), $r_{x_1x_2}P_{yx_2}$ is the indirect effect of the first independent variable (x_1) on the second independent variable (x_2). Because the correlations between the independent variables and the correlations between the independent variables and the dependent variable are known it is possible to calculate the path coefficients. When the equations are considered in a

matrix format, if the correlation matrix between the independent variables is shown as A , path coefficient vector as P and the correlation vector between the independent variables and the dependent variable as B , then the equation in matrix form can be written as:

$$P = A^{-1}B. \tag{4}$$

This equation becomes

$$\begin{bmatrix} P_{yx_1} \\ P_{yx_2} \\ \vdots \\ P_{yx_k} \end{bmatrix} = \begin{bmatrix} 1 & r_{x_1x_2} & \cdots & r_{x_1x_k} \\ r_{x_2x_1} & 1 & \cdots & r_{x_2x_k} \\ \vdots & \vdots & \ddots & \vdots \\ r_{x_kx_1} & r_{x_kx_2} & \cdots & 1 \end{bmatrix} \cdot \begin{bmatrix} r_{yx_1} \\ r_{yx_2} \\ \vdots \\ r_{yx_k} \end{bmatrix}. \tag{5}$$

Besides the direct effects of independent variables, it is also possible to calculate their indirect effects. Matrix representation of indirect effects is calculated by multiplying the $k \times k$ -sized K matrix with zero diagonal elements with the correlation matrix of the independent variables.

$$\underbrace{\begin{bmatrix} P_{yx_1} & 0 & \cdots & 0 \\ 0 & P_{yx_2} & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & P_{yx_k} \end{bmatrix}}_K \cdot \underbrace{\begin{bmatrix} r_{x_1x_1} & r_{x_1x_2} & \cdots & r_{x_1x_k} \\ r_{x_2x_1} & r_{x_2x_2} & \cdots & r_{x_2x_k} \\ \vdots & \vdots & \ddots & \vdots \\ r_{x_kx_1} & r_{x_kx_2} & \cdots & r_{x_kx_k} \end{bmatrix}}_A = \underbrace{\begin{bmatrix} P_{yx_1}r_{x_1x_1} & P_{yx_1}r_{x_1x_2} & \cdots & P_{yx_1}r_{x_1x_k} \\ P_{yx_2}r_{x_2x_1} & P_{yx_2}r_{x_2x_2} & \cdots & P_{yx_2}r_{x_2x_k} \\ \vdots & \vdots & \ddots & \vdots \\ P_{yx_k}r_{x_kx_1} & P_{yx_k}r_{x_kx_2} & \cdots & P_{yx_k}r_{x_kx_k} \end{bmatrix}}_D. \tag{6}$$

In the $k \times k$ -sized matrix D calculated in the above-mentioned matrix equation the diagonal values show the path coefficients and the other values show the indirect effect quantities. Matrix D is not a symmetrical matrix. It can be calculated in two different forms. In the indirect effect matrix written as $D = K \cdot A$, the values on the i th row and j th column show the indirect effect quantity that the j th independent variable made on the dependent variable over the i th independent variable. In general, the indirect effect matrix in the sources is calculated as $D = A K$. In this case, the values on the i th row and j th column show the indirect effect quantity that the i th independent variable made on the dependent variable via the j th independent variable. In the simulation study performed in this study, the calculations are done by the $D = K \cdot A$ formula. The correlation coefficient of the independent variable is written as:

$$r_{yy} = \sum_{i=1}^k \sum_{j=1}^k P_{yx_i} P_{yx_j} r_{x_i x_j} + P_{yxe}^2 = 1. \tag{7}$$

If the correlation between the independent variables is statistically insignificant, that is, equal to zero, then the correlations between the independent variable and the dependent

variables will be equal to the path coefficients in the model. For k independent variable;

$$r_{yy} = \sum_{i=1}^k P_{yx_i}^2 + P_{yx_e}^2 = 1, \tag{8}$$

Equation (8) provides convenience if used in complex path models where there is no correlation between the independent variables.

2.3. Path diagram

The path analysis technique starts by showing the variables that are thought to be related to each other completely in a diagram and the interpretation of the system is made by the path coefficients to be calculated. Also determination of such coefficients mathematically requires the determination of the cause and effect correlations system between the variables in a mathematical model. When the investigator determines the cause and effect correlation, he/she may benefit from the investigations made regarding the subject and also generates the path diagram for the cause and effect correlation together with the specialists.

Unilateral correlations that are thought to be present between the variables in the path model are shown by arrows that are drawn from a variable to another variable. The correlations between the independent variables in the model are shown by double-sided arrows; however, such arrows are drawn as curvilinear. Briefly, the values of the arrows on the path diagram are the representation of the path coefficients or the correlations or they show the numerical values. Besides, it is also possible to write equations for the model by considering the path diagram. When the path diagram is being interpreted, it starts from the independent variable and continued by following the arrows. There are four major situations that should be considered during interpretation. These are called, as we have mentioned above, the direct effect, indirect effect, unanalyzed effect and spurious effect.

The graphical representation in Figure 1 represents a classical path diagram for three independent variables. Four effects found as a result of the path analysis are

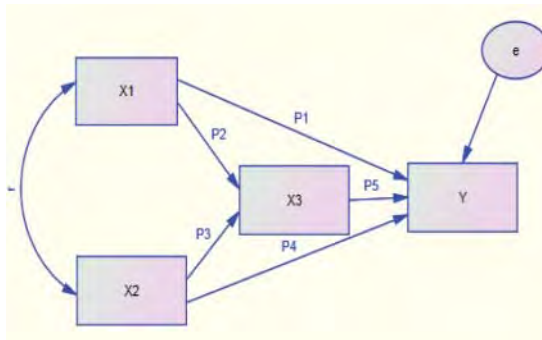


Figure 1. Path diagram sample.

Direct effect (DE): Direct effect means the effect of an independent variable in the path diagram on the dependent variable without any other effects.

Indirect effect (IE): It can be defined as the change created by an independent variable in the path diagram on the dependent variable via another independent variable. Indirect effects are the effects that can be calculated mathematically by hand. Path coefficients are multiplied and indirect effects are calculated.

Unanalyzed effect (UE): It is the effect that arises when a double-side correlation is present between the cause variables. This effect is also called the *U* (unanalyzed) effect. *U* effect is a different correlation from the path models. This correlation is accepted as unanalyzed effect.

Spurious effect (SE): The case of a common reason affecting both variables for which the correlation is examined is called a spurious effect. This effect is also called the *S* (spurious) effect.

3. Application

In this study; path models with 3, 5 and 7 different independent variables are selected. Among the independent variables in these selected models; three different correlation levels as low, medium and high are determined. These correlation matrices used are presented as follows:

$$\begin{matrix}
 \begin{matrix} y & x_1 & x_2 & x_3 \\ \left[\begin{array}{cccc} 1.0 & 0.7 & -0.5 & 0.2 \\ 0.7 & 1.0 & 0.1 & 0.1 \\ -0.5 & 0.1 & 1.0 & 0.0 \\ 0.2 & 0.1 & 0.0 & 1.0 \end{array} \right] \\ k = 3, \text{ Low correlation}
 \end{matrix} &
 \begin{matrix} y & x_1 & x_2 & x_3 \\ \left[\begin{array}{cccc} 1.0 & 0.5 & 0.4 & 0.4 \\ 0.5 & 1.0 & 0.0 & -0.2 \\ 0.4 & 0.0 & 1.0 & 0.0 \\ 0.4 & -0.2 & 0.0 & 1.0 \end{array} \right] \\ k = 3, \text{ Medium correlation}
 \end{matrix} &
 \begin{matrix} y & x_1 & x_2 & x_3 \\ \left[\begin{array}{cccc} 1.0 & 0.65 & 0.55 & 0.45 \\ 0.65 & 1.0 & 0.0 & 0.0 \\ 0.55 & 0.0 & 1.0 & 0.55 \\ 0.45 & 0.0 & 0.55 & 1.0 \end{array} \right], \\ k = 3, \text{ High correlation}
 \end{matrix}
 \end{matrix}, \tag{9}$$

$$\begin{matrix}
 \begin{matrix} y & x_1 & x_2 & x_3 & x_4 & x_5 \\ \left[\begin{array}{cccccc} 1.0 & 0.3 & 0.20 & -0.20 & 0.15 & 0.40 \\ 0.3 & 1.0 & -0.10 & 0.10 & 0.20 & -0.20 \\ 0.20 & -0.1 & 1.0 & 0.15 & -0.20 & 0.10 \\ -0.20 & 0.1 & 0.15 & 1.0 & 0.20 & 0.15 \\ 0.15 & 0.2 & -0.20 & 0.20 & 1.0 & -0.10 \\ -0.40 & -0.2 & 0.10 & 0.15 & -0.10 & 1.0 \end{array} \right] \\ k = 5, \text{ Low correlation}
 \end{matrix}
 \end{matrix}$$

$$\begin{matrix}
 \begin{matrix} y & x_1 & x_2 & x_3 & x_4 & x_5 \\ \left[\begin{array}{cccccc} 1.0 & 0.3 & 0.20 & -0.20 & 0.15 & -0.40 \\ 0.3 & 1.0 & -0.20 & 0.20 & 0.30 & -0.30 \\ 0.20 & -0.2 & 1.0 & 0.25 & -0.20 & 0.10 \\ -0.20 & 0.2 & 0.25 & 1.0 & 0.20 & 0.25 \\ 0.15 & 0.3 & -0.20 & 0.20 & 1.0 & -0.20 \\ -0.40 & -0.3 & 0.10 & 0.25 & -0.20 & 1.0 \end{array} \right] \\ k = 5, \text{ Medium correlation}
 \end{matrix}
 \end{matrix}$$

$$\begin{matrix}
 & y & x_1 & x_2 & x_3 & x_4 & x_5 & \\
 \begin{bmatrix}
 1.0 & 0.3 & 0.20 & -0.20 & 0.15 & -0.40 \\
 0.3 & 1.0 & -0.30 & 0.30 & 0.35 & -0.35 \\
 0.20 & -0.3 & 1.0 & 0.25 & -0.30 & 0.30 \\
 -0.20 & 0.3 & 0.25 & 1.0 & 0.30 & 0.25 \\
 0.15 & 0.35 & -0.30 & 0.30 & 1.0 & -0.30 \\
 -0.40 & -0.35 & 0.30 & 0.25 & -0.30 & 1.0
 \end{bmatrix} & & & & & & & \\
 & k=5, \text{ High correlation} & & & & & &
 \end{matrix} \tag{10}$$

$$\begin{matrix}
 & y & x_1 & x_2 & x_3x_4x_5x_6x_7 & & & \\
 \begin{bmatrix}
 1.0 & 0.30 & 0.20 & -0.20 & 0.15 & -0.40 & -0.20 & 0.50 \\
 0.30 & 1.0 & -0.10 & 0.10 & 0.20 & -0.20 & 0.15 & -0.10 \\
 0.20 & -0.10 & 1.0 & 0.15 & -0.20 & 0.10 & 0.20 & 0.10 \\
 -0.20 & 0.10 & 0.15 & 1.0 & 0.20 & 0.15 & -0.20 & 0.15 \\
 0.15 & 0.20 & -0.20 & 0.20 & 1.0 & -0.10 & 0.15 & -0.25 \\
 -0.40 & -0.20 & 0.10 & 0.15 & -0.10 & 1.0 & 0.25 & 0.25 \\
 0.20 & 0.15 & 0.20 & -0.20 & 0.15 & 0.25 & 1.0 & -0.10 \\
 0.50 & -0.10 & 0.10 & 0.15 & -0.25 & 0.25 & -0.10 & 1.0
 \end{bmatrix} & & & & & & & \\
 & k=7, \text{ Low correlation} & & & & & &
 \end{matrix}$$

$$\begin{matrix}
 & y & x_1 & x_2 & x_3x_4x_5x_6x_7 & & & \\
 \begin{bmatrix}
 1.0 & 0.30 & 0.20 & -0.20 & 0.15 & -0.40 & -0.20 & 0.50 \\
 0.30 & 1.0 & -0.20 & 0.20 & 0.30 & -0.30 & 0.25 & -0.25 \\
 0.20 & -0.20 & 1.0 & 0.25 & -0.20 & 0.10 & -0.30 & 0.30 \\
 -0.20 & 0.20 & 0.25 & 1.0 & 0.20 & 0.25 & 0.25 & -0.25 \\
 0.15 & 0.30 & -0.20 & 0.20 & 1.0 & -0.20 & -0.20 & 0.20 \\
 -0.40 & -0.30 & 0.10 & 0.25 & -0.20 & 1.0 & 0.15 & -0.15 \\
 -0.20 & 0.25 & -0.30 & 0.25 & -0.20 & 0.15 & 1.0 & 0.10 \\
 0.50 & -0.25 & 0.30 & -0.25 & 0.20 & -0.15 & 0.10 & 1.0
 \end{bmatrix} & & & & & & & \\
 & k=7, \text{ Medium correlation} & & & & & &
 \end{matrix}$$

$$\begin{matrix}
 & y & x_1 & x_2 & x_3x_4x_5x_6x_7 & & & \\
 \begin{bmatrix}
 1.0 & 0.30 & 0.20 & -0.20 & 0.25 & -0.30 & -0.22 & 0.19 \\
 0.30 & 1.0 & -0.20 & -0.25 & 0.24 & -0.24 & 0.31 & -0.31 \\
 0.20 & -0.20 & 1.0 & 0.19 & -0.14 & 0.14 & -0.30 & 0.25 \\
 -0.20 & -0.25 & 0.19 & 1.0 & 0.22 & 0.25 & 0.35 & -0.25 \\
 0.25 & 0.24 & -0.14 & 0.22 & 1.0 & 0.10 & 0.15 & 0.15 \\
 -0.30 & -0.24 & 0.14 & 0.25 & 0.10 & 1.0 & 0.00 & -0.20 \\
 0.22 & 0.31 & -0.30 & 0.35 & 0.15 & 0.00 & 1.0 & 0.10 \\
 0.19 & -0.31 & 0.25 & -0.25 & 0.15 & -0.20 & 0.00 & 1.0
 \end{bmatrix} & & & & & & & \\
 & k=7, \text{ High correlation} & & & & & &
 \end{matrix} \tag{11}$$

A 1000 replication with 50, 100, 250 and 500 different sample sizes regarding to all the specified models and correlation levels are derived using Minitab 16 statistical package program.

Such derived data are separated in groups for 1000 times and the path analysis is applied for every group. By means of the path coefficients in the result of the analysis and of previously determined correlations at different levels an indirect effects matrix is calculated by Equation (5). The normality of the distribution of such calculated indirect effects is examined by the Anderson–Darling normality test in Minitab 16 statistical package program. While the derived data have a standard normal distribution, the distribution of indirect effects obtained as a result of analysis is investigated. As a result of the simulation; it is observed that indirect effects diverge from normality when the sample size and number of variables increase.

3.1. Calculation of the path coefficients

Before starting the simulation; low, medium and high levels of correlations are defined between the independent variables for 3, 5 and 7 ($k = 3, k = 5$ and $k = 7$) different path models. Benefiting from these defined correlations 1000 replication data are derived for every sample size and for the correlations at every level. While the data are being derived, special macros are written in Minitab 16.

Algorithm of the macros is explained as distinguishing the derived data set in groups and seeing every group as a sample and making calculations that are specific for that data set. Thus 1000 data sets from every sample size and then 1000 groups are generated. The correlation matrices and path coefficients for these groups are stored separately in temporary memory files and the calculations are performed later. In a similar manner, the average of the intergroup correlation matrices from the stored memory is taken and the average correlation matrix is obtained. Accordingly, by using the obtained correlation matrices intergroup average path coefficients are calculated.

In Tables 1–3, calculated path coefficients are presented for average correlation matrices. The significance of the correlation matrices is statistically (at 95% significance level) tested. When the path coefficient values are observed, it can be said, by observing the 1000-replicated simulation result, that the path coefficients in the sample size that is greater than 100 are not affected by the sample sizes.

Table 1 presents the path coefficients obtained by low, medium and high correlations as a result of 1000 replications for the path models having three different variables 50, 100, 250 and 500 sample sizes.

Table 1. Average path coefficients obtained by low, medium and high correlations for $k = 3$.

Path coefficients		Sample (n)			
		$n = 50$	$n = 100$	$n = 250$	$n = 500$
Low	P_1	0.741421235	0.745495256	0.745973427	0.744060427
	P_2	−0.59340935	−0.57451509	−0.57518798	−0.57438451
	P_3	0.184837448	0.124653325	0.125806733	0.125726866
Medium	P_1	0.68952725	0.6067489	0.6056498	0.60408750
	P_2	0.43739701	0.4023159	0.3986353	0.40128679
	P_3	0.38574288	0.5216676	0.5213272	0.52125667
High	P_1	0.484974572	0.649417986	0.649627638	0.65009446
	P_2	0.269815166	0.436836478	0.434691171	0.432164321
	P_3	0.10560636	0.206042647	0.21137821	0.21256532

Table 2. Average path coefficients obtained by low, medium and high correlations for $k = 5$.

Path coefficients		Sample (n)			
		$n = 50$	$n = 100$	$n = 250$	$n = 500$
Low	P_1	0.259780993	0.256898134	0.258096235	0.25773555
	P_2	0.334477864	0.340063338	0.332609532	0.335568972
	P_3	-0.25818781	-0.26867756	-0.26231591	-0.26485095
	P_4	0.188871356	0.188173246	0.1862136	0.185849463
	P_5	-0.32270515	-0.31873578	-0.32499224	-0.32382546
Medium	P_1	0.338898017	0.330562864	0.3377689	0.337625605
	P_2	0.400677029	0.402900835	0.406984368	0.406212662
	P_3	-0.33842934	-0.34103160	-0.3406510	-0.34556967
	P_4	0.145426833	0.153810234	0.153674562	0.153002143
	P_5	-0.21927681	-0.22302646	-0.22493474	-0.22357729
High	P_1	0.477201632	0.472951587	0.478185536	0.477655936
	P_2	0.618994833	0.613587907	0.616819141	0.614744739
	P_3	-0.52326957	-0.52143605	-0.52491123	-0.52550079
	P_4	0.260371334	0.261377527	0.264402677	0.260551019
	P_5	-0.21662696	-0.21108697	-0.20595157	-0.20842388

Table 3. Average path coefficients obtained by low, medium and high correlations for $k = 7$.

Path coefficient		Sample (n)			
		$n = 50$	$n = 100$	$n = 250$	$n = 500$
Low	P_1	0.364161476	0.361681116	0.362135456	0.362244173
	P_2	0.445329068	0.443885082	0.443465834	0.444329719
	P_3	-0.53027707	-0.53185315	-0.53064998	-0.53142754
	P_4	0.475848262	0.477533261	0.476951203	0.477900979
	P_5	-0.33981911	-0.33859657	-0.33873867	-0.33825130
	P_6	-0.36115211	-0.36218416	-0.36176015	-0.36312949
	P_7	0.738871959	0.73867098	0.73969009	0.739407623
Medium	P_1	0.898632048	0.897390995	0.896210264	0.896167055
	P_2	-0.61758461	-0.61240481	-0.61295693	-0.61499601
	P_3	0.527752616	0.524375224	0.525613233	0.525455593
	P_4	-0.82302101	-0.81712191	-0.81750039	-0.81716957
	P_5	-0.01529724	-0.01234697	-0.01539039	-0.01405122
	P_6	-1.03699478	-1.03183247	-1.03078623	-1.03124772
	P_7	1.310586715	1.301846382	1.303761231	1.304719353
High	P_1	0.451656114	0.43488986	0.436579191	0.443317636
	P_2	0.15745583	0.164694944	0.159858273	0.160444919
	P_3	0.082522716	0.067644968	0.072550585	0.080552736
	P_4	0.183276075	0.193216694	0.192460916	0.188673742
	P_5	-0.20201783	-0.20974374	-0.20704478	-0.20488864
	P_6	-0.37226728	-0.35908862	-0.36148431	-0.36638241
	P_7	0.240315363	0.228209849	0.234169828	0.240116227

In Table 2, the path coefficients obtained by low, medium and high correlations as a result of 1000 replications for the path models having five different variables with 50, 100, 250 and 500 different sample sizes are presented.

In Table 3, the path coefficients obtained by low, medium and high correlations as a result of 1000 replications for the path models having seven different independent variables for 50, 100, 250 and 500 different sample sizes are given. It is seen that the path coefficients are not affected by the sample sizes at the same correlation level in the models with 3, 5 and 7 different variables.

3.2. Generation and interpretation of path diagrams

As a result of obtaining the data derivation and path coefficients by the AMOS program, path diagrams are generated. In these diagrams, bilateral arrows represent the correlation values, unilateral arrows represent the path coefficients and the direction of causality and angled nodes represent the standardized independent variables, and finally the eclipse nodes represent the error terms.

The path diagrams prepared by AMOS are presented in Figures 2–13. All the interpretations can be performed for all the above-mentioned models. It should be considered that in all the path models with seven variables and high correlations, there is no correlation between $X_5 - X_6$ and $X_6 - X_7$ independent variables. The reason is that the correlations obtained as a result of the tests are statistically insignificant. Such insignificant correlations are eliminated from the path model and the path diagram has taken its current form.

In Figure 2(a)–(d), the path diagrams with low, medium and high correlations having 50 sample sizes and 3 independent variables are given. For the path diagrams with low correlations, the correlation coefficient between X_1 and X_2 is calculated as 0.099, the correlation coefficient between X_1 and X_3 is calculated as 0.097 and the correlation coefficient between X_2 and X_3 is calculated as 0.096. Also the path coefficient between X_1 and Y is calculated as 0.741, and the path coefficient between X_2 and Y is calculated as -0.593 and the path coefficient between X_3 and Y is calculated as 0.184. When the effect of the other variables is kept stable, one-unit change in any of the independent variables in the model will cause the relevant dependent variable to change as much as the path coefficient quantity of the related variable. When the indirect effects are considered, the indirect effect of X_1 on Y over X_2 is calculated as $-0.593 \times 0.099 = -0.0587$. In other words, one-unit change in the X_1 variable will cause 0.0587 unit change on Y in reverse direction because of the correlation with X_2 . The correlations in the other figures are interpreted similarly.

3.3. Normality tests of the distribution of indirect effects

In order to test whether the indirect effects in the path models within the scope of this study are normal or not previously specified but different macros are written using Minitab 16 package program. Macros help in calculating every indirect effect in every path model and writing these indirect effects on the columns in the worksheet window. Thus all the indirect effect values are duly recorded. The normality test of such values is again performed by the Anderson–Darling normality test in Minitab 16 program. It means that the p values that are greater than .05 at 95% significance level have a normal distribution. Also the p values specified with .005* are written for the p values that are smaller than .005. In the below-mentioned schemes, the results of these tests are given.

In Table 4 in the path models obtained as a result of 1000 repetitions with three variables, Anderson–Darling normality test p values of the indirect effects of independent variables regarding the dependent variable are given. Considering such values while sample size increases in the low-relation path models, it can be said that indirect effects are closer to normal distribution. Same interpretation can be done for the medium- and high-correlated path models. However when the sample size is considered to be medium say from 50 to 100 and the correlation is high within the path models, the distribution of the indirect effect approaches to normal. This can also be observed in low-correlated path models when the sample size reaches 500.

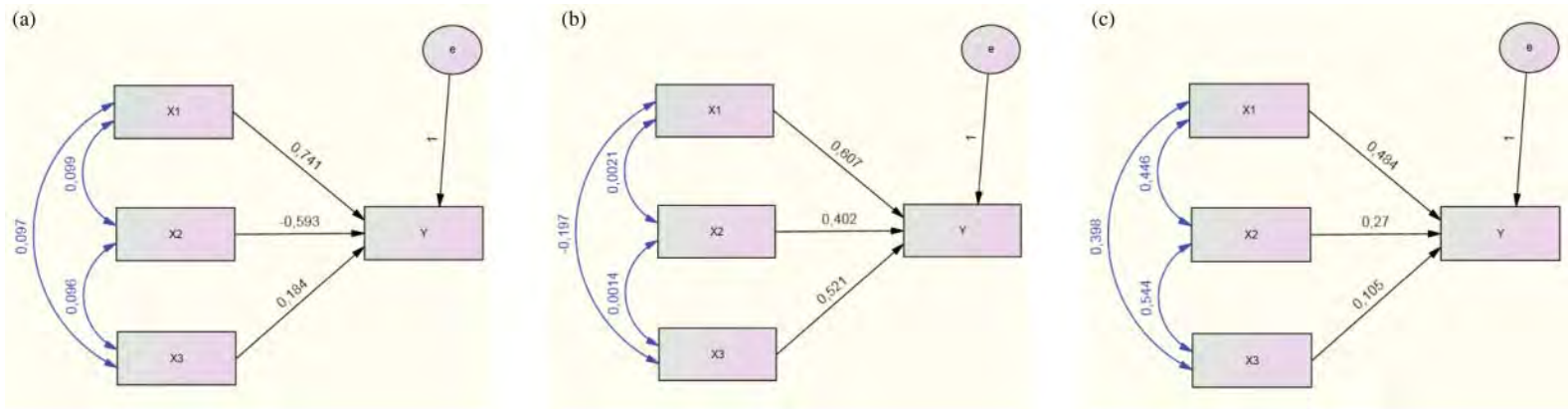


Figure 2. (a) $k = 3$ and $n = 50$. Low-correlation path diagram, (b) $k = 3$ and $n = 50$. Medium-correlation path diagram and (c) $k = 3$ and $n = 50$. High-correlation path diagram.

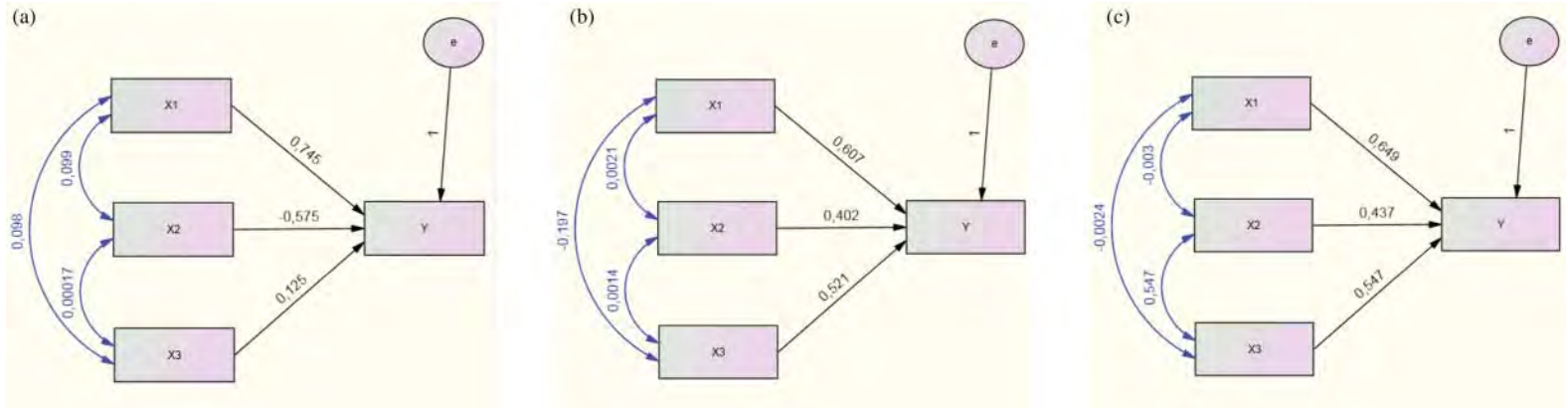


Figure 3. (a) $k = 3$ and $n = 100$. Low-correlation path diagram, (b) $k = 3$ and $n = 100$. Medium-correlation path diagram and (c) $k = 3$ and $n = 100$. High-correlation path diagram.

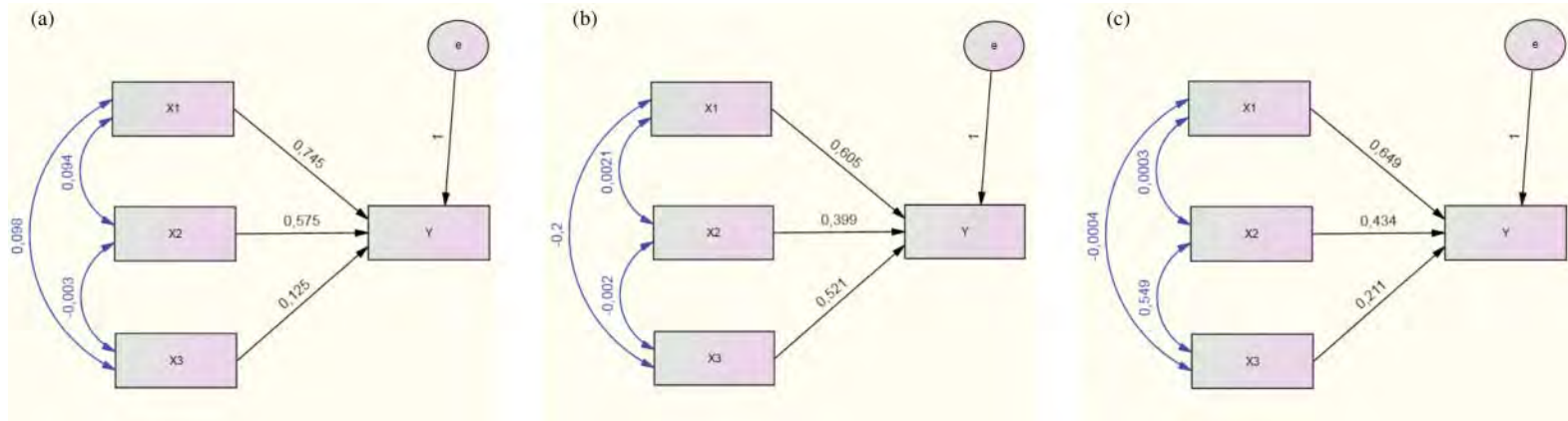


Figure 4. (a) $k = 3$ and $n = 250$. Low-correlation path diagram, (b) $k = 3$ and $n = 250$. Medium-correlation path diagram and (c) $k = 3$ and $n = 250$. High-correlation path diagram.

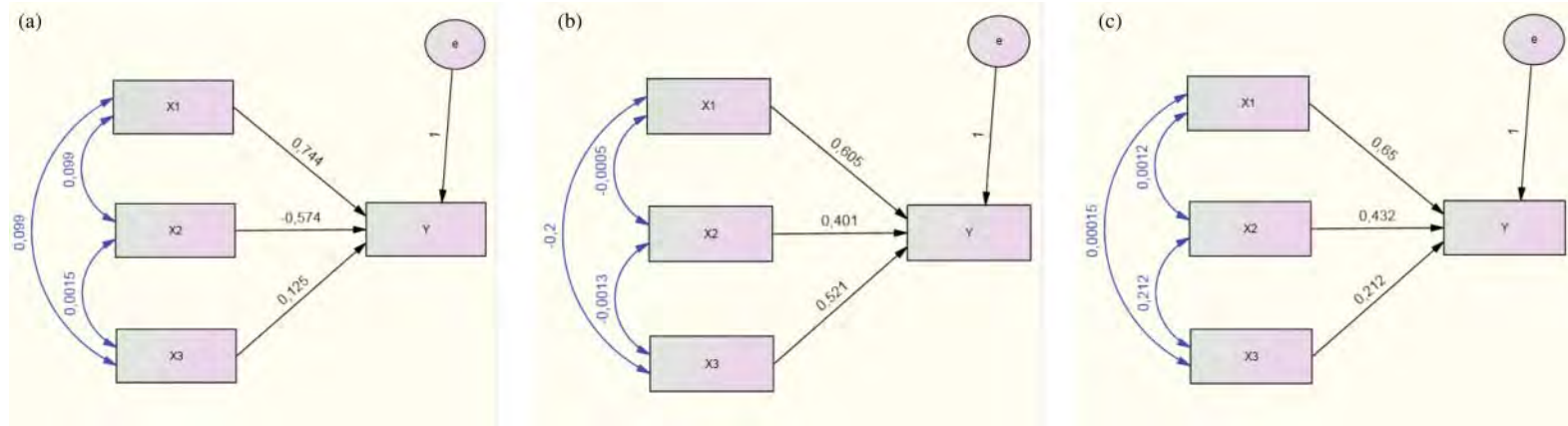


Figure 5. (a) $k = 3$ and $n = 500$. Low-correlation path diagram, (b) $k = 3$ and $n = 500$. Medium-correlation path diagram and (c) $k = 3$ and $n = 500$. High-correlation path diagram.

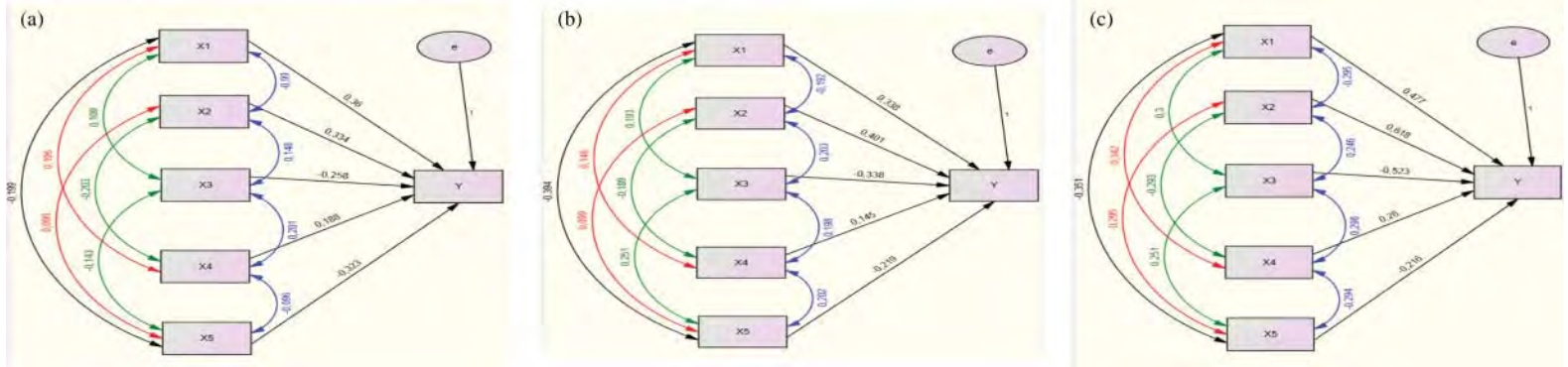


Figure 6. (a) $k = 5$ and $n = 50$ Low-correlation path diagram, (b) $k = 5$ and $n = 50$ Medium-correlation path diagram and (c) $k = 5$ and $n = 50$ High-correlation path diagram.

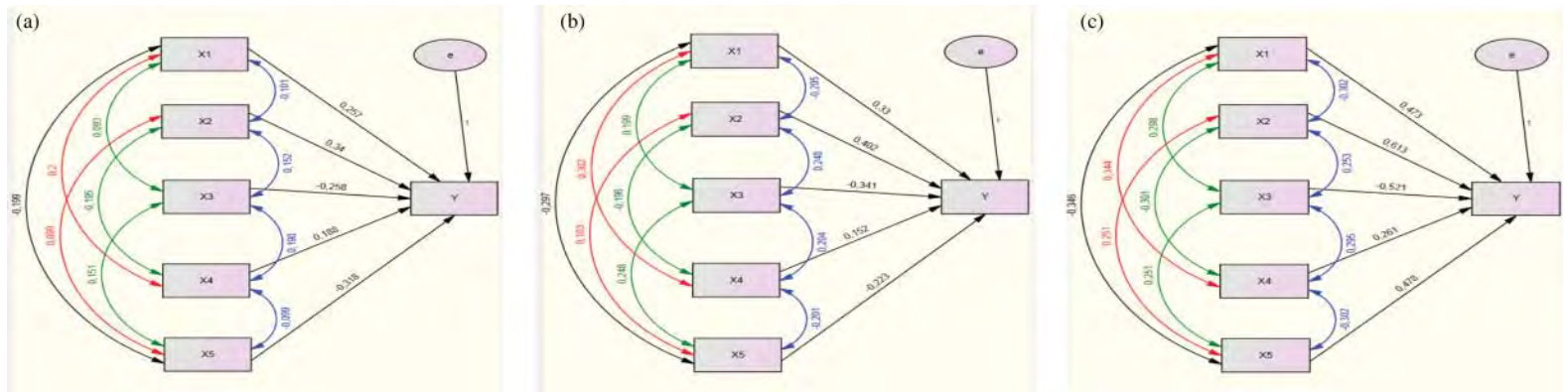


Figure 7. (a) $k = 5$ and $n = 100$. Low-correlation path diagram, (b) $k = 5$ and $n = 100$. Medium-correlation path diagram and (c) $k = 5$ and $n = 100$. High-correlation path diagram.

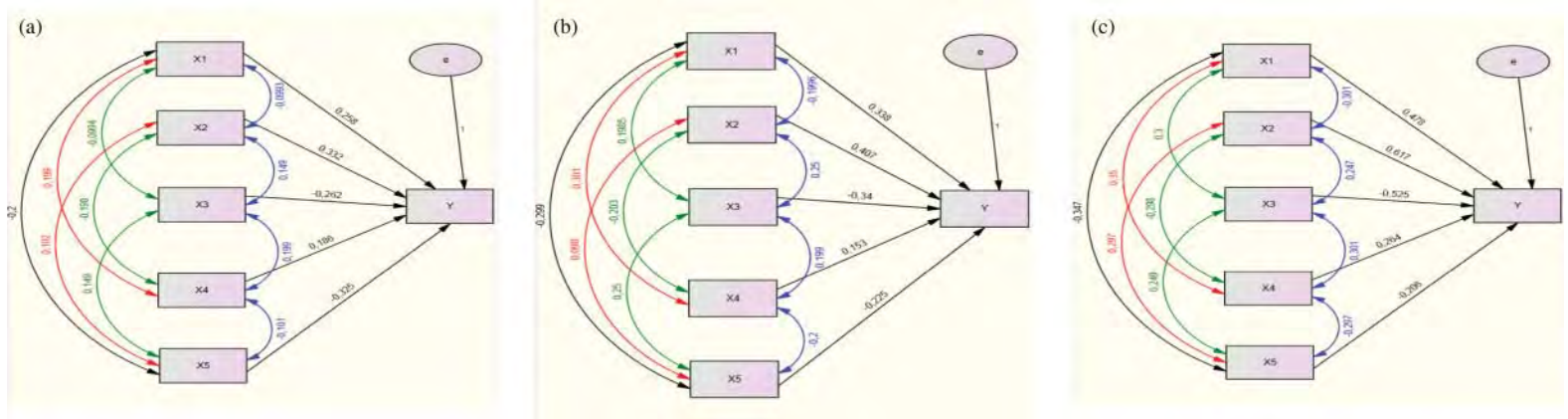


Figure 8. (a) $k = 5$ and $n = 250$. Low-correlation path diagram, (b) $k = 5$ and $n = 250$. Medium-correlation path diagram and (c) $k = 5$ and $n = 250$. High-correlation path diagram.

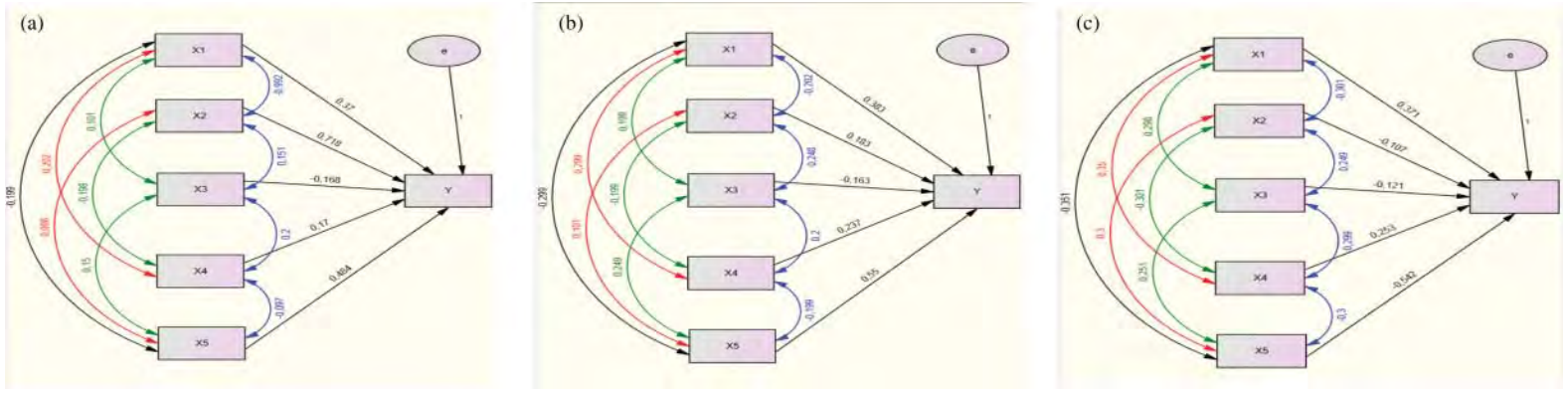


Figure 9. (a) $k = 5$ and $n = 500$. Low-correlation path diagram, (b) $k = 5$ and $n = 500$. Medium-correlation path diagram and (c) $k = 5$ and $n = 500$. High-correlation path diagram.

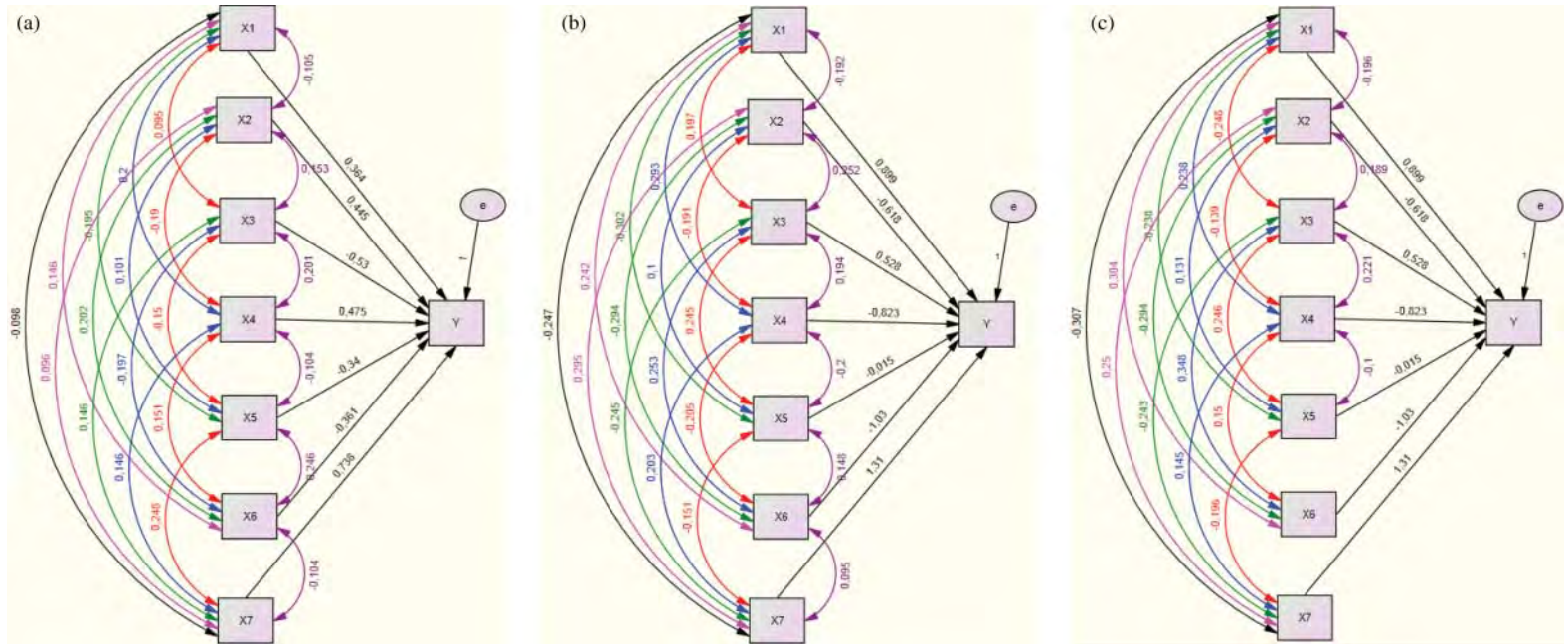


Figure 10. (a) $k = 7$ and $n = 50$. Low-correlation path diagram, (b) $k = 7$ and $n = 50$. Medium-correlation path diagram and (c) $k = 7$ and $n = 50$. High-correlation path diagram.

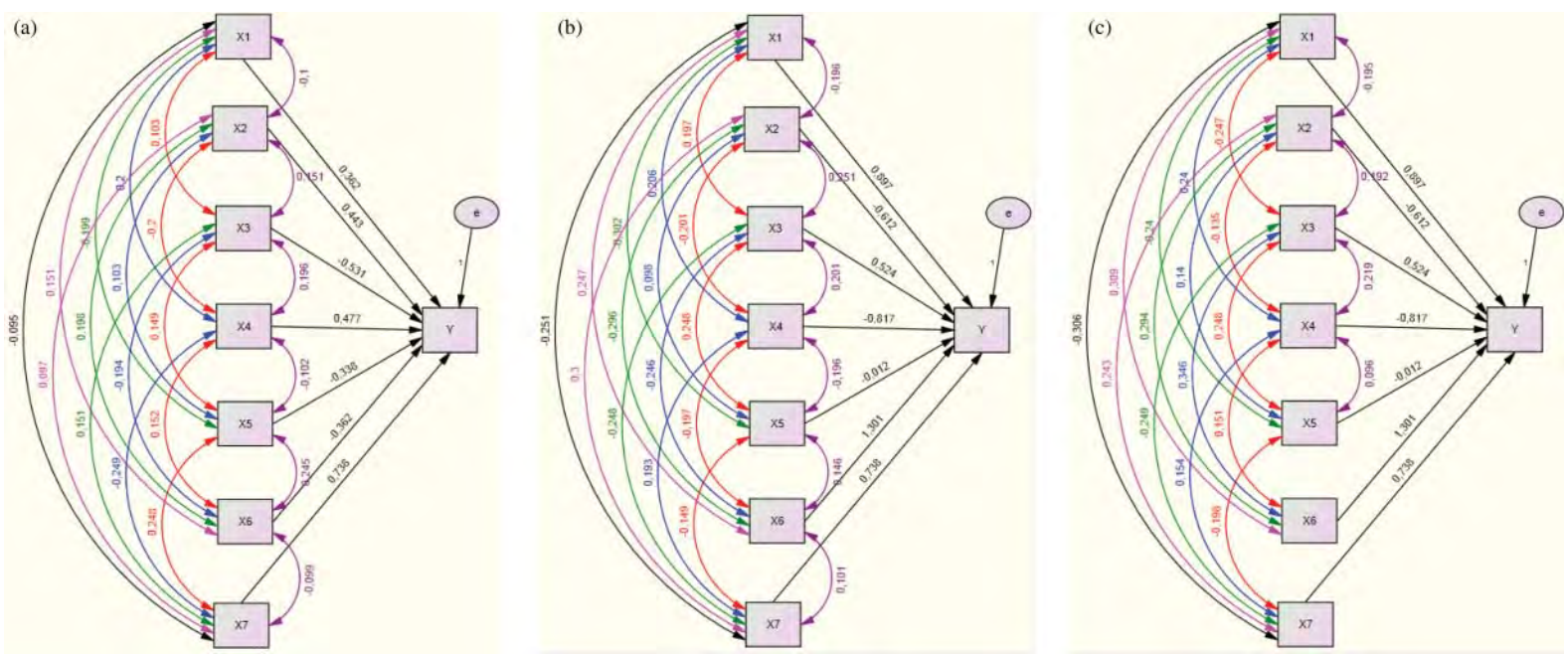


Figure 11. (a) $k = 7$ and $n = 100$. Low-correlation path diagram, (b) $k = 7$ and $n = 100$. Medium-correlation path diagram and (c) $k = 7$ and $n = 100$. High-correlation path diagram.

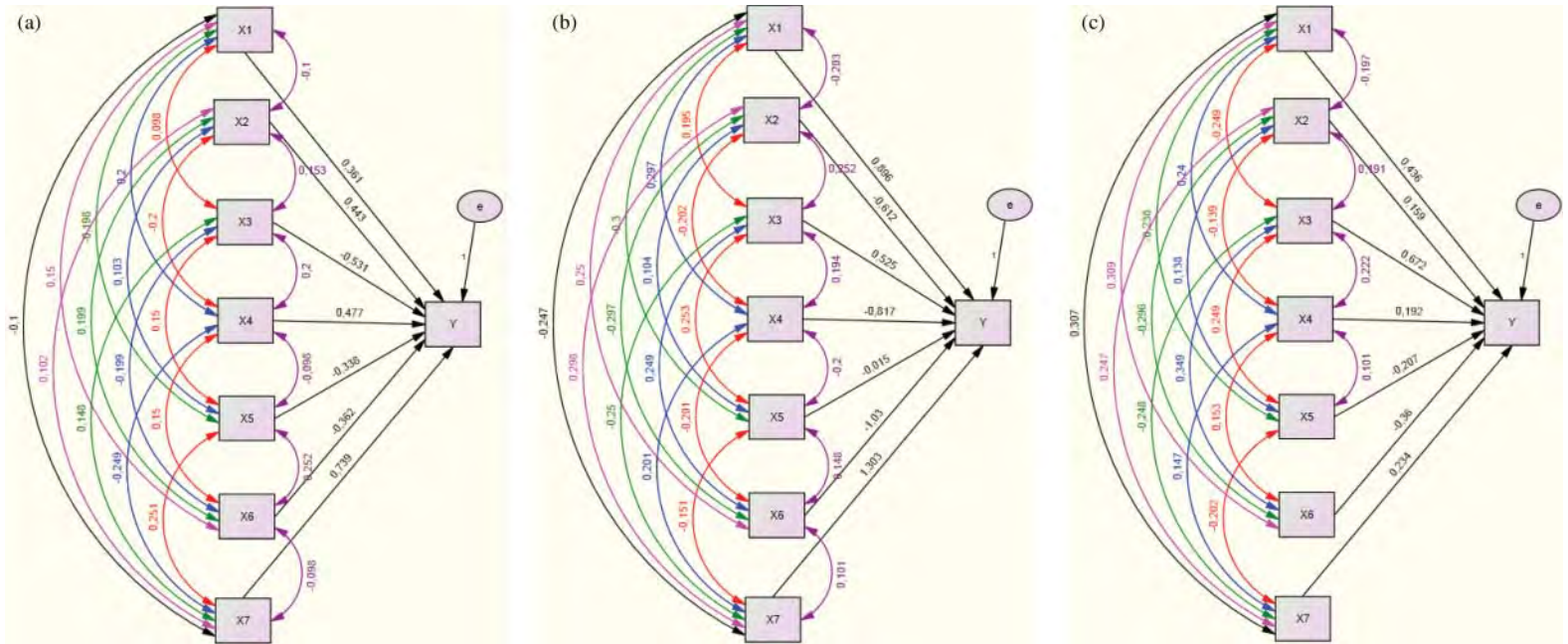


Figure 12. (a) $k = 7$ and $n = 250$. Low-correlation path diagram, (b) $k = 7$ and $n = 250$. Medium-correlation path diagram and (c) $k = 7$ and $n = 250$. High-correlation path diagram.

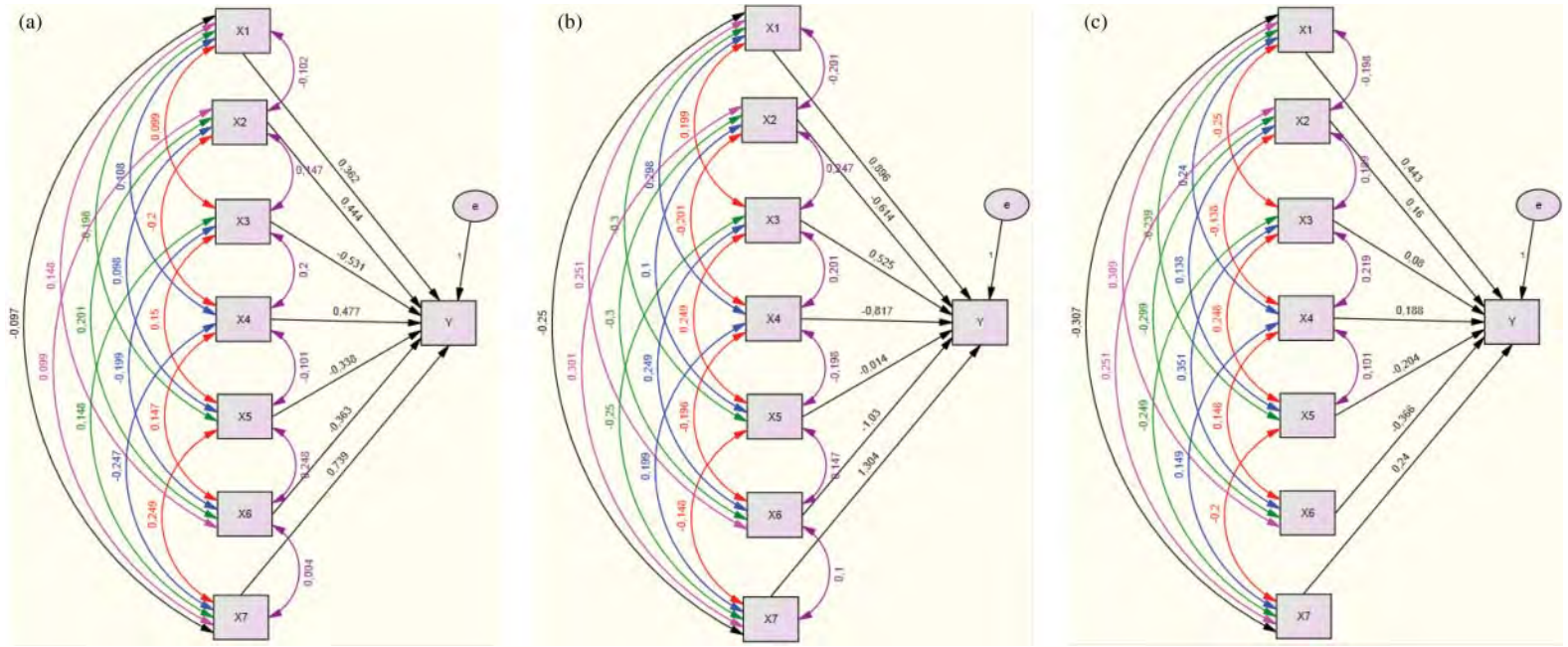


Figure 13. (a) $k = 7$ and $n = 500$. Low-correlation path diagram, (b) $k = 7$ and $n = 500$. Medium-correlation path diagram and (c) $k = 7$ and $n = 500$. High-correlation path diagram.

Table 4. Anderson–Darling normality test p values of the indirect effects for $k = 3$.

Relation level	IE	Sample width (n)			
		$n = 50$	$n = 100$	$n = 250$	$n = 500$
Low	X_1, X_2	0.104	0.324	0.991	0.049
	X_1, X_3	0.885	0.861	0.585	0.523
	X_2, X_1	0.174	0.335	0.911	0.079
	X_2, X_3	0.249	0.522	0.307	0.646
	X_3, X_1	0.005*	0.005*	0.005*	0.211
	X_3, X_2	0.005*	0.005*	0.009	0.495
Medium	X_1, X_2	0.805	0.551	0.456	0.107
	X_1, X_3	0.441	0.325	0.568	0.209
	X_2, X_1	0.021	0.137	0.460	0.078
	X_2, X_3	0.005*	0.085	0.101	0.949
	X_3, X_1	0.005*	0.107	0.923	0.454
	X_3, X_2	0.005*	0.299	0.043	0.943
High	X_1, X_2	0.005*	0.458	0.472	0.116
	X_1, X_3	0.005*	0.124	0.442	0.398
	X_2, X_1	0.005*	0.298	0.514	0.120
	X_2, X_3	0.005*	0.016	0.487	0.504
	X_3, X_1	0.005*	0.005*	0.786	0.548
	X_3, X_2	0.005*	0.005*	0.042	0.005*

In Table 5 in the path models with five variables obtained as a result of 1000 repetitions, Anderson–Darling normality test p values of the indirect effects of the independent variables are given. It is observed that most of the indirect effects in low- and medium-correlated path models do not show compliance to the normal distribution and the sample size does not have any effect on the distribution of indirect effects. In high-correlated path

Table 5. Anderson–Darling normality test p values of the indirect effects for $k = 5$.

Correlation level	IE	Sample width (n)			
		$n = 50$	$n = 100$	$n = 250$	$n = 500$
Low	X_1, X_2	0.005*	0.005*	0.005*	0.006
	X_1, X_3	0.005*	0.005*	0.005*	0.005*
	X_1, X_4	0.005*	0.005*	0.005*	0.041
	X_1, X_5	0.005*	0.005*	0.005*	0.044
	X_2, X_1	0.005*	0.005*	0.010	0.010
	X_2, X_3	0.005*	0.005*	0.032	0.816
	X_2, X_4	0.005*	0.005*	0.009	0.005*
	X_2, X_5	0.005*	0.005*	0.453	0.295
	X_3, X_1	0.005*	0.005*	0.005*	0.006
	X_3, X_2	0.005*	0.005*	0.007	0.005*
	X_3, X_4	0.005*	0.005*	0.005*	0.034
	X_3, X_5	0.005*	0.005*	0.005*	0.005*
	X_4, X_1	0.005*	0.005*	0.005*	0.005*
	X_4, X_2	0.005*	0.005*	0.005*	0.005*
	X_4, X_3	0.005*	0.005*	0.005*	0.005*
	X_4, X_5	0.005*	0.005*	0.005*	0.005*
	X_5, X_1	0.005*	0.005*	0.005*	0.005*
	X_5, X_2	0.005*	0.005*	0.005*	0.005*
	X_5, X_3	0.005*	0.005*	0.005*	0.005*
	X_5, X_4	0.005*	0.005*	0.005*	0.005*
Medium	X_1, X_2	0.005*	0.005*	0.006	0.005*

(continued).

Table 5. Continued

Correlation level	IE	Sample width (n)			
		n = 50	n = 100	n = 250	n = 500
High	X ₁ ,X ₃	0.005*	0.005*	0.005*	0.055
	X ₁ ,X ₄	0.005*	0.005*	0.029	0.005*
	X ₁ ,X ₅	0.005*	0.005*	0.005*	0.016
	X ₂ ,X ₁	0.005*	0.005*	0.015	0.006
	X ₂ ,X ₃	0.005*	0.039	0.258	0.039
	X ₂ ,X ₄	0.005*	0.005*	0.005*	0.279
	X ₂ ,X ₅	0.005*	0.460	0.977	0.019
	X ₃ ,X ₁	0.005*	0.005*	0.005*	0.154
	X ₃ ,X ₂	0.005*	0.005*	0.020	0.005*
	X ₃ ,X ₄	0.005*	0.005*	0.005*	0.027
	X ₃ ,X ₅	0.005*	0.005*	0.005*	0.005*
	X ₄ ,X ₁	0.005*	0.005*	0.005*	0.005*
	X ₄ ,X ₂	0.005*	0.005*	0.005*	0.005*
	X ₄ ,X ₃	0.005*	0.005*	0.005*	0.005*
	X ₄ ,X ₅	0.005*	0.005*	0.005*	0.005*
	X ₅ ,X ₁	0.005*	0.005*	0.016	0.005*
	X ₅ ,X ₂	0.005*	0.005*	0.005*	0.005*
	X ₅ ,X ₃	0.005*	0.005*	0.005*	0.005*
	X ₅ ,X ₄	0.005*	0.005*	0.005*	0.005*
	X ₁ ,X ₂	0.005*	0.022	0.280	0.084
	X ₁ ,X ₃	0.005*	0.005*	0.090	0.152
	X ₁ ,X ₄	0.005*	0.341	0.154	0.072
	X ₁ ,X ₅	0.005*	0.097	0.219	0.806
	X ₂ ,X ₁	0.005*	0.208	0.494	0.587
	X ₂ ,X ₃	0.106	0.008	0.028	0.037
	X ₂ ,X ₄	0.005*	0.039	0.164	0.095
	X ₂ ,X ₅	0.005*	0.866	0.053	0.634
	X ₃ ,X ₁	0.005*	0.005*	0.086	0.297
	X ₃ ,X ₂	0.005*	0.005*	0.019	0.005*
	X ₃ ,X ₄	0.005*	0.005*	0.014	0.092
	X ₃ ,X ₅	0.005*	0.005*	0.102	0.008
	X ₄ ,X ₁	0.005*	0.005*	0.005*	0.791
	X ₄ ,X ₂	0.005*	0.005*	0.005*	0.503
	X ₄ ,X ₃	0.005*	0.005*	0.005*	0.005*
	X ₄ ,X ₅	0.005*	0.005*	0.005*	0.006
	X ₅ ,X ₁	0.005*	0.005*	0.005*	0.626
	X ₅ ,X ₂	0.005*	0.005*	0.005*	0.049
	X ₅ ,X ₃	0.005*	0.005*	0.005*	0.005*
X ₅ ,X ₄	0.005*	0.005*	0.005*	0.006	

Table 6. Anderson–Darling normality test p values of the indirect effects for k = 7.

Correlation level	IE	Sample width (n)			
		n = 50	n = 100	n = 250	n = 500
Low	X ₁ ,X ₂	0.471	0.954	0.395	0.585
	X ₁ ,X ₃	0.137	0.034	0.110	0.363
	X ₁ ,X ₄	0.279	0.301	0.930	0.224
	X ₁ ,X ₅	0.412	0.731	0.026	0.152
	X ₁ ,X ₆	0.710	0.622	0.025	0.271
	X ₁ ,X ₇	0.091	0.277	0.630	0.946
	X ₂ ,X ₁	0.416	0.968	0.538	0.543
	X ₂ ,X ₃	0.568	0.678	0.988	0.325
	X ₂ ,X ₄	0.252	0.112	0.124	0.234
	X ₂ ,X ₅	0.420	0.506	0.291	0.047

(continued).

Table 6. Continued

Correlation level	IE	Sample width (<i>n</i>)			
		<i>n</i> = 50	<i>n</i> = 100	<i>n</i> = 250	<i>n</i> = 500
	X_2, X_6	0.048	0.592	0.844	0.804
	X_2, X_7	0.402	0.826	0.078	0.353
	X_3, X_1	0.117	0.125	0.308	0.506
	X_3, X_2	0.447	0.335	0.909	0.179
	X_3, X_4	0.097	0.193	0.238	0.027
	X_3, X_5	0.482	0.988	0.320	0.198
	X_3, X_6	0.880	0.350	0.709	0.619
	X_3, X_7	0.07	0.484	0.726	0.848
	X_4, X_1	0.861	0.040	0.608	0.075
	X_4, X_2	0.383	0.138	0.248	0.324
	X_4, X_3	0.333	0.506	0.242	0.028
	X_4, X_5	0.611	0.379	0.755	0.291
	X_4, X_6	0.483	0.857	0.215	0.327
	X_4, X_7	0.086	0.348	0.758	0.683
	X_5, X_1	0.430	0.820	0.065	0.181
	X_5, X_2	0.718	0.460	0.520	0.062
	X_5, X_3	0.838	0.719	0.320	0.080
	X_5, X_4	0.303	0.505	0.822	0.504
	X_5, X_6	0.552	0.991	0.483	0.301
	X_5, X_7	0.582	0.117	0.579	0.217
	X_6, X_1	0.791	0.533	0.042	0.097
	X_6, X_2	0.081	0.885	0.793	0.793
	X_6, X_3	0.879	0.485	0.564	0.767
	X_6, X_4	0.668	0.929	0.367	0.335
	X_6, X_5	0.116	0.421	0.237	0.222
	X_6, X_7	0.910	0.606	0.517	0.681
	X_7, X_1	0.182	0.385	0.526	0.912
	X_7, X_2	0.066	0.698	0.122	0.303
	X_7, X_3	0.014	0.441	0.595	0.825
	X_7, X_4	0.016	0.110	0.869	0.820
	X_7, X_5	0.080	0.212	0.367	0.293
	X_7, X_6	0.695	0.895	0.714	0.510
Medium	X_1, X_2	0.846	0.818	0.902	0.661
	X_1, X_3	0.343	0.368	0.138	0.875
	X_1, X_4	0.601	0.463	0.126	0.759
	X_1, X_5	0.127	0.135	0.190	0.273
	X_1, X_6	0.463	0.663	0.449	0.410
	X_1, X_7	0.379	0.510	0.711	0.337
	X_2, X_1	0.017	0.343	0.887	0.943
	X_2, X_3	0.005*	0.515	0.141	0.725
	X_2, X_4	0.005*	0.031	0.535	0.398
	X_2, X_5	0.107	0.047	0.468	0.887
	X_2, X_6	0.005*	0.008	0.784	0.045
	X_2, X_7	0.015	0.119	0.044	0.050
	X_3, X_1	0.005*	0.095	0.801	0.150
	X_3, X_2	0.005*	0.286	0.113	0.845
	X_3, X_4	0.005*	0.140	0.081	0.735
	X_3, X_5	0.005*	0.076	0.110	0.612
	X_3, X_6	0.083	0.049	0.006	0.218
	X_3, X_7	0.569	0.032	0.508	0.155
	X_4, X_1	0.005	0.742	0.290	0.955
	X_4, X_2	0.079	0.739	0.680	0.952
	X_4, X_3	0.270	0.848	0.34	0.226
	X_4, X_5	0.168	0.405	0.290	0.887
	X_4, X_6	0.050	0.057	0.843	0.912
	X_4, X_7	0.661	0.576	0.044	0.566
	X_5, X_1	0.005*	0.005*	0.005*	0.507
	X_5, X_2	0.005*	0.005*	0.005*	0.005*

(continued).

Table 6. Continued

Correlation level	IE	Sample width (<i>n</i>)			
		<i>n</i> = 50	<i>n</i> = 100	<i>n</i> = 250	<i>n</i> = 500
	X_5, X_3	0.005*	0.005*	0.005*	0.224
	X_5, X_4	0.005*	0.005*	0.005*	0.956
	X_5, X_6	0.005*	0.005*	0.005*	0.005*
	X_5, X_7	0.005*	0.005*	0.005*	0.077
	X_6, X_1	0.658	0.902	0.498	0.197
	X_6, X_2	0.780	0.375	0.727	0.626
	X_6, X_3	0.121	0.570	0.361	0.593
	X_6, X_4	0.511	0.111	0.980	0.770
	X_6, X_5	0.722	0.993	0.524	0.778
	X_6, X_7	0.554	0.107	0.103	0.690
	X_7, X_1	0.097	0.428	0.475	0.142
	X_7, X_2	0.866	0.232	0.375	0.523
	X_7, X_3	0.027	0.827	0.901	0.640
	X_7, X_4	0.121	0.242	0.087	0.599
	X_7, X_5	0.844	0.173	0.312	0.538
	X_7, X_6	0.720	0.094	0.101	0.428
High	X_1, X_2	0.005*	0.005*	0.005*	0.005*
	X_1, X_3	0.005*	0.005*	0.005*	0.005*
	X_1, X_4	0.005*	0.005*	0.005*	0.005*
	X_1, X_5	0.005*	0.005*	0.005*	0.005*
	X_1, X_6	0.005*	0.005*	0.043	0.189
	X_1, X_7	0.005*	0.005*	0.005	0.072
	X_2, X_1	0.005*	0.005*	0.005*	0.005*
	X_2, X_3	0.005*	0.005*	0.005*	0.005*
	X_2, X_4	0.005*	0.005*	0.005*	0.005*
	X_2, X_5	0.005*	0.005*	0.005*	0.005*
	X_2, X_6	0.005*	0.005*	0.017	0.115
	X_2, X_7	0.005*	0.005*	0.005*	0.006
	X_3, X_1	0.005*	0.005*	0.005*	0.504
	X_3, X_2	0.005*	0.005*	0.005*	0.126
	X_3, X_4	0.005*	0.005*	0.050	0.024
	X_3, X_5	0.005*	0.005*	0.069	0.342
	X_3, X_6	0.005*	0.005*	0.684	0.631
	X_3, X_7	0.005*	0.005*	0.037	0.083
	X_4, X_1	0.005*	0.005*	0.005*	0.005*
	X_4, X_2	0.005*	0.005*	0.005*	0.005*
	X_4, X_3	0.005*	0.005*	0.005*	0.005*
	X_4, X_5	0.005*	0.005*	0.005*	0.005*
	X_4, X_6	0.005*	0.005*	0.005*	0.005*
	X_4, X_7	0.005*	0.005*	0.005*	0.005*
	X_5, X_1	0.005*	0.005*	0.005*	0.005*
	X_5, X_2	0.005*	0.005*	0.005*	0.005*
	X_5, X_3	0.005*	0.005*	0.005*	0.005*
	X_5, X_4	0.005*	0.005*	0.005*	0.005*
	X_5, X_6	0.005*	0.005*	0.005*	0.018
	X_5, X_7	0.005*	0.005*	0.005*	0.005*
	X_6, X_1	0.005*	0.005*	0.009	0.011
	X_6, X_2	0.005*	0.005*	0.005*	0.005*
	X_6, X_3	0.005*	0.005*	0.038	0.433
	X_6, X_4	0.005*	0.005*	0.005*	0.005*
	X_6, X_5	0.005*	0.005*	0.087	0.014
	X_6, X_7	0.005*	0.005*	0.027	0.984
	X_7, X_1	0.005*	0.005*	0.033	0.089
	X_7, X_2	0.005*	0.005*	0.005*	0.005*
	X_7, X_3	0.005*	0.005*	0.005*	0.005*
	X_7, X_4	0.005*	0.005*	0.005*	0.005*
	X_7, X_5	0.005*	0.005*	0.005*	0.005*
	X_7, X_6	0.005*	0.005*	0.005*	0.102

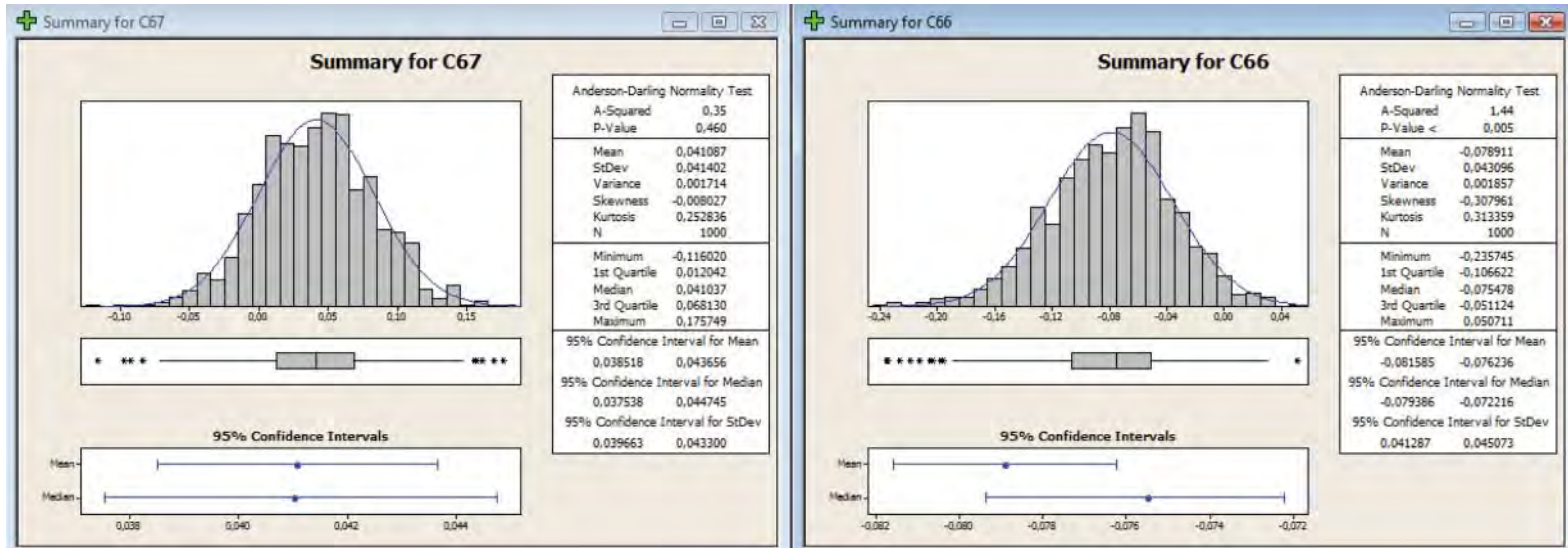


Figure 14. Examples of the indirect effects with or without normal distribution.

diagrams, some of the indirect effects of path models with 250 and 500 sample sizes have a normal distribution ($p < .05$).

In Table 6 in the path models with seven variables obtained as a result of 1000 repetitions, Anderson–Darling normality test p values for the indirect effects of independent variables on the dependent variable are given. Considering such values, most of the indirect effects in low-correlated path models have a normal distribution, and in medium-correlated path models indirect effects show less compliance to the normal distribution than the low- and high-correlated path models; distribution of the indirect effects move away from normality. Also in the path models with three and five variables, as mentioned before, it is observed that sample size does not have any effect on the distribution of indirect effects.

In the histograms obtained by Minitab 16 (Figure 14) it is shown that indirect effects are more similar to normal distribution in shape. It should be considered that the calculated p value is affected from the 1000 repetitions.

When Figure 14 is observed, it is seen that the distribution of the indirect effects with three independent variables has a normal distribution in Anderson–Darling normality test. End points are uniformly distributed in both sides of the distribution. It is also seen that although the distribution of the indirect effects with five independent variables does not seem to have a normal distribution in Anderson–Darling normality test, the end points are mostly accumulated in the left side of the distribution. It may be considered that this situation affects the result of the test. 95% confidence interval values of the indirect effects are given in Tables 7–16.

In Table 7, 95% confidence interval of values of the indirect effects for the path models with three variables are given. Such confidence intervals are calculated by using a unilateral t -test in Minitab 16. The confidence intervals including 0 (zero) value are accepted as insignificant. For example, in the simulation study performed with 50 sample size at low level the indirect effect between the first independent variable and the third independent variable is statistically insignificant.

Table 7. Confidence intervals and average values of the indirect effects for $k = 3$.

		$n = 50$		$n = 100$		$n = 250$		$n = 500$	
		Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper
Low	X_1, X_2	0.0661	0.0798	0.0699	0.0791	0.0676	0.0734	0.0719	0.0760
	X_1, X_3	-0.0537	0.0790	0.0687	0.0781	0.0702	0.0759	0.0721	0.0762
	X_2, X_1	-0.0639	-0.0519	-0.0609	-0.0538	-0.0567	-0.0522	-0.0587	-0.0555
	X_2, X_3	-0.0624	0.0195	-0.0037	0.0034	-0.0004	0.0043	-0.0024	0.0007
	X_3, X_1	0.0160	0.0194	0.0113	0.0130	0.0118	0.0129	0.0121	0.0129
	X_3, X_2	0.0159	0.0194	0.0008	0.0007	-0.0008	-0.0001	-0.0001	0.0005
Medium	X_1, X_2	-0.1773	-0.1653	-0.0024	0.0052	-0.0011	0.0038	-0.0020	0.0014
	X_1, X_3	-0.1468	-0.1346	-0.1236	-0.1160	-0.1233	-0.1189	-0.1223	-0.1189
	X_2, X_1	-0.1119	-0.1039	-0.0017	0.0034	0.0007	0.0025	-0.0013	0.0009
	X_2, X_3	0.1516	0.1596	-0.0018	0.0032	0.0024	0.0006	-0.0016	0.0006
	X_3, X_1	-0.0826	-0.0753	-0.1058	-0.0992	0.1062	0.1023	-0.1055	-0.1026
	X_3, X_2	0.1340	0.1413	-0.0023	0.0041	-0.0032	0.0008	-0.0022	0.0007
High	X_1, X_2	0.2124	0.2228	-0.0061	0.0021	-0.0024	0.0026	-0.0009	0.0026
	X_1, X_3	0.1883	0.1983	-0.0055	0.0026	-0.0029	0.0022	-0.0017	0.0019
	X_2, X_1	0.1162	0.1244	-0.0040	0.0015	-0.0015	0.0018	-0.0006	0.0017
	X_2, X_3	0.1417	0.1511	0.2360	0.2417	0.2372	0.2407	0.2369	0.2393
	X_3, X_1	0.0385	0.0453	-0.0016	0.0009	-0.0009	0.0007	-0.0005	0.0005
	X_3, X_2	0.0528	0.0617	0.1105	0.1152	0.1148	0.1177	0.1161	0.1181

Table 8. Confidence intervals and average values of the indirect effects for $k = 5$ and low correlation.

		$n = 50$		$n = 100$		$n = 250$		$n = 500$	
		Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper
Low	X_1, X_2	-0.0293	-0.0238	-0.0279	-0.0238	-0.0266	-0.0244	-0.0263	-0.0247
	X_1, X_3	0.0254	0.0309	0.0223	-0.0392	0.0245	0.0266	0.0253	0.0268
	X_1, X_4	0.0487	0.0548	0.0499	-0.0513	0.0500	0.0524	0.0512	0.0529
	X_1, X_5	-0.0554	-0.0492	-0.0532	-0.0389	-0.0530	-0.0505	-0.0521	-0.0504
	X_2, X_1	-0.0376	-0.0310	-0.0372	0.0388	-0.0343	-0.0316	-0.0342	-0.0322
	X_2, X_3	0.0461	0.0524	0.0492	-0.0349	0.0482	0.0510	0.0497	0.0517
	X_2, X_4	-0.0716	-0.0651	-0.0687	0.0392	-0.0670	-0.0641	-0.0674	-0.0654
	X_2, X_5	0.0295	0.0360	0.0313	-0.0172	0.0326	0.0352	0.0318	0.0338
	X_3, X_1	-0.0307	-0.0255	-0.0273	0.0664	-0.0271	-0.0249	-0.0273	-0.0258
	X_3, X_2	-0.0410	-0.0355	-0.0431	-0.0292	-0.0401	-0.0378	-0.0408	-0.0392
	X_3, X_4	-0.0551	-0.0492	-0.0554	-0.0458	-0.0536	-0.0511	-0.0538	-0.0521
	X_3, X_5	-0.0407	-0.0348	-0.0428	0.0340	-0.0402	-0.0379	-0.0406	-0.0389
	X_4, X_1	0.0350	0.0399	0.0356	-0.0238	0.0360	0.0380	0.0368	0.0382
	X_4, X_2	-0.0409	-0.0361	-0.0382	-0.0392	-0.0376	-0.0356	-0.0376	-0.0362
	X_4, X_3	0.0356	0.0406	0.0358	-0.0513	0.0361	0.0380	0.0364	0.0379
	X_4, X_5	-0.0201	-0.0160	-0.0201	-0.0389	-0.0194	-0.0178	-0.0186	-0.0174
	X_5, X_1	0.0610	0.0676	0.0618	0.0388	0.0637	0.0665	0.0634	0.0654
	X_5, X_2	-0.0344	-0.0280	-0.0335	-0.0349	-0.0346	-0.0320	-0.0326	-0.0307
	X_5, X_3	-0.0489	-0.0426	-0.0503	0.0392	-0.0498	-0.0471	-0.0493	-0.0475
	X_5, X_4	0.0279	0.0342	0.0297	-0.0172	0.0314	0.0340	0.0305	0.0324

Table 9. Confidence intervals and average values of the indirect effects for $k = 5$ and medium correlation.

		$n = 50$		$n = 100$		$n = 250$		$n = 500$	
		Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper
Medium	X_1, X_2	-0.0700	-0.0625	-0.0696	0.0436	-0.0687	-0.0657	-0.0692	-0.0671
	X_1, X_3	0.0607	0.0678	0.0637	-0.0656	0.0657	0.0688	0.0664	0.0685
	X_1, X_4	0.0957	0.1038	0.0968	-0.0824	0.1001	0.1034	0.0999	0.1022
	X_1, X_5	-0.1044	-0.0964	-0.1015	-0.0675	-0.1030	-0.0996	-0.1023	-0.0999
	X_2, X_1	-0.0814	-0.0735	-0.0849	-0.0819	-0.0831	-0.0796	-0.0832	-0.0808
	X_2, X_3	0.0962	0.1043	0.0975	0.0485	0.1001	0.1035	0.0996	0.1022
	X_2, X_4	-0.0790	-0.0708	-0.0815	0.0284	-0.0847	-0.0811	-0.0823	-0.0799
	X_2, X_5	0.0358	0.0437	0.0385	0.0327	0.0386	0.0418	0.0398	0.0420
	X_3, X_1	-0.0682	-0.0610	-0.0704	0.0293	-0.0693	-0.0662	-0.0700	-0.0679
	X_3, X_2	-0.0880	-0.0807	-0.0876	0.0684	-0.0869	-0.0838	-0.0869	-0.0846
	X_3, X_4	-0.0721	-0.0648	-0.0726	0.0216	-0.0694	-0.0664	-0.0702	-0.0680
	X_3, X_5	-0.0885	-0.0812	-0.0870	-0.0533	-0.0867	-0.0836	-0.0874	-0.0852
	X_4, X_1	0.0401	0.0461	0.0444	0.0467	0.0452	0.0477	0.0450	0.0467
	X_4, X_2	-0.0298	-0.0250	-0.0316	0.0436	-0.0323	-0.0304	-0.0312	-0.0299
	X_4, X_3	0.0270	0.0318	0.0295	-0.0656	0.0296	0.0314	0.0299	0.0312
	X_4, X_5	-0.0303	-0.0257	-0.0325	-0.0824	-0.0317	-0.0299	-0.0311	-0.0298
	X_5, X_1	0.0619	0.0685	0.06420	-0.0675	0.0660	0.0687	0.0660	0.0679
	X_5, X_2	-0.0242	-0.0192	-0.0248	-0.0819	-0.0232	-0.0213	-0.0231	-0.0218
	X_5, X_3	-0.0568	-0.0509	-0.0573	0.0485	-0.0577	-0.0551	-0.0566	-0.0549
	X_5, X_4	0.0425	0.0483	0.0431	0.0284	0.0440	0.0462	0.0435	0.0450

When considered generally, 27 of 144 indirect effects in all the path models with three variables are seen statistically insignificant. Accordingly, it may be suitable to use the regression analysis in the path models with three variables.

In Table 10, 95% confidence intervals of the indirect effects regarding the path models with five variables are given. The interpretations made for the models with three variables

Table 10. Confidence intervals and average values of the indirect effects for $k = 5$ and high correlation.

		$n = 50$		$n = 100$		$n = 250$		$n = 500$	
		Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper
High	X_1, X_2	-0.1457	-0.1361	-0.1461	-0.1396	-0.1458	-0.1420	-0.1452	-0.1423
	X_1, X_3	0.1381	0.1477	0.1379	0.1444	0.1418	0.1459	0.1411	0.1439
	X_1, X_4	0.1576	0.1673	0.1599	0.1665	0.1652	0.1694	0.1657	0.1685
	X_1, X_5	-0.1708	-0.1612	-0.1672	-0.1605	-0.1680	-0.1637	-0.1688	-0.1659
	X_2, X_1	-0.1900	-0.1783	-0.1887	-0.1811	-0.1880	-0.1833	-0.1869	-0.1834
	X_2, X_3	0.1468	0.1579	0.1513	0.1589	0.1500	0.1551	0.1516	0.1550
	X_2, X_4	-0.1872	-0.1758	-0.1883	-0.1805	-0.1862	-0.1814	-0.1865	-0.1831
	X_2, X_5	0.1773	0.1890	0.1821	0.1896	0.1806	0.1854	0.1824	0.1858
	X_3, X_1	-0.1619	-0.1517	-0.1596	-0.1523	-0.1600	-0.1556	-0.1582	-0.1551
	X_3, X_2	-0.1346	-0.1245	-0.1348	-0.1281	-0.1320	-0.1275	-0.1325	-0.1295
	X_3, X_4	-0.1602	-0.1501	-0.1578	-0.1505	-0.1601	-0.1558	-0.1586	-0.1555
	X_3, X_5	-0.1329	-0.1223	-0.1345	-0.1276	-0.1332	-0.1288	-0.1333	-0.1301
	X_4, X_1	0.0849	0.0921	0.0878	0.0928	0.0907	0.0937	0.0901	0.0921
	X_4, X_2	-0.0788	-0.0721	-0.0810	-0.0763	-0.0802	-0.0773	-0.0792	-0.0773
	X_4, X_3	0.0742	0.0809	0.0749	0.0796	0.0780	0.0808	0.0769	0.0788
	X_4, X_5	-0.0796	-0.0727	-0.0807	-0.0761	-0.0799	-0.0771	-0.0791	-0.0771
	X_5, X_1	0.0734	0.0805	0.0707	0.0754	0.0700	0.0727	0.0720	0.0740
	X_5, X_2	-0.0666	-0.0603	-0.0654	-0.0614	-0.0623	-0.0598	-0.0632	-0.0615
	X_5, X_3	-0.0555	-0.0497	0.0547	0.0509	-0.0524	-0.0501	-0.0530	-0.0514
	X_5, X_4	0.0604	0.0668	0.0618	0.0660	0.0599	0.0624	0.0616	0.0635

Table 11. Confidence intervals and average values of the indirect effects for $k = 7$ and low correlation.

		$n = 50$		$n = 100$		$n = 250$		$n = 500$	
		Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper
Low	X_1, X_2	-0.0413	-0.0350	-0.0385	-0.0339	-0.0377	-0.0349	-0.0380	-0.0360
	X_1, X_3	0.0313	0.0377	0.0353	0.0398	0.0341	0.0370	0.0352	0.0372
	X_1, X_4	0.0694	0.0757	0.0704	0.0747	0.0711	0.0739	0.0710	0.0728
	X_1, X_5	-0.0739	-0.0677	-0.0743	-0.0701	-0.0731	-0.0702	-0.0728	-0.0709
	X_1, X_6	0.0499	0.0565	0.0524	0.0569	0.0531	0.0559	0.0527	0.0547
	X_1, X_7	-0.0389	-0.0324	-0.0365	-0.0322	-0.0379	-0.0351	-0.0361	-0.0342
	X_2, X_1	-0.0506	-0.0428	-0.0474	-0.0417	-0.0461	-0.0428	-0.0467	-0.0442
	X_2, X_3	0.0644	0.0722	0.0646	0.0700	0.0660	0.0695	0.0642	0.0666
	X_2, X_4	-0.0885	-0.0807	-0.0916	-0.0861	-0.0905	-0.0873	-0.0899	-0.0874
	X_2, X_5	0.0409	0.0487	0.0431	0.0484	0.0439	0.0474	0.0426	0.0451
	X_2, X_6	0.0861	0.0939	0.0854	0.0909	0.0864	0.0899	0.0881	0.0905
	X_2, X_7	0.0389	0.0470	0.0405	0.0460	0.0437	0.0471	0.0428	0.0452
	X_3, X_1	-0.0552	-0.0459	-0.0583	-0.0517	-0.0542	-0.0500	-0.0546	-0.0516
	X_3, X_2	-0.0859	-0.0767	-0.0840	-0.0775	-0.0832	-0.0790	-0.0797	-0.0768
	X_3, X_4	-0.1110	-0.1019	-0.1077	-0.1012	-0.1081	-0.1041	-0.1081	-0.1053
	X_3, X_5	-0.0844	-0.0752	-0.0830	-0.0761	-0.0817	-0.0776	-0.0809	-0.0779
	X_3, X_6	0.0999	0.1091	0.1004	0.1070	0.1033	0.1074	0.1046	0.1074
	X_3, X_7	-0.0820	-0.0725	-0.0837	-0.0775	-0.0808	-0.0765	-0.0805	-0.0776
	X_4, X_1	0.0914	0.0998	0.0928	0.0984	0.0937	0.0974	0.0937	0.0961
	X_4, X_2	-0.0947	-0.0863	-0.0985	-0.0926	-0.0974	-0.0940	-0.0967	-0.0940
	X_4, X_3	0.0913	0.0994	0.0908	0.0967	0.0936	0.0971	0.0947	0.0972
	X_4, X_5	-0.0537	-0.0455	-0.0520	-0.0460	-0.0487	-0.0451	-0.0497	-0.0471
	X_4, X_6	0.0680	0.0763	0.0697	0.0756	0.0694	0.0732	0.0694	0.0719
	X_4, X_7	-0.1258	-0.1176	-0.1218	-0.1162	-0.1204	-0.1169	-0.1197	-0.1171

are also valid for these models. The indirect effects of confidence intervals capturing zero value are statistically insignificant .

In Tables 15 and 16, 95% confidence intervals of the indirect effects for the path models with seven variables in high correlation are given. The interpretations made for the models

Table 12. Confidence intervals and average values of the indirect effects for $k = 7$ and low correlation.

		$n = 50$		$n = 100$		$n = 250$		$n = 500$	
		Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper
Low	X_5, X_1	-0.0865	-0.0809	-0.0852	-0.0811	-0.0868	-0.0842	0.0333	0.0352
	X_5, X_2	-0.0873	-0.0815	0.0857	0.0818	-0.0863	-0.0838	-0.0850	-0.0832
	X_5, X_3	-0.0562	-0.0496	-0.0569	-0.0524	-0.0560	-0.0531	-0.0851	-0.0833
	X_5, X_4	-0.0763	-0.0699	-0.0742	-0.0697	-0.0733	-0.0705	-0.0548	-0.0528
	X_5, X_6	0.0677	0.0740	0.0682	0.0728	0.0703	0.0732	-0.0740	-0.0720
	X_5, X_7	-0.0579	-0.0516	-0.0574	-0.0529	-0.0556	-0.0526	0.0715	0.0734
	X_6, X_1	-0.0920	-0.0860	-0.0909	-0.0866	-0.0926	-0.0899	-0.0546	-0.0527
	X_6, X_3	0.0343	0.0409	0.0335	0.0380	0.0338	0.0367	-0.0913	-0.0894
	X_6, X_4	-0.0785	-0.0656	-0.0746	-0.0657	-0.0775	-0.0717	0.0342	0.0362
	X_6, X_5	0.0642	0.0775	0.0674	0.0766	0.0729	0.0786	-0.0738	-0.0698
	X_6, X_7	0.1015	0.1148	0.1079	0.1165	0.1067	0.1126	0.0714	0.0753
	X_7, X_1	-0.1951	-0.1826	-0.1882	-0.1797	-0.1866	-0.1813	0.1080	0.1120
	X_7, X_2	0.1774	0.1897	0.1789	0.1872	0.1832	0.1885	-0.1851	-0.1813
	X_7, X_3	-0.0836	-0.0699	-0.0774	-0.0683	-0.0750	-0.0692	0.1822	0.1860
	X_7, X_4	-0.0865	-0.0809	-0.0852	-0.0811	-0.0868	-0.0842	-0.0738	-0.0698
	X_7, X_5	-0.0873	-0.0815	0.0857	0.0818	-0.0863	-0.0838	0.0333	0.0352
	X_7, X_6	-0.0562	-0.0496	-0.0569	-0.0524	-0.0560	-0.0531	-0.0850	-0.0832

Table 13. Confidence intervals and average values of the indirect effects for $k = 7$ and medium correlation.

		$n = 50$		$n = 100$		$n = 250$		$n = 500$	
		Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper
Medium	X_1, X_2	-0.1820	-0.1655	-0.1819	-0.1709	-0.1852	-0.1785	-0.1833	-0.1782
	X_1, X_3	0.1696	0.1847	0.1717	0.1826	0.1713	0.1782	0.1761	0.1811
	X_1, X_4	0.2557	0.2705	0.2610	0.2717	0.2629	0.2696	0.2650	0.2699
	X_1, X_5	-0.2781	-0.2631	-0.2765	-0.2658	-0.2726	-0.2659	-0.2714	-0.2666
	X_1, X_6	0.2105	0.2259	0.2170	0.2277	0.2208	0.2276	0.2232	0.2279
	X_1, X_7	-0.2311	-0.2154	-0.2304	-0.2198	-0.2247	-0.2180	-0.2268	-0.2219
	X_2, X_1	0.1124	0.1242	0.1164	0.1242	0.1220	0.1267	0.1223	0.1259
	X_2, X_3	-0.1617	-0.1503	-0.1571	-0.1492	-0.1572	-0.1522	-0.1534	-0.1499
	X_2, X_4	0.1126	0.1239	0.1193	0.1275	0.1215	0.1263	0.1220	0.1257
	X_2, X_5	-0.0668	-0.0559	-0.0641	-0.0564	-0.0662	-0.0613	-0.0632	-0.0598
	X_2, X_6	0.1762	0.1879	0.1774	0.1854	0.1795	0.1846	0.1831	0.1865
	X_2, X_7	-0.1866	-0.1757	-0.1877	-0.1796	-0.1855	-0.1806	-0.1872	-0.1838
	X_3, X_1	0.0991	0.1087	0.1004	0.1072	0.1004	0.1046	0.1031	0.1061
	X_3, X_2	0.1285	0.1384	0.1277	0.1345	0.1305	0.1348	0.1281	0.1311
	X_3, X_4	0.0981	0.1078	0.1025	0.1089	0.1001	0.1043	0.1044	0.1073
	X_3, X_5	0.1246	0.1349	0.1267	0.1336	0.1305	0.3480	0.1293	0.1324
	X_3, X_6	0.1280	0.1380	0.1258	0.1330	0.1287	0.3290	0.1295	0.1324
	X_3, X_7	-0.1335	-0.1236	-0.1345	-0.1275	-0.1332	-0.2910	-0.1332	-0.1303
	X_4, X_1	-0.2484	-0.2340	-0.2474	-0.2373	-0.2460	-0.2397	-0.2461	-0.2415
	X_4, X_2	0.1505	0.1651	0.1588	0.1693	0.1620	0.1683	0.1622	0.1669
	X_4, X_3	-0.1665	-0.1521	-0.1698	-0.1601	-0.1623	-0.1559	-0.1668	-0.1624
	X_4, X_5	0.1565	0.1713	0.1552	0.1654	0.1607	0.1671	0.1596	0.1640
	X_4, X_6	0.1609	0.1754	0.1569	0.1668	0.1612	0.1673	0.1581	0.1627
	X_4, X_7	-0.1768	-0.1616	-0.1625	-0.1526	-0.1673	-0.16100	-0.1650	-0.1606

with 3 and 5 variables are also valid for the path models with seven variables. The indirect effects of confidence intervals capturing zero value are also treated to be statistically insignificant.

Table 14. Confidence intervals and average values of the indirect effects for $k = 7$ and medium correlation.

		$n = 50$		$n = 100$		$n = 250$		$n = 500$	
		Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper
Medium	X_5, X_1	0.0033	0.0011	0.0023	0.0010	0.0025	0.0018	-0.002	-0.0017
	X_5, X_2	0.0005	0.0029	0.0012	0.0024	0.0018	0.0025	0.0017	0.0022
	X_5, X_3	-0.2608	-0.2428	-0.2621	-0.2496	-0.2619	-0.2539	-0.2622	-0.2567
	X_5, X_4	0.2960	0.3140	0.2998	0.3123	0.3022	0.3101	0.3072	0.3126
	X_5, X_6	-0.2706	-0.2527	-0.2610	-0.2478	-0.2605	-0.2528	-0.2600	-0.2545
	X_5, X_7	0.2032	0.2211	0.1980	0.2102	0.2035	0.2112	0.1995	0.2053
	X_6, X_1	-0.1618	-0.1435	-0.1577	-0.1452	-0.1571	-0.1490	-0.1551	-0.1494
	X_6, X_3	-0.1092	-0.0897	-0.1106	-0.0979	-0.1084	-0.1004	-0.1060	-0.1003
	X_6, X_4	-0.3350	-0.3125	-0.3346	-0.3192	-0.3270	-0.3172	-0.3302	-0.3231
	X_6, X_5	0.3758	0.3970	0.3829	0.3984	0.3847	0.3943	0.3902	0.3968
	X_6, X_7	-0.3329	-0.3099	-0.3324	-0.3166	-0.3300	-0.3206	-0.3306	-0.3239
	X_7, X_1	0.2562	0.2797	0.2432	0.2585	0.2570	0.2669	0.2566	0.2635
	X_7, X_2	-0.2102	-0.1865	-0.2025	-0.1866	-0.2027	-0.1923	-0.1973	-0.1899
	X_7, X_3	0.1132	0.1376	0.1240	0.1399	0.1271	0.1371	0.1270	0.1342
	X_7, X_4	0.0033	0.0011	0.0023	0.0010	0.0025	0.0018	-0.0022	-0.0017
	X_7, X_5	0.0005	0.0029	0.0012	0.0024	0.0018	0.0025	0.0017	0.0022
	X_7, X_6	-0.2608	-0.2428	-0.2621	-0.2496	-0.2619	-0.2539	-0.2622	-0.2567

Table 15. Confidence intervals and average values of the indirect effects for $k = 7$ and high correlation.

		$n = 50$		$n = 100$		$n = 250$		$n = 500$	
		Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper
High	X_1, X_2	-0.0916	-0.0818	-0.0887	-0.0819	-0.0880	-0.0830	-0.0895	-0.0865
	X_1, X_3	-0.1172	-0.1061	-0.1120	-0.1043	-0.1113	-0.1060	-0.1125	-0.1093
	X_1, X_4	0.1019	0.1131	0.1011	0.1084	0.1026	0.1070	0.1049	0.1080
	X_1, X_5	-0.1116	-0.1009	-0.1089	-0.1015	-0.1062	-0.1010	-0.1076	-0.1044
	X_1, X_6	0.1313	0.1431	0.1304	0.1389	0.1328	0.1370	0.1352	0.1387
	X_1, X_7	-0.1449	-0.1326	-0.1367	-0.1287	-0.1369	-0.1310	-0.1383	-0.1348
	X_2, X_1	-0.0355	-0.0293	-0.0339	-0.0298	0.0324	-0.0302	-0.0326	-0.0309
	X_2, X_3	0.0267	0.0332	0.0290	0.0328	0.0292	0.0314	0.0296	0.0312
	X_2, X_4	-0.0264	-0.0209	0.0242	0.0208	0.0234	-0.0214	-0.0230	-0.0216
	X_2, X_5	0.0179	0.0229	0.0208	0.0242	0.0213	0.0232	0.0214	0.0228
	X_2, X_6	-0.0500	-0.0418	-0.0509	-0.0456	0.0491	-0.0459	-0.0492	-0.0469
	X_2, X_7	0.0362	0.0434	0.0382	0.0429	0.0379	0.0406	0.0392	0.0412
	X_3, X_1	-0.0246	-0.0162	-0.0200	-0.0146	0.0199	-0.0166	-0.0213	-0.0190
	X_3, X_2	0.0109	0.0179	0.0111	0.0157	0.0129	0.0155	0.0142	0.0161
	X_3, X_4	0.0137	0.0217	0.0128	0.0177	0.0145	0.0175	0.0166	0.0187
	X_3, X_5	0.0160	0.0243	0.0144	0.0198	0.0163	0.0196	0.0188	0.0212
	X_3, X_6	0.0235	0.0348	0.0185	0.0256	0.0228	0.0270	0.0268	0.0300
	X_3, X_7	-0.0250	-0.0168	-0.0197	-0.0143	0.0193	-0.0160	-0.0212	-0.0189
	X_4, X_1	0.0403	0.0474	0.0436	0.0481	0.0450	0.0478	0.0445	0.0466
	X_4, X_2	-0.0293	-0.0237	0.0275	0.0242	0.0280	-0.0259	-0.0269	-0.0254
	X_4, X_3	0.0375	0.0441	0.0403	0.0447	0.0415	0.0442	0.0403	0.0421
	X_4, X_5	0.0144	0.0196	0.0175	0.0208	0.0186	0.0204	0.0186	0.0199
	X_4, X_6	0.0250	0.0305	0.0276	0.0312	0.0285	0.0306	0.0272	0.0287
	X_4, X_7	0.0234	0.0289	0.0281	0.0319	0.0270	0.0290	0.0273	0.0288

4. Results and discussion

Via the regression analysis the coefficients of the direct effects between the variables can be accessed. However, besides the direct effects between the variables, it is also important to specify the indirect effects. A path analysis can evaluate the causality correlation of the variables with each other and can explain the correlations by a diagram. The path analysis

Table 16. Confidence intervals and average values of the indirect effects for $k = 7$ and high correlation.

		$n = 50$		$n = 100$		$n = 250$		$n = 500$	
		Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper
High	X_5, X_1	-0.0038	0.0005	0.0013	0.0017	0.0012	0.0004	-0.0005	0.0005
	X_5, X_2	0.0365	0.0421	0.0396	0.0434	0.0406	0.0429	0.0403	0.0419
	X_5, X_3	-0.1180	-0.1079	-0.1145	-0.1071	-0.1144	-0.1100	-0.1146	-0.1116
	X_5, X_4	0.1047	0.1149	0.1022	0.1092	0.1053	0.1090	0.1083	0.1114
	X_5, X_6	-0.1347	-0.1234	-0.1272	-0.1197	-0.1283	-0.1230	-0.1304	-0.1271
	X_5, X_7	-0.0583	-0.0503	-0.0570	-0.0517	0.0570	-0.0537	-0.0554	-0.0531
	X_6, X_1	-0.0024	0.0048	-0.0011	0.0037	0.0016	0.0012	-0.0008	0.0012
	X_6, X_3	-0.0052	0.0024	-0.0056	-0.0004	0.0029	-0.0001	-0.0001	0.0018
	X_6, X_4	-0.0788	-0.0686	-0.0726	-0.0661	-0.0740	-0.0690	-0.0754	-0.0724
	X_6, X_5	0.0559	0.0649	0.0522	0.0578	0.0562	0.0598	0.0589	0.0614
	X_6, X_7	-0.0627	-0.0541	-0.0593	-0.0536	0.0596	-0.0561	-0.0612	-0.0586
	X_7, X_1	0.0321	0.0392	0.0328	0.0373	0.0332	0.0358	0.0350	0.0369
	X_7, X_2	-0.0511	-0.0430	-0.0474	-0.0424	0.0489	-0.0458	-0.0494	-0.0471
	X_7, X_3	-0.0018	0.0042	0.0000	0.0038	0.0001	0.0021	-0.0012	0.0000
	X_7, X_4	-0.0038	0.0005	0.0013	0.0017	0.0012	0.0004	-0.0005	0.0005
	X_7, X_5	0.0365	0.0421	0.0396	0.0434	0.0406	0.0429	0.0403	0.0419
	X_7, X_6	-0.1180	-0.1079	-0.1145	-0.1071	-0.1144	-0.1100	-0.1146	-0.1116

can also provide detailed answers to the problems of the examiner without eliminating the structure consisting of the cause and effect correlation between the independent variables. Without decreasing the number of variables and without having any information loss the examiner can easily develop his/her study. Besides the effect of an independent variable in the path analysis on the dependent variable, it is also possible to see the effect on the other dependent variables. This situation makes the path analysis the preferred method over the other multivariate analysis methods.

In the path models obtained as a result of the simulation studies, the normality of the distribution of indirect effects is tested via the Anderson–Darling normality test. According to the results obtained, most of the indirect effects in the path models with three and seven variables have a normal distribution, but most of the path models with five variables are away from the normal distribution. Briefly, it is possible to say that the number of variables is effective on the indirect effects.

When the distribution of the indirect effects is examined in terms of the sample sizes, it can be said that the distribution of the indirect effects in path models with 250 and 500 samples is closer to the normal distribution than the path models with 50 and 100 samples.

When the distribution of indirect effects is examined in terms of correlation levels, it is observed that the indirect effects of the high-correlated path models digress from normal distribution. Accordingly, it is possible to say that when the correlation level increases, the distribution of the indirect effects digresses from normal distribution.

Moreover, although the path coefficients of the path models do not get affected by the sample size and correlation level it is found that indirect effects are affected by these values.

It is seen that most of the indirect effects of the path models with 3, 5 and 7 variables are statistically significant at 95% confidence interval.

In order to interpret the path analysis and explain the causal correlation, the number of variables should not be a lot. When the number of variables increases, the indirect effect on the variables increases because the causal structure widens, and accordingly the model gets more complicated.

Disclosure statement

No potential conflict of interest was reported by the authors.

References

- [1] R. Boudon, *A method of linear causal analysis: Dependence analysis*, Am. Sociol. Rev. 30 (1965), pp. 365–374.
- [2] M.T. Brannick, *Path analysis* (2010). Available at <http://luna.cas.usf.edu/~mbrannic/files/regression/Pathan.html>.
- [3] D.R. Dewey, and K.H. Lu, *A correlation and path analysis of crested wheatgrass seed production*, Agron. J. 51 (1959), pp. 515–518.
- [4] O.D. Duncan, *Path analysis: Sociological examples*, Am. J. Sociol. 72 (1966), pp. 1–16.
- [5] C.C. Li, *Path Analysis a Primer*, The Boxwood Press, Pacific Grove, CA, 1975.
- [6] S.W. Martin, and A.H. Meek, *A path model of factors influencing morbidity and mortality in Ontario Feedlot Calves*, Can. J. Vet. Res. 50 (1986), pp. 15–22.
- [7] R.J. Mitchell, *Testing evolutionary and ecological hypotheses using path analysis and structural equation modeling*, Funct. Ecol. 6 (1992), pp. 123–129.
- [8] E.J. Pedhazur, *Multiple Regression in Behavioral Research: Explanation and Prediction*, Harcourt Brace College Publishers, Fort Worth, TX, 1997.
- [9] F.A. Smith, J.H. Brown, and T.J. Valone, *Path analysis: A critical evaluation using long-term experimental data*, Am. Nat. 149 (1997), pp. 29–42.
- [10] S. Wright, *Correlation and causation*, J. Agricult. Res. 20 (1921), pp. 557–585.
- [11] S. Wright, *Path coefficients and path regression: Alternative on complementary concepts*, Biometrics 16 (1960), pp. 189–202.
- [12] S. Wright, *Genetic and biometric foundation*, Vol. 1, The University of Chicago Press, Chicago, 1968.