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A Path Analysis On The Strategic Determinants Of The Average Revenue Per User In The Saudi Telecom Sector

Dr. Talal Alsaif
Assistant Professor, University of Ha'il, College of Business Administration

ABSTRACT

This study compared a restructured hierarchical regression using structural equation modeling (SEM) with a path analysis SEM Regression using The Rules of Casual Order. The dataset originated from Jones & Alshammari (2017) which studied the Value-Added Intellectual Coefficient (VAIC) determinants and capital expenditures (CAPEX) effects on the average revenue per user (ARPU). The comparisons showed CLE and CEEcap explained 61% of ARPU. For every 1 unit of change in CLE and CEEcap combined, produces 2 units of change in ARPU. The results on HCE_{cap} and SCE_{cap} where inconsistent, regression weights were insignificant at the $p \leq .001$ level, and both determinants did not correlate with Revenue. This study showed that causation can be established prior to any multivariate or SEM statistical procedures. The rules of casual order are an effective way of designing a model based on reality and shows the true effects among observed variables.

INTRODUCTION

The difference between multiple regression and path analysis

The strength of association establishes a dependent variable's interpretation using two or more independent variables. Path analysis is considered an extension of multiple regression which explicitly formulate casual models (Bryman & Cramer, 2011). Although Bryman & Cramer (2011) strongly emphasize the path analysis cannot establish causality, it can be applied using the rules of causal order to establish cause and effect (p. 309). Davis (1985) examines The Rules of Casual Order as a precursor to any statistical applications. He further emphasizes that The Rules of Casual Order, "...have nothing to do with statistics." and are premised on the concept of, "after cannot cause before" (Davis, 1985, p.11). This study will apply The Rules of Casual Order to establish causality of the ARPU based on organizational activities that represent strategic determinants. Upon structuring a model based of The Rules of Casual Order, path analysis is used to examine and compare the model to a hierarchal regression model.

The ARPU strategic determinants

Before the application of casual order, a thorough discussion on the determinants is needed. The activities of the organization that captures strategic implementation are recorded in the general ledger. Therefore, to develop a casual order that shows the determinants with causality on ARPU, accounting items are utilized. Both Kaplan & Norton (2008) and Porter (1985) discussion this aspect of strategic implementation indirectly or not actually mentioning the role of these accounting items directly. Kaplan & Norton (2008) mentions capital budgeting and the role OPEX, CAPEX and STRATEX play in strategy execution. However, the accounting items are a part

of the financial systems used to classify spending on strategy execution (Kaplan & Norton, 2008, p. 115).

Porter (1985) also acknowledge the accounting items but under the activities that transpire inside the value chain. He describes the value chain as a basic tool that systematically examines all activities an organization performs (p.33). Both Porter (1985) and Kaplan & Norton (2008) agree that organizational activities that reflect strategy execution should be separated from normal activities. This was clearly stated by Porter (1985) as a necessary isolation and no grouped together with the normal operational activities under the same accounting classifications (p.39).

ARPU is a key performance indicator that is globally recognized in all telecommunication companies worldwide. Jones & Alshammari (2017) expands on the ARPU as a global KPI used to determine network expansion and mediate between network and service provisioning of telecom technologies (p. 161). Based Kaplan & Norton (2008) view of productivity and efficiency alignment between the corporate, business, and functional level strategies, ARPU facilitates this alignment. In addition to ARPU as a global KPI, and a strategic organizational alignment component, it also acts as a key forecast indicator for the adoption rate of advanced technologies (Stordahl & Elnegaard, 2007). This study identifies the causality based on the ARPU determinants as represented as accounting line-items. The formula for the KPI is:

$$ARPU = \frac{\text{Revenue}}{\text{Total Subscribers}}$$

The objectives of this study are:

1. Demonstrate with path analysis the difference between association and causation.
2. The direct and indirect effects of CAPEX Labor on the ARPU.
3. What the levers of strategic implementation and how do they affect ARPU.

REVIEW OF LITERATURE

What defines association?

Association rules are defined as correlations between attributes (Hair, Joseph F., Anderson, Rolph E., Tatham, Ronald L., Black, 1998). Correlations such as the Pearson Correlation estimates the linear association between attributes or variables (Kline, 2016). Given that correlations play and important role in SEM and establishes the degree of association between variables, there are factors that affect correlations (Schumacker, Randall E; Lomax, 2004). Three factors that affect correlations, but have no effect on causation are level measurement, nonlinearity, and missing values. There are more factors that affect correlations, but the point of mentioning the factors is to highlight that associations measured by correlation can be spurious (Bryman & Cramer, 2011, p.9). These factors to do not remove the possibilities of a spurious relationship or causality between two or more variables. This is the major difference between associations and causation.

What defines causation?

Causation must be established prior to the statistical measure of association such as correlation or regression. Both Bryman & Cramer (2011) and Davis (1985) acknowledge this point. There is a key point of establishing causality, mentioned by Bryman & Cramer (2011) which is, "...cause precedes effect" (p.10). Davis (1985) mentions this same point in the form of rules necessary to establish the cause and effect between two variables (p.8). These ten rules precede statistics and are based on the third principle of casual order - "after cannot cause before" (Davis, 1985, p.11).

Davis (1985) three principles of casual order are:

1. Causal analysis in social research depends on assumptions about causal direction.
2. Assumptions depend on empirical beliefs about how the world works.
3. Assumptions are not arbitrary or whimsical. They are based on ten rules. Davis (1985) ten rules of causal order are presented in Table 1.

This study will design a causal design of a composite ARPU of four leading telecom companies in the Kingdom of Saudi Arabia. A path analysis on this design is compared to hierarchal regression model from Jones & Alshammari (2017), re-created using SEM. The purpose of this procedure is to test Davis (1985) rules of causal order. Since both models are created in SEM, the three criteria for a statistical significant comparison between the two models is based on Schumacker & Lomax (2004) which states:

1. The model must have a non-statistically significant chi-square.
2. A root-mean-square error (RMSEA) value of .05 or less.
3. A statistical significance of individual parameter estimates for the path models.
4. The magnitude and direction of parameter estimates must make sense.

SEM is used in this comparison between models, but there are necessary differences in the determinants used in the path analysis model. The path analysis model will use subscribers and Revenue determinants that comply with the rules of casual order as opposed to statistically significant Pearson Correlation results. This means that the nature of accounting line-items, any calculations between them, and value as represented by special accounting treatments will dictate determinant inclusion.

VAIC, Capex labor, and accounting line-items strategic determinants

At this point value-add from an accounting and intangible perspective must be discussed because the variables in both models warrants justification. Pulic (2004) leverages accounting line-items to calculate the VAIC to reflect intangible value of an organization. There has been criticism regarding Dr. Pulic's VAIC indicator and inconsistencies when correlated with traditional financial measures (Andriessen, 2004; Iazzolino & Laise, 2013; Stahle et al., 2011). However, Jones & Alshammari (2017) address this criticism upon observing the behavior of VAIC versus homogenous effects and establish as posit which states:

> *When VAIC measured in terms of productivity and equity ratios such as ROA and ROE, given all organizations in a market index or exchange as a sample size, a moderating effect measuring customers' responses to the wide range of products and services in terms of Revenue is needed (p. 167).*

This study uses the determinants of VAIC in conjunction with determinants that represent value based on special accounting treatments like capitalization for internal software development. The determinants of VAIC and formulas are shown in Table 2.

What is Capex labor?

The special accounting treatment that signals value creation is capital expenditures or capex. Under the Statement of Position 98-1 by the AICPA Board, the procedures for special treatment allows all cost related to the application development of internal software or networks be capitalized (Financial Accounting Standards Board, 1998). A. H. Jones (2018) demonstrates the value-added by cost savings with a hypothetical example. In this example a fraction of a capitalized internal software development project cost was recorded as an expense on an income statement while the remaining amount on the balance sheet as an asset. The total capitalized cost of the project was $2 Million dollars, thus $41,667 was recorded as an expense to the income statement for 36 months. The effect of this special treatment increased the organization's earnings per share by 66%. In this study capitalized labor costs are included as a determinant of Revenue in both the path analysis and hierarchal regression models.

The levers of strategic implementation and how do they affect ARPU

As previously mentioned, Porter (1985) acknowledged strategic activities of an organization inside the cost structure and called them value activities. Porter (1985) also acknowledge that these value activities are recorded under accounting classifications albeit they should not be grouped with non-strategic ongoing organizational activities (p.39). Like Porter (1985), Kaplan & Norton (2008) also believed that strategic activities should be separated from accounting classifications in OPEX and CAPEX (p.115). Prior to both Porter (1985) and Kaplan & Norton (2008), Drucker (2008)[1] mentioned activity-based costing as a new way of measuring strategic activities oppose to the traditional cost accounting classifications (p.341). What is gathered from the three studies is that the accounting line-items is the place where strategic activities reside for measuring strategy implementation. This strengthens Pulic (2004) VAIC formula as a method for measuring intellectual capital. Intellectual capital is the source that brings together labor and equipment to create value in the organization. Public (2004) use accounting line-items to create variables for human, structural, and equipment which are used to calculate the VAIC. See Table 2. Both capitalized labor and the VAIC determinants are used as levers of strategy implementation for re-interpreting ARPU and identifying the cause of it in this study.

Given the direction this of this study and the underpinnings of the determinants, path analysis, and hierarchal regression, the research question is as follows:

1. Does The Rules of Casual Order and path analysis produce a lower RMSEA of a ARPU model than a RMSEA in a hierarchal regression model of ARPU?
2. Does The Rules of Casual Order and path analysis produce a higher R^2 than a hierarchal regression model of ARPU?

[1] Drucker (2008) is a revised edition of Dr. Peter Drucker's book entitled *Management* originally written in 1970.

Based on the two research questions alignment with RMSEA, the hierarchal regression was re-created in SEM. Furthermore, since the RMSEA and R^2 values are the basis of answering the research questions, the hypotheses are as follows:

1. $H_0 = RMSEA_{\text{pa model}} \leq RMSEA_{\text{hreg model}}$
2. $H_1 = RMSEA_{\text{pa model}} > RMSEA_{\text{hreg model}}$

1. $H_0 = R^2_{\text{pa model}} \geq R^2_{\text{hreg model}}$
2. $H_1 = R^2_{\text{pa model}} < R^2_{\text{hreg model}}$

Where *pa model* = path analysis model and *hreg model* = SEM (reconstructed) hierarchal regression model.

METHODS AND ANALYSIS

Reconstructing Jones & Alshammari (2017)

Jones & Alshammari (2017) developed a ARPU hierarchal equation on a composite of financial statements from 2008-2015 on four telecom companies in Saudi Arabia. Table 3 show summary of the Jones & Alshammari (2017) ARPU hierarchal equation results. This study reconstructs the hierarchal equation in SEM. Figure 1 shows the reconstructed ARPU hierarchal equation. Figure 2 show the strategic 32-Item path analysis model. Table 4 shows the RMSEA and R^2 comparison between the reconstructed ARPU SEM model and the strategic 32-Item path analysis model.

Tables 3 and 4 show the R^2 for both the difference between the reconstructed ARPU SEM model whereby R^2 =.71 and Jones & Alshammari (2017) hierarchal equation model R^2 = .78. De Jong (1999), Graham (2008), and Turulja & Bajgoric (2020) explain why hierarchical regression results are higher than regression performed in SEM. First, De Jong (1999) observed that hierarchical regression model does not have latent variables for errors. This may cause overstated R^2 results in hierarchical regressions. Graham (2008) observed that hierarchical regressions does not account for correlations between variables. Strength of correlations are used to determine the order of selection of independent variables to enter the regression. SEM required correlated variables entry in the model—see Figure 2. Turulja & Bajgoric (2020) summarizes the key differences between SEM and multivariate regressions like hierarchical.

The differences between SEM and multivariate regressions clearly add an explanation why Jones & Alshammari (2017) hierarchal equation model R^2 is .78 and the reconstructed ARPU SEM model R^2 is .71—lower. Turulja & Bajgoric (2020) mentions:

1. SEM is a confirmatory rather than an exploratory approach to data analysis.
2. SEM allows error estimation.
3. SEM allows analyzing observed (manifest) variables, as well as unobserved (latent) variables.
4. SEM represents the most straightforward technique for analyzing and modeling of indirect effects.

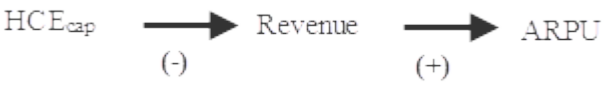
Based on the explanations by De Jong (1999), Graham (2008), and Turulja & Bajgoric (2020) highlighting the difference between SEM and multivariate regressions, the coefficient determination R^2 for the reconstructed ARPU SEM model reflects a more accurate value. This

study uses and the reconstructed ARPU SEM model whereby R^2 is .71 to compare with the strategic 32-Item path analysis model.

The Restructured ARPU SEM Model showed a R^2 equal to .71. This is different from the Jones & Alshammari (2017) hierarchical regression which used the same variables excluding Revenue. As previously mentioned, prior research on the differences between hierarchical regression and regression using SEM concluded the SEM method provides a more accurate coefficient determination R^2. Before the discussion on the comparison between the Restructured ARPU SEM Model and the Strategic 32-Item Path Analysis Model, the design of the path model is needed.

Table 8 explains how the path model was designed using The Rules of Casual Order. Rule 1 was frequently used based on the commonly known requirements for starting a company. Rule 1 is similar to the universal rule in deployment of advanced telecommunications technologies mentioned in Stordahl & Elnegaard (2007). Stordahl & Elnegaard (2007) states that demand must precede strategic deployment of advanced technologies (p.161). Similarly, the strategic determinants of VAIC shown in Table 2 to include CLE must be present first before ARPU.

Rules 6 and 8 are applicable once the path model is completed. Rule 6 of causal order is based on the positive and negative signs of the path coefficient estimates. Bivariates whereby the path coefficient estimates are both positive and negative among the direct, indirect, and spurious effects represent an inconsistent system.



Rule 8 requires the HCE_{cap} and Revenue bivariate must correlate. If the bivariate do not correlate, then it can not be a good explanation for a dependent variable. Below is a partial Pearson Correlation matrix which shows the HCE_{cap} does not correlate with Revenue—it is a poor explainer of ARPU. SCE_{cap} is also a poor explainer of ARPU.

	HCE_{cap}	SCE_{cap}	Revenue	ARPU
HCE_{cap}	1			
SCE_{cap}	.979**	1		
Revenue	.218	.175	1	
ARPU	.355*	.311	.852**	1

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Table 6 represents Rules 9 and 10. Table 6 shows the direct, indirect, spurious, and casual effects. The key results in this table are explained in the conclusion of this study.

CONCLUSION

The purpose of this study was to compare a restricted hierarchical regression SEM model to a path model designed utilizing the applicable rules of casual order by Davis (1985). The strategic determinants mentioned in Table 2 were used to identify the extent of causation with ARPU. Rules of casual order dictates that the variables that cause the effect should be the starting point for construction of a model. This was not the case in Jones & Alshammari (2017). The formula ARPU comprise of Revenue and subscribers. The cause of subscribers is beyond the scope of this study because it would require an instrument that quantified motives of consumer behavior. However, the causes of Revenue are well within the scope of this study and are the same determinants used by Public (2004) and Financial Accounting Standards Board (1998) with regards to the accounting treatment of CAPEX.

The results in accordance The Rules of Casual Order showed CLE and CEEcap explained 61% of ARPU[2]. This translates into every 1 unit of change in CLE and CEEcap combined, produces 2 units of change in ARPU. The results on HCEcap and SCEcap were inconsistent, regression weights in Table 3 were insignificant at the $p \leq .001$ level, and both determinants did not correlate with Revenue.

In summary, this study showed that causation can be established prior to any multivariate or SEM statistical procedures. The rules of casual order are an effective way of designing a model based on reality and shows the true effects among observed variables. It is the true effects among observed variables, that are well-known prior variables of a dependent variable, which form the basis of theoretical guidance needed to effective utilized path analysis.

[2] The Casual effects in Table 6 show: CLE = 0.600 and CEEcap = 1.476. The sum of CLE and CEEcap equal 2.08. The sum divided by 3.428 = .61.

Table 1 – The Ten Rules of Casual Order

	Category	Explanation
1	**Ordering *X* and *Y*** ***X* → *Y*** Assumption: ***X*** cause ***Y*** when:	a. ***Y*** starts after ***X*** freezes. b. ***X*** is linked to an earlier step in a well-known sequence. c. ***X*** never changes and ***Y*** sometimes change. d. ***X*** is more stable, harder to change , or more fertile.
2	**System Order**	If there is a path staring from ***X*** and returning to it without retracing any steps, ***X*** and all variables on the path form a loop. **Variables in a loop have no order.**
3	**Spurious Association**	If a prior variable has a casual path to the independent variable and a casual path to the dependent variable, it will contribute a statistical association between them that is spurious.
4	**Polarities**	Reversing poles for one variable reverses the signs of each of its relationships. Reversing poles for both variables leaves the sign of their relationship unchanged.
5	**The Sign Rule** **(+)** x **(-)** **→ ←**	The sign of a path is given by multiplying the signs of its arrows. *(or)* A path of nonzero arrows will be positive unless it contains an odd number of negative arrows.
6	**Consistency**	A system is inconsistent if at least one pair of variables has both positive and negative signs among its direct, indirect, and spurious effects—otherwise consistent. If a system is consistent, all negative arrows can be eliminated by reversing polarities.
7	**Control**	When estimating a direct effect of X_i on X_j, control all prior and intervening variables—that is, control all variables not consequent to X_j.
8	**Explanation (Correlation)**	A test variable, X_t, explains X_iX_j when X_iX_j bivariate is nonzero and the partial, controlling for X_t, is zero or trivially small. Unless X_t is related to both X_i and X_j it is a poor candidate for an explainer.
9	**Effect Analysis**	In addition to *XY* bivariate (A) and the direct XY effect (C), calculate the casual effect (B) by controlling prior variables only. (A-B) gives the spurious effect and (B-C) is the indirect portion due to intervening variables.
10	**Paths**	In a linear system the total casual effect of X_i on X_j is the sum of the values of all the paths from X_i to X_j.

Table 2 – The Determinants of VAIC

No#	Strategic VAIC formulas	Accounting line-item formulas
1	VAIC = HSE + SCE + CEE Where: HCE = Human Capital Efficiency SCE = Structural Capital Efficiency CEE = Capital Employed Efficiency	
2	VA = Value-Add	VA = OE + SW + DA
3	VA_{cap} = Value-Add + Capex	VA = OE + SW + DA + Capex
4	HCE = VA / HC	HCE = (OE + SW + DA) / SW
5	HCE_{cap} = VA_{cap} / HC	HCE_{cap} = (OE + SW + DA + Capex) / HC
6	CEE_{cap} = VA / (CE - CIP)	CEE_{cap} = (OE + SW + DA) / (TA-AD) - CIP
7	CLE = VA / CIP	CLE = (OE + SW + DA) / CIP
8	SCE_{cap} = (VA_{cap} − HC) / VA_{cap}	SCE_{cap} = (OE + SW + DA + Capex) – SW / (OE + SW + DA + Capex)
9	Leverage	LV = TD / TA
10	Size	Natural Log (Market Capitalization)

OE = Operating Expense
SW = Salaries & Wages
DA = Depreciation & Amortization
Capex = Capital Expenditures
CIP = Construction in Progress
CLE - Capitalized Labor Expense
TA = Total Assets
AD = Accumulated Depreciation
TD = Total Debt

Table 3 – ARPU Hierarchal Regression versus Reconstructed ARPU SEM Model

Jones & Alshammari (2017)

ARPU Hierarchal Regression Results

$$ARPU = 10.06 + 3.56(Size) - 20.42(LV) + 3.90(HCE) + 16.53(CLE) + 1029(CEE_{cap})$$

Variable	sr	B	β	t	VIF
Constant		10.06			
Size	.23	3.56	.15	1.20	1.78
Leverage	-.10	-20.42	-.05	-.51	1.07
HCE	.29	3.90	.19	1.57	1.82
CLE	.43*	16.53	.34	2.45	2.28
CEE_{cap}	.51**	1028.98	.55	3.06	3.90
R	.89				
R^2	.78***				

* p < .05, ** p < .01, *** p <.001. Note: sr = semi-partial correlation coefficient

Table 4 - Reconstructed ARPU SEM Model versus Strategic 32-Item Path Analysis Model

Models	R^2	*df*	X^2 (N=32)	RMSEA	GFI
Reconstructed ARPU SEM Model	.71	6	4.239	.000	.958
Strategic 32-Item Path Analysis Model	.73	6	5.438	.000	.950

Table 5 – The Strategic 32-Item Model Regression Weights

Direct and Indirect Paths			Estimate	S.E.	C.R.	*p*
Revenue	←	SCE_{cap}	66.735	50.614	1.319	0.187
Revenue	←	HCE_{cap}	-0.606	0.479	-1.265	0.206
Revenue	←	CLE	0.549	0.112	4.911	***
Revenue	←	CEE_{cap}	117.612	11.405	10.312	***
ARPU	←	Revenue	10.845	1.171	9.265	***

*** The regression weight is significant at the .001 level

Table 6 – The Strategic 32-Item Model Total, Direct, Indirect, Spurious and Casual Estimates

Effects	SCE_{cap}	CLE	CEE_{cap}	HCE_{cap}	Total Effects
(A) Total	0.857	0.857	0.857	0.857	3.428
(B) Casual	0.793	0.600	1.476	-0.787	2.082
(C) Direct	0.427	0.323	0.795	-0.424	1.121
(A-B) Spurious	0.064	0.257	-0.619	1.644	1.346
(B-C) Indirect	0.366	0.277	0.681	-0.363	0.961

Table 7 – The Strategic 32-Item Model Correlation Estimates

Correlation Effects	Estimates (r)
HCE_{cap} ↔ CEEcap	.333
CEE_{cap} ↔ CLE	.414
CEE_{cap} ↔ SCEcap	.245
HCE_{cap} ↔ SCEcap	.979

Table 8 – Application of The Rules of Casual Order and Strategic 32-Item Path Model Design

Rules			
Rule 1	1a. Y starts after X freezes. 1b. X is linked to an earlier step in a well-known sequence.	ARPU = Revenue / Total Subscribers VA_{cap} and VA have correlation r of .931 and .991 respectively thus Revenue effect on ARPU includes VA_{cap} and VA.	Revenue →ARPU
Rule 1 Rules 6 & 8 support exclusion from any influence on ARPU once the path model is constructed.	1a. Y starts after X freezes. 1d. X is more stable, harder to change , or more fertile.	$HCE_{cap} = VA_{cap} / HC$ From the start of an organization salaries and wages must be present before any Revenue is recognized.	HCE_{cap} → Revenue
Rule 1 Rules 6 and 8 support exclusion from any influence on ARPU once the path model is constructed.	1a. Y starts after X freezes. 1d. X is more stable, harder to change , or more fertile.	$SCE_{cap} = VA_{cap} / HC$ From the start of an organization operating cost excluding salaries and capital equipment must be present before any Revenue is recognized.	SCE_{cap} → Revenue
Rule 1 Rules 6 and 8 thru 10.	1a. Y starts after X freezes. 1d. X is more stable, harder to change , or more fertile. 6. System consistent. 8. CLE ↔ Revenue explains ARPU. Rules 9 and 10 explained in conclusion.	CLE = VA / CIP From the start of an organization operating and CAPEX must be present before any Revenue is recognized.	CLE → Revenue

Rule 1 Rules 6 and 8 thru 10.	1a. Y starts after X freezes. 1d. X is more stable, harder to change , or more fertile. 6. System consistent. 8. CEE_{cap} ↔ Revenue explains ARPU. Rules 9 and 10 explained in conclusion.	CEE_{cap} = VA / (CE - CIP) From the start of an organization investments capital, operating and CAPEX must be present before any Revenue is recognized.	CEE_{cap} → Revenue

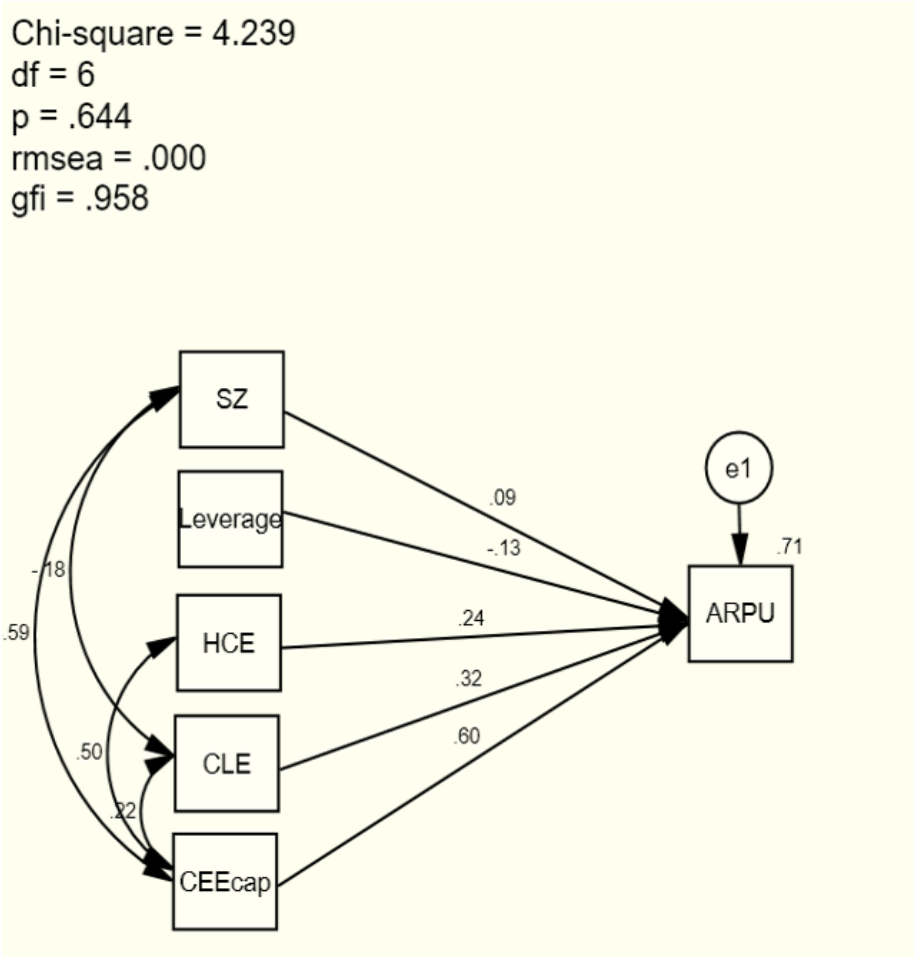


Figure 1 - Reconstructed ARPU SEM Model

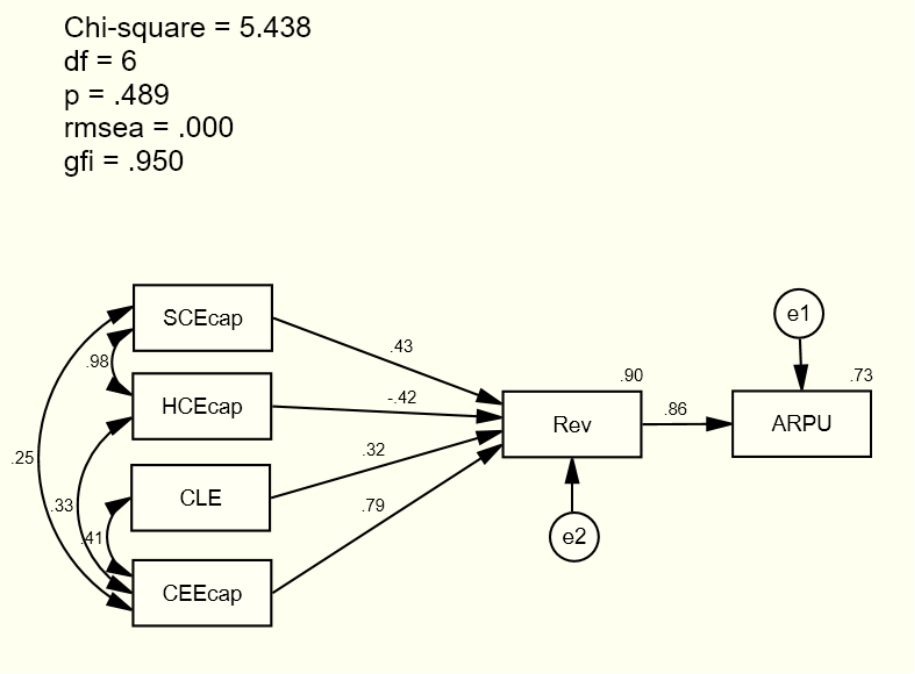


Figure 2 - Strategic 32-Item Path Analysis Model

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