Statistically Validating a Theory Represented by a Venn Diagram

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Abstract: To date, there has been no proposed method to statistically validate Venn diagrams. We seek to correct this shortcoming. This paper is a review of a proposed method that offers the possibility of statistically validating Venn diagrams through the lens of the management vs. leadership debate in business. Through this research, we demonstrate a way to statistically validate Venn diagrams by using a modified method of exploratory factor analysis (EFA). First, when performing EFA to validate a Venn, we suggest the scree plot of eigenvalues will indicate how many circles should be in the diagram. Additionally, when normally conducting EFA, cross-loaded items are removed. However, when using EFA to validate a Venn, we propose items that cross load should be retained and placed in the corresponding intersection of the two (or more) circles of the diagram. Applying this method to a sample of 431 (n=431) employees aged 25 years or older, we created a statistically validated Venn diagram that identifies those skills that are uniquely management, uniquely leadership, and the overlap as reported by employees. As a result, this research provides scholars with the opportunity to classify actions as leadership or management based on their placement within the statistically validated Venn diagram of management skills and leadership skills. Importantly, through the application of this new research method, we bring the possibility of statistical confirmation to many of our social science theories that are represented by Venn diagrams. In the Discussion section, we offer a critique of possible limitations of the method and mistakes that researchers can make when applying this method.

Keywords: Validation, Venn diagrams, Management vs. leadership, Skills based, Exploratory factor analysis

1. Introduction

Venn diagrams illustrate sets of information, their intersections, and their differences (Moktefi and Lemanski, 2022). They serve the purpose of giving a picture to an idea. However, to date, Venn diagrams have simply been pictorial representations of ideas without determining their validity or if items placed within the Venn are in the correct locations. We propose that a modified version of exploratory factor analysis (EFA) could be utilized to statistically validate Venn diagrams based on data. The purpose of this study is to determine if a modified method of exploratory factor analysis could offer a way to statistically validate Venn diagrams.

By using this proposed method, we can use statistical analysis to confirm the placement of each item within a Venn, thus validating the content of the Venn diagram. The proposed method offers a solution to the current shortcomings of Venn diagrams and provides social scientists with a tool to move their ideas from theory into something more concrete and data-driven.

As a demonstration of this method, we statistically validated a proposed Venn diagram that illustrates the differences and overlaps between management skills and leadership skills. By doing so, we made two main contributions; to the field of leadership, we offer statistical backing for the differences and overlap between management skills and leadership skills. However, more importantly, we offer a new method that allows statistical confirmation of many social science theories represented by Venn diagrams.

This paper's organization is deliberate. In the next section, we explain Venn diagrams and briefly explore the concept of EFA cross-loadings as they relate to and differ between traditional EFA applications and the validation of Venn diagrams. This introduction aims to establish a shared understanding of their definitions and terminology. Then, we provide the context of the management vs leadership theory debate. Owing to that debate, an unvalidated model, attributed to Jamieson and Donald (2020), emerged as a response to the theoretical debate. Using that unvalidated Venn diagram as our case study, we demonstrate how application of our proposed method can statistically validate or correct item placements within a proposed Venn diagram, thus providing data backed evidence into a mostly, to this point, theoretical debate.

One of our goals is to provide a step-by-step walkthrough that can be replicated. This is accomplished in our method section. Our new method seeks to ensure that each item within the Venn diagram is positioned based on empirical data rather than solely relying on existing literature. After confirming item placement based on mathematics, we consult the literature to assess whether there is support for these newly established positions. Lastly, we offer a critique of this newly proposed method by highlighting some shortcomings and possible misapplications in our discussion. We undertake this structured exploration in service of our research question:

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Can a modified method of exploratory factor analysis be applied to create and/or validate Venn diagrams and their overlapping segments?

2. Overview of Venn Diagrams

Venn diagrams represent a relationship model using integrating ideas demonstrated by overlapping circles or patterns. Venn diagrams were created by John Venn sometime in the late 1800s to expand diagrammatic reasoning. Though originally applied to deliberating logic, they are more likely to be seen today as presenting a discernable method of understanding the relationships and connectivity of various societal elements (Moktefi and Lemanski, 2022). They serve to compare as well as sort and classify. Venn diagrams can be used in almost any discipline and are thoroughly customizable (Gilbert, Winters and Kimmins,2019).

Venn diagrams can have an unlimited number of circles but the complexity of it sometimes renders the visual to be just as confusing as the original problem one sets out to explain once more than three circles are represented. For more entangled ideas, computer software has been written to aid in their interpretation. The circles of Venn diagrams demonstrate where elements stand alone and then overlap and/or integrate. The parts of the diagram are labeled as unions, sets, and integrations.

To identify the terminology, the union of the circles is all the data in however many circles are shown. The intersection contains all the data points that pertain to both. The intersection or that part of the visual where the circles overlap represents a comparison of the information. As Venn diagrams have evolved, their usefulness and benefits have become interdisciplinary to sort and classify as well as compare ideas and concepts that may or may not be statistical or mathematical in nature (Houser, 2020).

2.1 Overview of Exploratory Factor Analysis Cross Loadings

Spearman (1904) was first to use exploratory factor analysis (EFA). Since that time, it has become a commonly used tool that is shared across multiple disciplines (Bartholomew, 1995). "Factor analysis is a hybrid of social and statistical science" (Fricker, Kulzy and Appleget, 2012, p. 30). Specifically,

> *"Exploratory factor analysis (EFA) is one of a family of multivariate statistical methods that attempts to identify the smallest number of hypothetical constructs (also known as factors, dimensions, latent variables, synthetic variables, or internal attributes) that can parsimoniously explain the covariation observed among a set of measured variables (also called observed variables, manifest variables, effect indicators, reflective indicators, or surface attributes). That is, to identify the common factors that explain the order and structure among measured variables…." (Watkins, 2018, p 1).*

We propose the identified factors from factor analysis would be equivalent to the sets (circles) in a Venn diagram.

EFA seeks to identify unique variables to identify a factor. Variables that provide information on multiple factors, known as cross-loadings, are often culled from the variable list (Costello and Osborne, 2005). For example, figure 1 shows two distinct factors with no overlap.

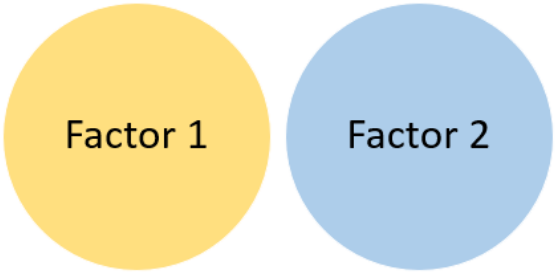

Figure 1: Showing two distinct factors with no overlap

Removing items with overlap (cross loaded items) is standard procedure owing to the EFA goal of data reduction or trying to reduce the number of variables. What if, however, we wanted information about the overlap in a Venn diagram? Cross loadings contain information about the overlap, or intersection, between sets as represented in figure 2.

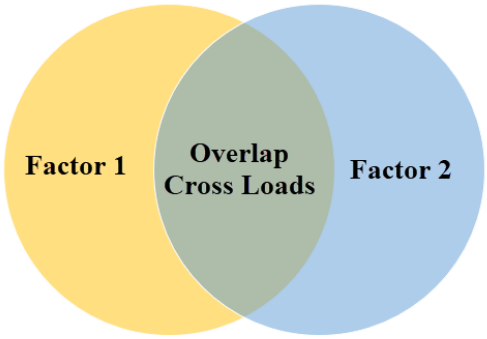

Figure 2: Showing two factors with overlap in the middle (a two-circle Venn diagram)

Keeping cross-loadings in the model would give us statistical information on the validity of the proposed overlap.

Therefore, we ask:

Research Question: can a modified method of exploratory factor analysis be applied to create and/or validate Venn diagrams and their overlapping segments?

*Please note that a detailed critique of EFA steps and challenges is provided in the discussion section of this paper.

To test our research question, we apply this proposed method to the case study of the management vs. leadership debate.

2.2 Case Study: Management VS Leadership Debate

Questions regarding the similarities, differences, and interactions between management and leadership are a recurring subject in business literature (Hunter, Bedell-Avers and Mumford, 2007; Kotter, 1990; Simonet and Tett, 2013; Yukl and Lepsinger, 2005). Yukl and Lepsinger (2005) observed that the debate has gone on so long because we narrowly define the roles in a way that prevents us from understanding how these two concepts work together to affect outcomes and how they integrate with one another.

One proposed reason for this shortcoming is the lack of operationalization and justification as outlined by Hunter, Bedell-Avers, and Mumford (2007):

> *To begin to address the problems arising from potentially false assumptions when conducting a typical leadership study, researchers must first be more explicit in their operationalizations and justification for what a leader is and why, precisely, a given sample represents "leaders". For example, in many cases managers may in actuality be acting as leaders. However, without addressing the operationalization issue directly, we may be drawing false conclusions about leadership and leadership behaviors. (p. 438).*

Taking a skills-based approach can allow us to correct for the issue highlighted by Hunter, Bedell, and Mumford and we can better conceptualize leadership and management and how they interact. Importantly, if researchers had agreed upon skills that are uniquely management and others that are uniquely leadership, we could identify when someone is acting in a leadership capacity or in a management capacity based on the primary skill being used.

Consider the Venn diagram in figure 3. This Venn is based on the research of Jamieson and Donald (2020) regarding the overlap between management skills and leadership skills:

Figure 3: Jamieson and Donald's Venn Diagram Showing the Overlaps and Distinctions Between Management and Leadership

If accurate, this Venn diagram offers a categorization of leadership skills and management skills and could address the shortcomings of researchers not having a list of skills exclusively management and exclusively leadership. However, this Venn is based on leadership theory and a known weakness in leadership research is that debates have been largely theoretical without data and statistics to support them. Tourish (2015) laments how many of our leadership publications are a simple selection of a well-known leader that discusses their practices in specific situations. The generalization of these case studies is dubious at best and lacks data to demonstrate their soundness. Additionally, sometimes a manager may be acting in a leadership capacity (Hunter, Bedell-Avers and Mumford, 2007). Thus, categorizing based on "who" performed the action instead of the action itself is problematic at best.

Jamieson and Donald (2020) sought to provide a contextual framework to integrate leadership and management skills within a discipline's curriculum. To accomplish this, leadership theory was examined including historical leadership and transformational leadership. However, skills-based leadership, and the capability model of leadership proved most useful because it could be applied. From this, they created the Leadership-Management Development Matrix (LMDM). At length, the Jamieson and Donald (2020) model amplifies the differences between management and leadership by distinguishing an individual's contribution to a work system to that of the skills needed to accomplish leadership of others in that same system. To illustrate their research and the scaffolding and skills-based progression of leadership and management skills, Jamieson and Donald proposed the Venn diagram found in Figure 3. Consequently, while Jamieson and Donald's model could offer a solution and allow us to conceptualize leadership and management through their operationalizations and skills-based tasks, no data is present to support the correctness of this model. This reality holds true for other theories represented by Venn diagrams. Therefore, we propose that by using a modified factor analysis, statistical validation can be provided to substantiate or refute this proposed model, which will be used as our case study.

3. Methods

3.1 Method Overview

The goal of this research was to determine if a modified method of EFA could be employed to statistically validate Venn diagrams (including their overlapping segments). To accomplish this, we first employed a customized approach to exploratory factor analysis to ascertain the accurate placement of each item within the unvalidated sample model that grew from the management vs leadership theory debate. To achieve this, data collection was conducted as the initial step. During this process, survey participants were shown each item listed in the proposed Venn diagram and asked to select (using a Likert scale) how much the task was a management task or a leadership task. Following data collection, a scree plot was created and utilized to determine the appropriate number of circles to comprise the new Venn diagram. Subsequently, exploratory factor analysis was conducted, ensuring that cross-loads were appropriately assigned and placed in their corresponding overlaps within the Venn diagram.

After the statistically created Venn diagram was completed and all items were categorized by their placement owing to the modified exploratory factor analysis, a literature review was conducted to ensure that there is theoretical backing for the placement of each item (that the Venn diagram made through statistics also makes sense to scholars). To date, this is the first application of this proposed method to validate a proposed Venn

diagram. Therefore, to aid in replication and understanding, we supplied all our code and datasets so others could replicate our results.

3.2 Data Collection

In determining the appropriate survey participants, consideration was given to demographic and ideology diversity. The goal of this research was to secure comments from employees within the general population. It was acknowledged that a sample that overrepresented education and business expertise would result if researchers created a survey and sent it to their networks with a request to share. The goal was to determine what employees view as leadership and management skills. Fortunately, a solution was presented in the use of Amazon's Mechanical Turk (MTurk). MTurk is a labor market or online pool of participants that will take surveys for a small free.

MTurk has become a widely accepted sampling platform in academic research and its samples are valid (Hauser and Schwarz, 2015; Smith, et al., 2016). Additionally, MTurk is a commonly used platform for sampling by researchers who publish in the top leadership journals (Archer and Kam 2022; Can, 2020; Kuhn and Maleki, 2017; Cheung, Sinclair and Sliter, 2017; Giacomin, Tskhay and Rule, 2021; Marasi, Wall and Brewer, 2019; Wall, et al., 2022).

For this study, 435 participants were recruited and received nominal compensation of $0.50. The survey was created in Qualtrics and an advertisement and link were listed on MTurk. Questions were presented using a 5-point Likert scale asking, "Are the following skills more important for successful managers or for organizational leaders?" with a list of the skills provided. Answers ranged from 1 to 5, with 1 being "Most Important to Managers", 3 being "Equally Important to Both" and 5 being "Most Important to Leaders".

In addition to the 24 skills questions and demographic questions, the survey offered one attention check. The attention check consisted of the question "Please click "Most Important to Managers" to show you are reading the questions." Three participants were removed for failure to respond appropriately. Thus, the final data set was comprised of 432 respondents.

3.3 Survey Participants

When setting the parameters for survey inclusion, it was delineated within the MTurk system that the survey should only be made available to those who reside within the United States. Additionally, the parameter of age being 18-24 was set at false with the goal of securing a sample with several years of work experience. This decision was made based on data from the department of labor that shows the average 25-year-old has had 6.3 jobs (U.S. Bureau of Labor Statistics, 2022). We thought it was important for our participants to have had a variety of work experiences to inform their opinions.

All survey participants resided in the United States and were 25 years or older. Age distributions were as follows: 39% were 25-34, 38% were 35-44, 10% were 25-54%, 8% were 55-64 and 3% were over 64. Females represented 40% of participants, 58% of participants were male, and the rest preferred to not identify. Education levels were also secured. Most reported having a bachelor's degree (58%) while 12% had advanced degrees, 18% had associate degrees or some college, and the remainder had high school diplomas or preferred not to reply. Individuals who identified as White/Caucasian were 82%, Black/African American 8%, Asian 6%, Others 3%, and the remainder preferred not to say. When asked," What best describes your employment status over the last 3 months?", 86% reported working full-time, 6% working part-time, 4% retired, 3% unemployed but looking, and the remainder (1%) were other.

3.4 Sample Size

The first step in the analysis was to determine if our sample size was appropriate for our goals. When using EFA, there are two methods for determining the appropriateness of sample size.

Sample size Method 1: Item Ratio

The first method is to use item ratio. This is calculated as the number of subjects per item. "Gorsuch (1983, p.332) and Hatcher (1994, p. 73) recommend a minimum subject-to-item ratio of at least 5:1" (Osborne and Costello, 2014, p 2). Therefore, to accomplish this suggested minimum with our 24-question survey, we needed n = 124 participants, which was surpassed with our sample size of 432. Additionally, Costello and Osborne, (2005) note, "Strict rules regarding sample size for exploratory factor analysis have mostly disappeared" (p4). They go on to share results that demonstrate 62.9% of academic publications that use factor analysis had ratios of 10:1 or less and almost 1/6 had ratios of 2:1 or less. Only 15.4% of published research had ratios that represented

>10:1, ≤ 20:1. Thus, cumulatively 78.6% of papers have ratios less than or equal to this range. Since our ratio is 18:1 we have clearly surpassed the ratio sample size requirement.

Sample size Method 2: Sample Size (n)

Sample size (n) is the other method used for determining the appropriateness of dataset size, and some argue this is a more important consideration. Comfrey and Lee (1992) offer the following "The adequacy of sample size might be evaluated very roughly on the following scale: 50 – very poor; 100 – poor; 200 – fair; 300 – good; 500 – very good; 1000 or more – excellent" (p. 217). Our sample size was 432, which is 44% higher than what is required to reach the "good" threshold. Therefore, we have clearly surpassed the sample size (n) threshold. Once it was determined that our sample size was adequate for our research purpose, we moved forward with our first test of validation for the Venn diagram.

3.5 Correlation Matrix

It is important to note that viewing the correlation matrix would be an important step in traditional EFA and in creating a Venn diagram from a dataset. However, we tested a Venn diagram that had already been created based on theory. Therefore, we did not remove items because our goal was to statistically confirm the placement of each item within the Venn diagram segments.

3.6 Scree Plot: First test of Venn Diagram Validation

The first check of validity for the proposed Venn diagram comes with the scree plot test. The scree plot tells us how many factors are present within the data. Since the model is represented by the Venn diagram, and the Venn is comprised of two overlapping circles, the scree plot test should support a two-factor model if the two-circle Venn is to be validated.

To accomplish this, the following code was run in the Stata Statistical Software Package:

pca planning controlling coordinating allocating scheduling organizing managingplan goaloriented solvingproblems engaging accountability makingdecisiosn responsible integrity honesty socialcultural vision influencing motivatingandinspiringothers alignment context thinktransform modelvalues executeplan
screeplot

The results of the scree plot are as presented in figure 4:

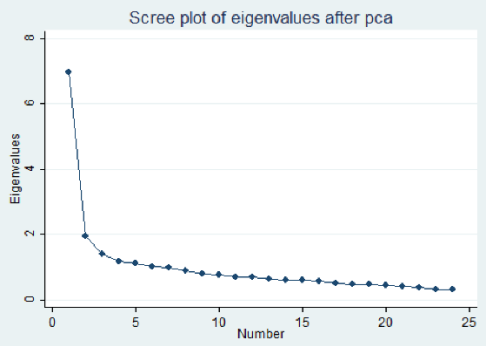

Figure 4: Scree Plot of Leadership and Management Data

The scree plot of eigenvalues does not contradict the two-factor model (thus, the two-circle Venn diagram). Therefore, we moved forward with the next step in the validation process.

3.7 Exploratory Factor Analysis

Next, to conduct an exploratory factor analysis, the following code for exploratory factor analysis was input into the Stata Statistical Software Package.

**factor loadings, communalities (1-uniqueness), and proportion of variance*

set more off

factor planning controlling coordinating allocating scheduling organizing managingplan goaloriented solvingproblems engaging accountability makingdecisiosn responsible integrity honesty socialcultural vision

influencing motivatingandinspiringothers alignment context thinktransform modelvalues executeplan , pcf factors (2)

After determining the factors unrotated, we tested to see which rotation we should use. We input the code:

estat common

The output is a table that reveals the correlation between the factors. If the correlation between factors is less than 0.3, the varimax rotation should be used. If the correlation between factors is more than 0.3, promax is the more appropriate rotation.

Our results indicated a correlation of less than 0.3 (results = 0). Thus, we proceed with inputting the following code into Stata to use varimax rotation on our data.

Rotate, blanks(.3)

Below is the code, in its entirety, employed to produce the results we used to build our Venn diagram.

**factor loadings, communalities (1-uniqueness), and proportion of variance*

set more off

factor planning controlling coordinating allocating scheduling organizing managingplan goaloriented solvingproblems engaging accountability makingdecisiosn responsible integrity honesty socialcultural vision influencing motivatingandinspiringothers alignment context thinktransform modelvalues executeplan , pcf factors (2)

rotate, blanks(.3)

The results are presented in Table 1.

4. Results

Table 1: Results of Exploratory Factor Analysis Showing Management Skills, Leadership Skills, and the Overlap

Item	Differences	Management	Overlap	Leadership
Planning		.5477		
Controlling		.4143		
Coordinating		.7172		
Allocating Resources	Was Mgt. should be Lead			.3254
Scheduling		.7576		
Organizing		.7019		
Managing a Plan		.5662		
Goal Oriented			.3656, .4152	
Solving Problems	Was Both should be Mgt.	.5760		
Engaging			.3971, 4250	
Accountability	Was Both should be Lead			.4725
Making Decisions	Was Both should be Lead			.4424
Being Responsible			.5028, .3560	
Integrity			.4555, .4396	
Honesty			.4900, .4583	
Social and Cultural Intelligence			.4062, .5060	
Creating a Vision				.7034
Influencing				.6982
Motivating and Inspiring				.5733

Item	Differences	Management	Overlap	Leadership
Creating alignment	Was Lead should be Both		.3651, .3357	
Understanding Context	Was Lead should be Mgt	.5616		
Thinking and transforming				.5219
Modeling Values				.5530
Executing the Plan	Was Lead Should be Mgt	.6051		
Portion of the Variance		.2081		.1623
Total Variance .3704				
Scale Reliability Coefficient (Cronbach's alpha) .8876				
Chi2 (276) =3213.81				
Prob >Chi2 = 0.000				
Observations: 432				

When performing traditional EFA, item reduction owing to low loads and cross loads would follow. However, the goal of this modified method is not to reduce items but to categorize those that load in a single factor (circle of the Venn diagram) and those that cross-load across factors (fall with the intersects). Thus, the next step was to plot the items of the Venn diagram.

Plotting resulted in the statistically validated Venn diagram provided in figure 5.

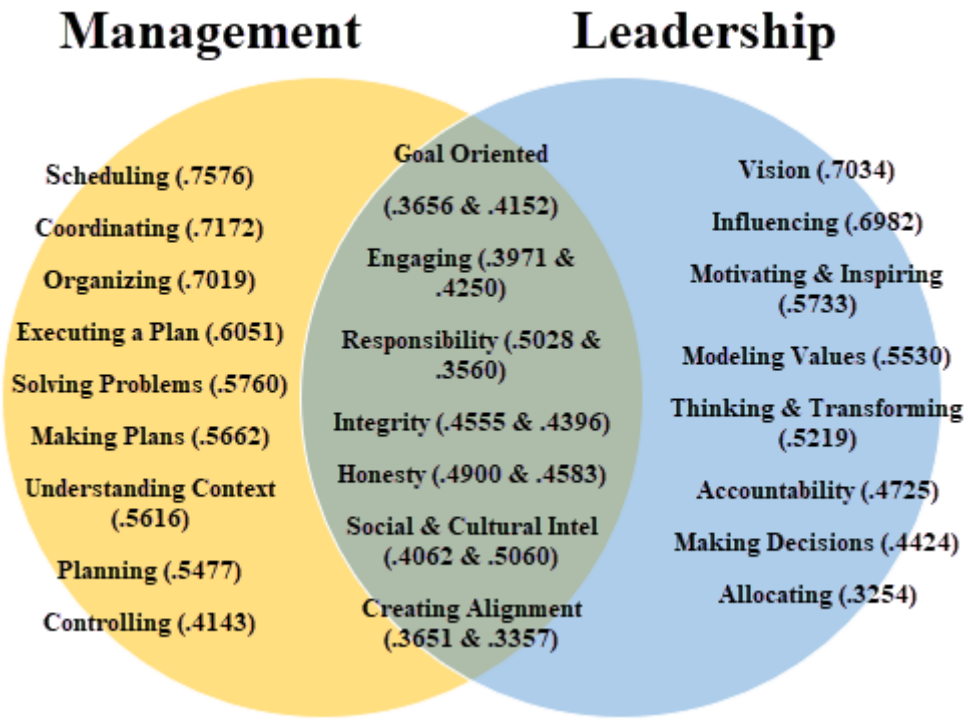

Figure 5: Statistically Validated Venn Diagram Showing Management Skills and Leadership Skills

After the creation of the statistically validated Venn diagram, it was important for authors to conduct a literature review. This review served the dual purpose of confirming the theoretical basis for the positioning of each element and ensuring that the mathematical construction of the Venn diagram resonated with scholarly principles. In the next sections, the differences between the originally proposed Venn diagram and the mathematically crated Venn are explored. To ensure the data-based placement of these differences had theoretical justification, it was appropriate to conduct a literature review after the creation of the model.

4.1 Difference Between Proposed and Validated Venn Diagram.

Notably, there are some differences between the theory and the data-supported results, and those differences are highlighted in column 2 of Table 1. However, researchers would first like to focus on the similarities. Jamieson and Donald (2020) proposed 24 skills and their placement between management and leadership. Considering their original Venn diagram, data supports that they were correct over 70% of the time. It is also important to note they created the original Venn without the aid of a statistical method to test Venn diagrams because that method is only now being presented here.

4.2 Allocating Resources Falls Within the Leadership Sphere

Jamieson and Donald's (2020) original model classified allocating resources as a management skill. Yet, results indicate it is a leadership skill. Placing allocating resources within the leadership sphere does have theoretical backing. Survey participants likely saw this as helping to ensure that others have the needed resources to accomplish their goals. This fits within the framework of path-goal leadership. Where, "…leaders can help followers along the path to their goals by selecting specific behaviors that are best suited to the follower's needs and to the situation in which followers are working" (Northouse, 2015, p. 116). Often, followers view resources as necessary and a lack of resources as something that can prevent them from succeeding. Thus, ensuring followers have the needed resources to succeed falls under the obligation of the leader.

4.3 Solving Problems Falls Within the Management Sphere

At first, we were surprised that solving problems, which had been in the intersect of the original model, fell within the management domain when validated. However, we were reminded by Hunter, Bedell-Avers, and Mumford (2007) that managers and leaders may flow between these spheres and sometimes a leader may act as a manager because that is what is needed. Yet it is important to realize that data suggests this is viewed as management by followers.

The notion that solving problems is in the management domain is backed by literature. Zaleznik (1981) confirms that the essence of a manager is that of a problem solver who ponders the problems that need to be solved and the best way to achieve results. Schwarzmuller, et al. (2018) advocated that being a problem solver is a core competency for an effective manager. Typically, managers are expected to be acute problem solvers. Managers are typically in a position to see the problems because they tend to reside in the thick of their active business. Braudis (2018) postulates that managers solve problems they see while leaders are held to a standard of seeing problems before they develop.

4.4 Accountability and Making Decisions Are in the Leadership Sphere.

Jamieson and Donald's (2020) original model placed both accountability and making decisions in the intersect of management and leadership. However, data supports the placement of these two items in the leadership sphere. Making responsible decisions precedes measuring the outcomes and professing one's place in the process as well as its results. Some researchers put forward that managers are in a unique position to make decisions for which they may or may not be held accountable (Lerner and Tetlock, 1999), thus implying that the leader is ultimately held accountable. This would coincide with whether one is accountable during the process or accountable post-process (Patil, Vieider and Tetlock, 2014). This supports the idea that the person standing before the authority (the leader) will ultimately be held accountable for what happens as a result of the processes the entity utilizes (Frederick, et al., 2016). Furthermore, this aligns with the findings of Phillips and Phillips (2020) who succinctly spotlight the courageous leaders who hold themselves accountable for all levels of decisions and outcomes despite uncertainties.

4.5 Executing a Plan and Understanding Context Fall Within the Management Sphere

Although originally placed in the leadership section, data shows that executing a plan and understanding context fall within the management sphere.

Context evolves and adaptability is crucial. Kotter (2000) described managers as grappling with complexity. Managers work within an organizational structure they must create and sustain. Consequently, they are expected to have an integral understanding of the internal and external framework necessary to achieve their goals. Included in that contextual framework are environmental factors, matters of policy and regulation, and societal and cultural challenges necessary to shape the strategies behind one's business activities (Trapp, 2014).

Similarly, executing a plan is the responsibility of the manager, as strategic plans are often global and vaguely written. Managers should clarify and add meaning to these broad expectations and "lofty strategic objectivities"

through day-to-day activities (MacLennan and Markides, 2021, p. 88). Janiesch and Kuhlencamp (2019) discussed the acumen required for the manager to execute a plan in a changing and evolving context. Such an observation addresses the successful manager's awareness of capacity specific to monitoring contextual changes for intervention and adaptation of execution.

4.6 Was Leadership but Should Be Both: Creating Alignment

Creating alignment was originally placed in the leadership sphere. However, through the validation process, it falls within the intersect, indicating that it is both a management and leadership task. This confirmation is affirmed when one considers alignment is about alliances and agreements and outcomes depend on shared intentions (Ungureanu, Bertolotti and Pilati, 2019). Though one might think aligning is the sole responsibility of leadership, it entails the establishment of goals and the building of strategies to coincide with purpose and vision; ergo, alignment is not a singular reflective task. Alignment might be inter-departmental, cross-departmental, and company-wide. Indeed, Trevor and Varco (2016) argued that leaders and managers are challenged to align teams and units, and undeniably, alignment at the enterprise level is vital for the truest connection of organizational strategy to organizational purpose.

4.7 Results Conclusion

Through our newly proposed method, we were able to find statistical justification for each item within the proposed Venn diagram. However, the data suggested that some items were misplaced (originally placed in the wrong section of the Venn diagram). Following this, we conducted a literature review to determine that theoretical justification did exist for the data-suggested placements, which indicated that data and theory matched and resulted in a Venn diagram supported by statistics and theory.

5. Discussion

5.1 Methodological Critique: Additional Questions to be Answered Regarding This New Methodology

The modified EFA method described here allows us to build and validate Venn diagrams. However, to become commonly practiced and applied with confidence, the method needs academically accepted norms and benchmarks. While we depend on many of the already established best practices of EFA, our assumptions that these practices are transferable may be faulty. Additionally, some procedures will be unique to validating a Venn diagram.

The most glaring need is to establish the proper cutoff for determining cross loads. While our example above has secondary loads of .3 or higher when cross-loaded, that may not be the case for all data. Thus, a reasonable benchmark for the cross-load inclusion in the overlapping section of the Venn needs to be determined. For example, if a primary load is .7 and a secondary cross load is 0.2, should this variable be included as part of the primary circle or the intersection?

Negative cross-loads also need to be considered. Should a variable that has a positive primary load and a negative secondary load be placed in the primary (single?) category or the intersection?

Another important statistic for EFA evaluation is the variance explained. Armstrong and Soelberg (1968) justified a benchmark of 60%. That is, to be considered strong, an EFA should account for 60% of the variance. However, this benchmark was set with the intention of data reduction as a primary goal. When performing EFA, a higher variance often can be achieved by removing low-load and cross-load items. Since the goal of this new application is not a reduction in items, we may determine that a lower benchmark cutoff is justified. Better yet, if the goal is simply to validate the distinct sections and intersections of the circles of a Venn diagram, perhaps the total variance explained should not be considered at all. In specific cases, the item placement within a Venn diagram may be enough to accomplish the researcher's goal.

Additionally, the new approach needs a standard for determining how many items define a set of the Venn diagram. When performing traditional EFA, best practice calls for a factor to be comprised of at least 3 items, but flexibility is offered for the design of the study (Tabachnick and Fidell, 2007). One can imagine a Venn diagram that resulted in a circle with one item in the main circle and 2 items in the intersect. Therefore, if trying to honor a three-item cutoff, items in the independent circle and the overlap should be considered. However, additional research should be conducted to determine if the 3-item minimum is still valid under the new framework.

5.2 Methodological Critique: Number of circles within the Venn (how many components to retain)

Finally, we must offer an honest critique of ways in which this method can be mismanaged. One possible misuse of this method can be found in the practice of using Scree plots and/or eigenvalues to determine the number of circles within the Venn diagram. Because we borrow this practice from factor analysis (determining how many factors to retain), we also inherit one of the issues of this method.

Owing to this inherited issue with factor analysis and the difficulty of determining the number of factors to include (or how many circles make up our Venn diagram), we echo the advice of Ford, MacCallum, and Tait (1986):

> *Since evidence suggests that it is better to overestimate rather than to underestimate the number of factors (Guertin, Guertin and Ware, 1981; Levonian and Comrey, 1966; Rummel, 1970), it is suggested that researchers examine the highest to the lowest number of factors until the most interpretable solution is found (Hakstian, Rogers and Cattell, 1982). (Ford, MacCallum and Tait, 1986, p. 294)*

While we echo this advice, we openly acknowledge this method leaves interpretation up to the researcher instead of having hard cutoffs. Unlike methods like regression analysis, there is not an agreed benchmark for statistical validation. With regression, you either achieve or fail to achieve the .05/.10 level for statistical significance. The success or lack thereof is clear. However, with factor analysis, interpretation is still required and, thus, the possibility of misinterpreting must be acknowledged. Therefore, determining the number of circles that should be included within the Venn diagram can be misinterpreted.

5.3 Methodological Critique: Rotation

Again, because this method derives from factor analysis, we also inherit the critiques of that commonly accepted method. Another concern that we acknowledged is rotation. Researchers should pick their rotation method based on the project's needs. More specifically, an orthogonal rotation (often conducted through a varimax rotation) is used for simple structures while oblique rotations allow for complex structures.

In this research, we used the varimax rotation, assuming that leadership and management are simple structures. We also tested the correlation between our factors to ensure that our data met the <0.3 benchmark. Owing to the goals of this method application (validating a Venn diagram) we argue that varimax is the most appropriate rotation method because each circle of the Venn diagram is distinct and not correlated with the others. However, we would be academically dishonest if we did not also draw attention to the critique that researchers should consider alternative constructs to decrease the potential to be biased (Ford, MacCallum and Tait, 1986). This same sentiment is persuasively expressed by Sass and Schmitt (2010). We acknowledge researchers may be enamored with simple structure because it is clean and easily explained (Sass and Schmitt, 2010). The correlation of factors should be determined before opting for a rotation pattern.

5.4 Methodological Critique: Must be Grounded in Theory

Finally, we come to one of the largest weaknesses of this method, and that is an inability to mathematically guard against bad theory.

Armstrong and Soelberg (1968) demonstrated that random numbers linked to variables can be analyzed and results can be "meaningful" as they relate to factor interpretation. Therefore, being able to find meaningful results in factor analysis is dependent not only on the mathematics behind the process but also on the theory used to create the items and variables. Owing to this reality (and it is a reality that holds in most statistical methods), researchers are urged to guard against this weakness. To do so, they must ensure that variables and variable constructs are informed by a thorough review of literature and strongly linked to theory. Additionally, guarding against sampling error by ensuring a large enough sample size and an accepted ratio-to-factor must be employed whenever using this method (Cliff and Pennell, 1967). Researchers can help to strengthen the integrity of results by doing so.

6. Future Research and Conclusion

The purpose of this study was to determine if a modified method of exploratory factor analysis could offer a way to statistically validate Venn diagrams or confirm item placement within Venn diagrams. This objective was achieved. Through this study, the authors offer a significant step forward in the realm of social science research by introducing a rigorous and data-driven approach to creating and validating Venn diagrams. To date, Venn diagrams have been pictorial representations and while they could aid in understanding, they lacked statistical backing. Our newly proposed method addresses this long-standing short coming of Venn diagrams, and we

demonstrated how the application of a modified version of exploratory factor analysis (EFA) could be utilized to position items within the Venn diagram, thus creating a Venn diagram based on empirical data and enhancing its validity and credibility.

In this study, this newly proposed method was applied to the leadership vs. management theory debate. This work underlines the significance and importance of empirical evidence in validating and refining our understanding of complex concepts and relationships. While the context of this example was business, our work has established a structured framework that can be applied to a wide range of social science theories represented by Venn diagrams.

Finally, we concede that this method offers promise but still has limitations. Because this is the first application of this method, many of the best practices and benchmarks from traditional exploratory factor analysis are used. For example, the 0.3 cutoff is used for load factors as is a common practice in EFA. However, scholars have had decades to finetune the EFA process and after the same fine-tuning, academic debates, testing, and applications, it may be found that EFA for Venn validation should have different benchmarks than the traditional EFA application. We recommend that researchers conduct similar studies to determine whether modifications to the proposed method need to be implemented. Questions related to this method and debate are welcomed and needed to progress this method and deepen our understanding of leadership and the social sciences.

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