Mediation, Moderation, and Multi-level Modelling (Mostafa Sayyahi)

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Summary

      First, using the random slope linear growth model, the study shows that the divestiture type affects the initial status and the growth rate of strategic emphasis. The results suggest that, on average, MBOs have less strategic emphasis initial status than spinoffs, but they also have a positive strategic emphasis growth rate.

      Secondly, using moderated mediation analysis on a random slope linear growth model, the study suggests that there are no significant direct, mediated through strategic emphasis, or total effects in the relationship between divestiture type and performance, measured as return on asset.

Introduction

Here a theoretical model is introduced, and it is asked to provide the method section of a paper. The model is described in figure 1.
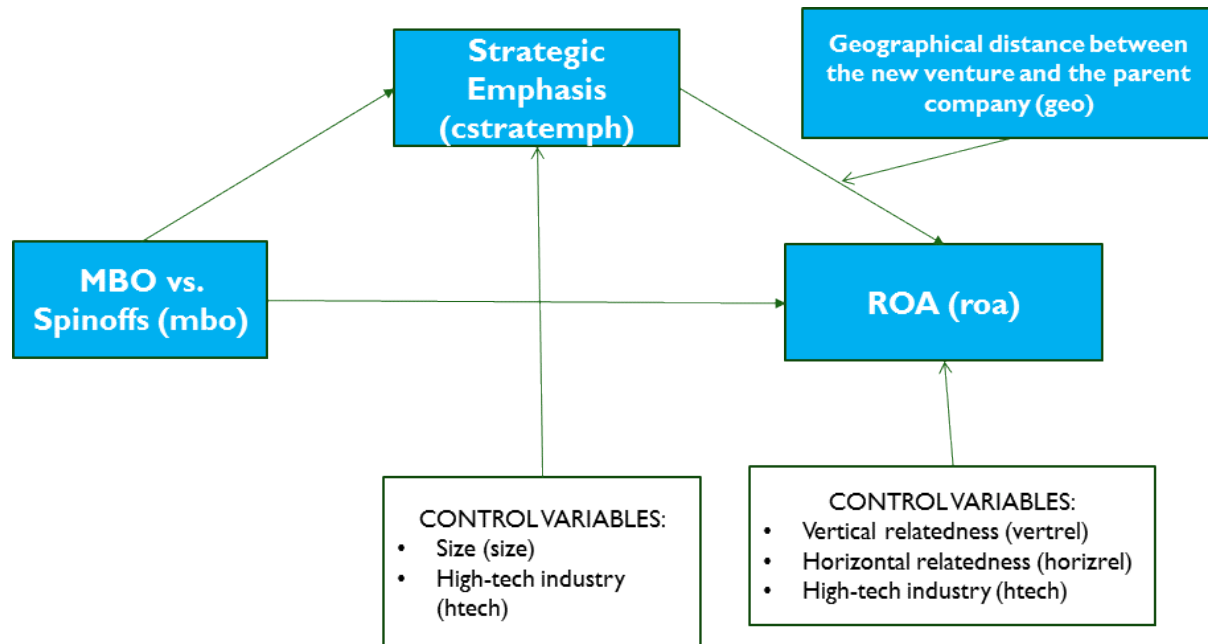

FIGURE 1

Based on this theoretical model, three hypotheses are made and studied. In what follows, first, the hypotheses related to this theoretical model are mentioned; second, the design and methodology to study these hypotheses are described; and finally, the respective results are provided and discussed.

Hypotheses

Three main hypotheses related to this model is as follows:

H1: Effect of divestiture type on strategic emphasis

H1a: In the first year after divestiture, the strategic emphasis is less in the case of MBOs rather than spinoffs.

H1b: After divestiture and over time, the increase in strategic emphasis is more in the case of MBOs rather than spinoffs.

H2: Effect of divestiture type on firm's performance

H2a: After divestiture, the direct effect of divestiture type on performance growth is more in the case of MBOs rather than spinoffs.

H2b: After divestiture, the mediated effect of divestiture type on performance growth via strategic emphasis is more in the case of MBOs rather than spinoffs.

H2c: After divestiture, the mediated effect of divestiture type on performance growth via strategic emphasis is stronger when geographical distance is smaller.

H2d: After divestiture, the total effect of divestiture type on performance growth, both the direct effect and the mediated effect via strategic emphasis, is more in the case of MBOs rather than spinoffs.

Research design and methods

Data

The data is given in a Stata file and contains multi-level longitudinal data of firm performance over five years after divestiture; it is an unbalanced dataset, meaning that some observations of firm performance in specific years may not be available. The reported variables include all of the variables in the theoretical model as well as the time since divestiture and the year of the observation. Also, another column named "mbotime" is the time since divestiture for MBOs, and it contains zeros for spinoffs. Since there is no additional information on the database, further explanation about measures is impossible. This point limits the data cleaning process; for example, one firm has the size of zero, and since there is no explanation about the measure, I decided to keep this observation. Observations that contain no values for any of the main variables, approximately 18% of total observations, are dropped. The only transformation in the original database is that Size, Vertical Relatedness, Horizontal Relatedness, and Geographical Distance variables are cantered around zero.

Variables:

Here are the main variables used in this study:

- Dependent Variables:
    - Related to Hypotheses set 1: Strategic Emphasis
    - Related to Hypotheses set 2: Performance measured as ROA
- Independent Variables:
    - MBO (dummy)
    - Time
    - Time*MBO
    - Strategic Emphasis
    - Time*Strategic Emphasis
    - Geographical Distance
- Control Variables:
    - Size
    - High-tech Industry (dummy)
    - Vertical Relatedness
    - Horizontal Relatedness

Growth Curve Analysis

Due to the nature of provided data, I decided to perform a growth curve analysis on this data. I assumed a nested structure: the higher level is the firm, and the lower level is the time since divestiture. Variance decomposition analysis shows that this assumption is true for the first set of hypotheses, the effect of divesture type on strategic emphasis: the within first-level variance is sufficiently large, and the between-group variance is also large. For the second set of hypotheses, the effect of divesture type on performance, variance decomposition analysis shows that within first-level variance is sufficiently large, but the between-group variance is rather small. This analysis suggests that growth models should be applied, but a nested structure

is not necessary, but for simplicity of analysis, a nested model is also applied to this section. It should be noted that a nested structure with type of investiture at the highest level, firm's id in the second level, and time since divestiture in the lowest level is examined. The variance decomposition analysis suggests that the variance between investiture-type groups is very small, and therefore, adding a level for divestiture type is not necessary. The specification of growth models is specified using the log-likelihood ratio test. This specification includes having a random slope for time rather than a fixed slop and having a quadratic growth model rather than a linear growth model. To sum up, a two-level growth model with firms' id in the second level and time in the first level is used for both sets of hypotheses.

In what follows, the unconditional mean model, the unconditional growth model, and the conditional growth model for this study are explained. In each section, evidence from data is provided to support the chosen model in each set of hypotheses.

1. Unconditional Mean Model

The first step is to fit an unconditional mean model without any predictor to decide whether it is necessary to have a growth model or not. The model detail is as follows:

- Level 1:
    - $Y_{ti} = \pi_{0i} + \varepsilon_{ti}$ where $\varepsilon_{ti} \sim iid\ N(0, \sigma^2)$
- Level 2:
    - $\pi_{0i} = \beta_{00} + r_{0i}$ where $r_i \sim iid\ N(0, \tau_\pi)$
- Compact Model:
    - $Y_{ti} = \beta_{00} + r_i + \varepsilon_{ti}$
- Details:
    - t and i denote time and firm's id, respectively
    - π_{0i} : mean Y, either strategic emphasis or ROA, (across time) of firm i;
    - ε_{ti}: time-level random error. It represents variance across time (i.e., within level-1 variance)
    - β_{00}: grand mean of Y;
    - r_{0i}: random *between-firm* residual. It represents variance between firms

Decision criteria come from the following fractions:

- % Within level-1 variance: $\frac{\sigma^2}{\sigma^2 + \tau_\pi}$
- % Between level-1 variance or variance between firms $\frac{\tau_\pi}{\sigma^2 + \tau_\pi}$

After running the unconditional mean model for strategic emphasis, the between level-1 variance is 17%, suggesting a hierarchical model and inclusion of firm-level. Also, the within individuals' variance is 83%, suggesting a growth model.

After running the unconditional mean model for ROA, the between level-1 variance is about 1% which suggests that a hierarchical model is unnecessary. Also, the within individuals' variance is 99% which suggests lots of variance between time and having a growth model. Since it does not affect the results and for simplicity of our analysis, I considered a two-level growth model similar to the strategic emphasis model.

Log-likelihood ratio test between a random intercept model and a random intercept and slope model is conducted to investigate whether adding a random slope for time results in a better model.

- Compact Random Intercept Model:
  - $Y_{ti} = \beta_{00} + r_i + \varepsilon_{ti}$
- Compact Random Intercept and Slope Model:
  - $Y_{ti} = \beta_{00} + r_{0i} + r_{1i}\text{TIME} + \varepsilon_{ti}$ where $r_{ji} \sim iid\ N(0, \tau_{\pi j})$
- Details:
  - r_{1i}: random slope between-firms

The log-likelihood ratio test for both models, namely for strategic emphasis and ROA, suggests that a model with random effect fits the data better at the significance level of 1%.

2. Unconditional Growth Model
This section explains the decision criteria of choosing between a linear or quadratic growth model. similarly, a log-likelihood test suggests which model is better for the study.

- Level 1:
  - $Y_{ti} = \pi_{0i} + \pi_{1i}\ \text{TIME}_i + \pi_{2i}\ TIME_i^2 + \varepsilon_{ti}$
- Level 2:
  - $\pi_{0i} = \beta_{00} + r_{0i}$ $\qquad$ $r_{0i} \sim N(0, \tau_{\pi 0})$
  - $\pi_{1i} = \beta_{10} + r_{1i}$ $\qquad$ $r_{1i} \sim N(0, \tau_{\pi 1})$
  - $\pi_{2i} = \beta_{20}$
- Compact Quadratic Model:
  - $Y_{ti} = \beta_{00} + \beta_{10}\text{TIME}_i + \beta_{20}TIME_i^2 + r_{0i} + r_{1i}\text{TIME}_i + \varepsilon_{ti}$

The difference between linear and quadratic growth models is in the inclusion of $\beta_{20}TIME_i^2$ in the compact model. The log-likelihood ratio test for strategic emphasis and ROA models suggests that a quadratic growth model works not better than the linear model even at the 10% significance level. Therefore, the linear growth model is used for both strategic emphasis and ROA models. Figures 2 and 3 certify that linear models are suitable.
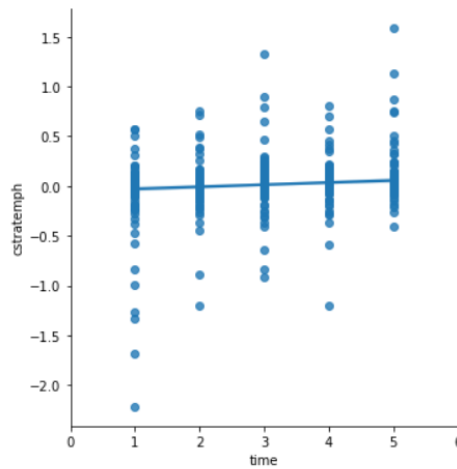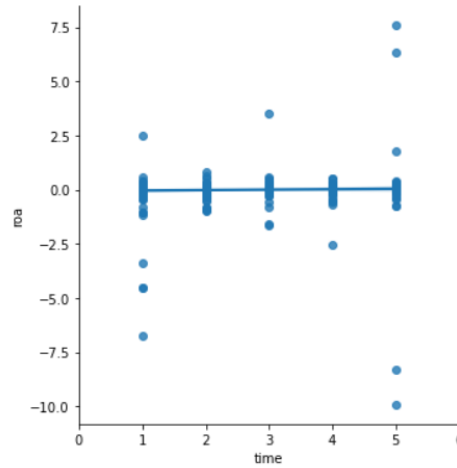

FIGURE 2

FIGURE 3

3. **Conditional Growth Model**

   In this section, the final model is introduced. X_i is the variable of interest, divestiture type. β_{01} shows the initial difference in intercept for different divestiture types, and β_{11} shows the difference in growth rate for different divestiture types.

- Level 1:

   o $Y_{ti} = \pi_{0i} + \pi_{1i} \text{TIME}_i + \varepsilon_{ti}$

- Level 2:

   o $\pi_{0i} = \beta_{00} + \beta_{01}X_i + r_{0i}$

   o $\pi_{1i} = \beta_{10} + \beta_{11b}X_i + r_{1i}$

- Compact Model:

   o $Y_{ti} = \beta_{00} + \beta_{10}\text{TIME}_i + \beta_{01}X_i + \beta_{11}X_i\text{TIME}_i + r_{0i} + r_{1i}\text{TIME}_i + \varepsilon_{ti}$

Moderated Mediation Analysis

Due to the fact that the theoretical model is a moderated mediation model, it is necessary to run moderated mediation analysis using a bootstrap method to attain unbiased coefficients and standard errors. The main variable of interest is the growth effect of divestiture type, the interaction between time and divestiture type variables. Also, in two separate analyses, the mediator is considered the strategic emphasis and its growth. We run the bootstrap on different moderating values, namely 0.25, 0.50, and 0.75 percentiles of geographical distance, for 50 times.

Results

Descriptive Statistics
Table1 and Table2 show the summary statistics and correlation matrix of data used in this study. There is no multicollinearity problem in this dataset.

	count	mean	std	min	25%	50%	75%	max
time	808	2.88	1.41	1.00	2.00	3.00	4.00	5.00
roa	808	-0.00	0.72	-9.93	0.00	0.00	0.10	7.59
mbo	808	0.37	0.48	0.00	0.00	0.00	1.00	1.00
cstratemph	808	0.01	0.23	-2.22	-0.02	-0.01	0.05	1.59
size	808	-0.00	1.78	-6.82	-1.31	-0.06	1.41	3.52
htech	808	0.65	0.48	0.00	0.00	1.00	1.00	1.00
vertrel	808	-0.00	0.03	-0.01	-0.01	-0.01	-0.00	0.35
horizrel	808	-0.00	0.46	-0.82	-0.50	0.04	0.47	0.47
geo	808	0.00	765.54	-320.74	-320.74	-317.74	-88.28	6464.56

TABLE 1
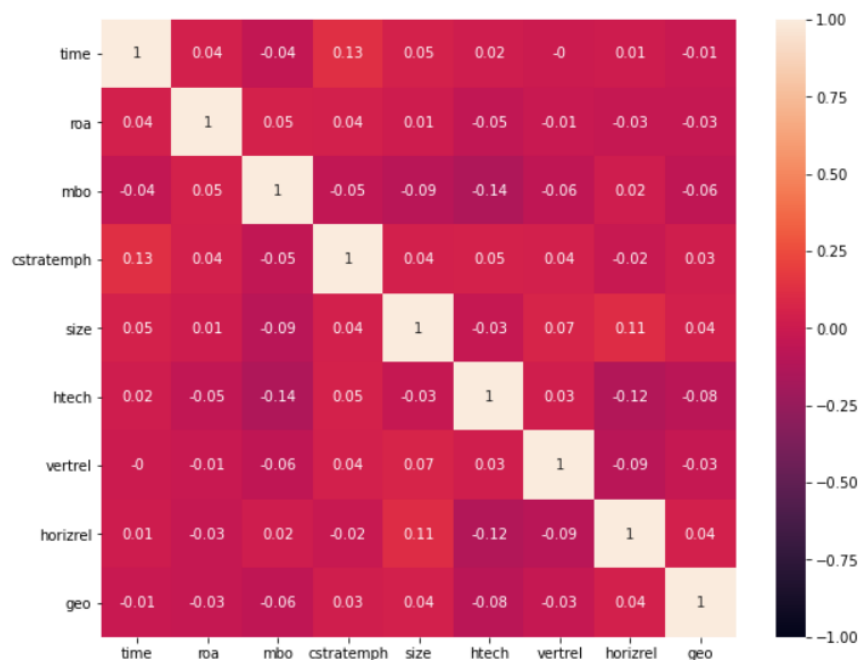
TABLE 2

Hypotheses set 1: Effect of Divestiture Type on Strategic Emphasis
Table 3 is the output of the growth models that assessed the relationship between divestiture type on strategic emphasis. The result suggests MBO divestiture affects both initial status and growth rate of strategic emphasis at the 10% significance level, meaning that Hypotheses 1a and 1b are confirmed. Figure 4 clearly suggests that in the MBO cases and unlike spinoff cases,

there is more increase in strategic emphasis over time from a lower starting point, confirming the regression results.

	Strategic Emphasis	
	Model 1	Model 2
Intercept	-0.0635**	-0.0327
	-0.0254	-0.0313
mbo		-0.0769*
		-0.0443
time	0.0208***	0.0125
	-0.0064	-0.0079
time:mbo		0.0221*
		-0.013
size	0.0061	0.0058
	-0.0055	-0.0056
htech	0.0237	0.0224
	-0.0208	-0.0214
time Var	0.0909***	0.0873***
	-0.0255	-0.0249
Group Var	1.3011***	1.2741***
	-0.3157	-0.3133
Group x time Cov	-0.3065***	-0.2928***
	-0.0838	-0.0819
-2 log-likelihood	-153.9222	-144.2272
Incremental χ2 (Δdf)		9.6950(2)

Standard errors are reported below coefficients.
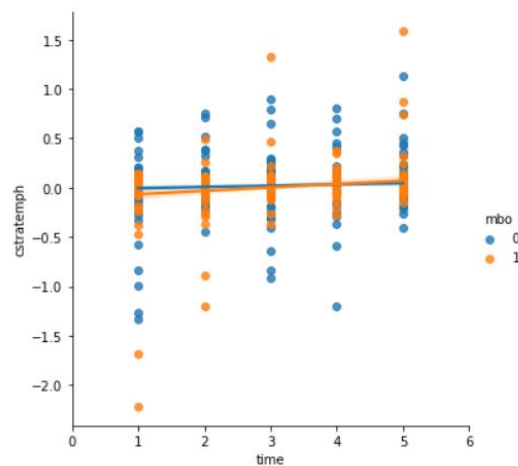
* p<.1, ** p<.05, ***p<.01

TABLE 3

FIGURE 4

Hypotheses set 2: Effect of Divestiture Type on ROA Mediated by Strategic Emphasis
Table 4 is the result of the growth models for the second set of hypotheses. Since this is a moderated mediation model, the coefficients and standard errors should be re-estimated using the bootstrap method to correct coefficients and standard errors.

	ROA			
	Control Model	**Direct Effect Model**	**Total Effect Mediation Model**	**Total Effect Moderated Mediation Model**
Intercept	-0.0296	-0.0446	-0.0224	-0.0129
	-0.0731	-0.0917	-0.0954	-0.0923
time	0.0293	0.0211	-0.0001	-0.0016
	-0.0259	-0.0331	-0.0355	-0.0352
mbo		0.0153	-0.0089	-0.028
		-0.1374	-0.1319	-0.1319
time:mbo		0.0253	0.029	0.0348
		-0.0536	-0.0559	-0.0562
cstratemph_hat			-1.4209***	-1.4430***
			-0.4836	-0.4865
time:cstratemph_hat			0.6900***	0.6863***
			-0.2597	-0.2231
geo				-0.0002***
				-0.0001
time:geo				0.0001**
				0
cstratemph_hat:geo				-0.0004
				-0.0008
time:cstratemph_hat:geo				0
				-0.0003
htech	-0.0718	-0.0608	-0.0449	-0.0485
	-0.0474	-0.0478	-0.0791	-0.0626
horizrel	-0.0991**	-0.0993**	-0.131	-0.1283*
	-0.0502	-0.0502	-0.1081	-0.0735
vertrel	-0.2146	-0.1477	-0.116	-0.1734
	-0.775	-0.7752	-0.97	-0.9522
time Var	0.2288***	0.2330***	0.2879	0.2930*
	-0.0453	-0.046	-0.3209	-0.1692
Group Var	1.1612***	1.1892***	1.1081	1.1192***
	-0.3022	-0.3071	-0.6995	-0.4248
Group x time Cov	-0.5154***	-0.5262***	-0.5364	-0.5445**
	-0.1132	-0.115	-0.3787	-0.2174
-2 log-likelihood	1652.1885	1657.621	1677.398	1735.6342
Incremental χ2 (Δdf)		5.4324(2)	19.7769(2)	58.2362(4)

Standard errors are reported below coefficients.

* p<.1, ** p<.05, ***p<.01

TABLE 4

Mediated by *strategic emphasis*	Moderator at 0.25 Percentile				Moderator at 0.5 Percentile				Moderator at 0.75 Percentile			
	Estimate	Lower CI bound	Upper CI bound	P-value	Estimate	Lower CI bound	Upper CI bound	P-value	Estimate	Lower CI bound	Upper CI bound	P-value
ACME (control)	-0.002066	-0.025553	0.01647	0.92	-0.00199	-0.023611	0.015448	0.64	-0.000223	-0.016743	0.020137	0.88
ACME (treated)	-0.002066	-0.025553	0.01647	0.92	-0.00199	-0.023611	0.015448	0.64	-0.000223	-0.016743	0.020137	0.88
ADE (control)	0	0	0	0	0	0	0	0	0	0	0	0
ADE (treated)	0	0	0	0	0	0	0	0	0	0	0	0
Total effect	-0.002066	-0.025553	0.01647	0.92	-0.00199	-0.023611	0.015448	0.64	-0.000223	-0.016743	0.020137	0.88
Prop. mediated (control)	1	1	1	0	1	1	1	0	1	1	1	0
Prop. mediated (treated)	1	1	1	0	1	1	1	0	1	1	1	0
ACME (average)	-0.002066	-0.025553	0.01647	0.92	-0.00199	-0.023611	0.015448	0.64	-0.000223	-0.016743	0.020137	0.88
ADE (average)	0	0	0	0	0	0	0	0	0	0	0	0
Prop. mediated (average)	1	1	1	0	1	1	1	0	1	1	1	0

TABLE 5

Mediated by *strategic emphasis growth*	Moderator at 0.25 Percentile				Moderator at 0.5 Percentile				Moderator at 0.75 Percentile			
	Estimate	Lower CI bound	Upper CI bound	P-value	Estimate	Lower CI bound	Upper CI bound	P-value	Estimate	Lower CI bound	Upper CI bound	P-value
ACME (control)	0.00713	-0.014307	0.044807	0.6	0.004204	-0.013526	0.029467	0.68	0.005997	-0.005196	0.027087	0.36
ACME (treated)	0.00713	-0.014307	0.044807	0.6	0.004204	-0.013526	0.029467	0.68	0.005997	-0.005196	0.027087	0.36
ADE (control)	0.019614	-0.11471	0.137686	0.8	0.007034	-0.075316	0.11082	0.88	0.013719	-0.074649	0.105908	0.84
ADE (treated)	0.019614	-0.11471	0.137686	0.8	0.007034	-0.075316	0.11082	0.88	0.013719	-0.074649	0.105908	0.84
Total effect	0.026744	-0.109068	0.14075	0.64	0.011238	-0.071214	0.115776	0.8	0.019716	-0.067186	0.127085	0.64
Prop. mediated (control)	0.06096	-1.669345	2.039995	0.68	0.005031	-2.109146	1.012948	1	0.052674	-0.52741	5.403191	0.68
Prop. mediated (treated)	0.06096	-1.669345	2.039995	0.68	0.005031	-2.109146	1.012948	1	0.052674	-0.52741	5.403191	0.68
ACME (average)	0.00713	-0.014307	0.044807	0.6	0.004204	-0.013526	0.029467	0.68	0.005997	-0.005196	0.027087	0.36
ADE (average)	0.019614	-0.11471	0.137686	0.8	0.007034	-0.075316	0.11082	0.88	0.013719	-0.074649	0.105908	0.84
Prop. mediated (average)	0.06096	-1.669345	2.039995	0.68	0.005031	-2.109146	1.012948	1	0.052674	-0.52741	5.403191	0.68

TABLE 6

Table 5 shows the result of moderated mediation analysis for the mediated effect of divestiture type on performance growth via *strategic emphasis*. As the results suggest, there is no significant direct, mediated, or total effect for these relationships. Therefore, all hypotheses in set H2 are rejected. It should be noted that the p-values for average direct effect, ADE, are zero, but the estimated coefficients are also zero, suggesting no significant effect.

Also, Table 6 shows the result of moderated mediation analysis for the mediated effect of divestiture type on performance growth via *strategic emphasis growth*. Also, these results suggest there is no significant direct, mediated, or total effect for these relationships.

In Addition, running a model without a moderator, meaning elimination of geographical distance from the model, does not affect the mediation analysis results, no significant result! You can refer to Tables 7 and 8 for these results.

Mediated by *strategic emphasis*	Estimate	Lower CI bound	Upper CI bound	P-value
ACME (control)	-0.001504	-0.016567	0.013755	0.8
ACME (treated)	-0.001504	-0.016567	0.013755	0.8
ADE (control)	0	0	0	0
ADE (treated)	0	0	0	0
Total effect	-0.001504	-0.016567	0.013755	0.8
Prop. mediated (control)	1	1	1	0
Prop. mediated (treated)	1	1	1	0
ACME (average)	-0.001504	-0.016567	0.013755	0.8
ADE (average)	0	0	0	0
Prop. mediated (average)	1	1	1	0

TABLE 7

Mediated by *strategic emphasis growth*	Estimate	Lower CI bound	Upper CI bound	P-value
ACME (control)	0	0	0	0
ACME (treated)	0	0	0	0
ADE (control)	0.081091	-0.007537	0.166982	0.2
ADE (treated)	0.081091	-0.007537	0.166982	0.2
Total effect	0.081091	-0.007537	0.166982	0.2
Prop. mediated (control)	0	0	0	0
Prop. mediated (treated)	0	0	0	0
ACME (average)	0	0	0	0
ADE (average)	0.081091	-0.007537	0.166982	0.2
Prop. mediated (average)	0	0	0	0

TABLE 8

Finally, It should be noted that the omission of outliers from the dataset, using the z-score greater than four, leads to no significant results even in the hypotheses set1.