THE USE OF LEADERSHIP RESEARCH MATERIALS BY TECHNOLOGY LEADERS IN THE UNITED STATES OF AMERICA

BY

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TABLE OF CONTENTS

LIST OF TABLES

ABSTRACT

A research study was conducted addressing the specific problem of senior technology leaders in physical sciences technology companies in the USA underutilizing scholarly leadership research (SLR). The purpose of the study was to learn via surveys how often senior technology leaders access, use, and share SLR and non-scholarly leadership materials (NSLM) to inform their leadership decisions for the benefit of their organizations. The study was supported by a literature review addressing the alignment of the problem with leadership theories, the need for leaders to use SLR, the economic relevance of addressing the problem, the efforts of company leaders to address the problem, and the historical and current methods of leader learning. The quantitative methodology included online surveys of three groups of senior technology leaders, senior managers, directors, and vice presidents from 33 physical sciences technology companies in the USA. The causal-comparative research design enabled the calculation of means of counts of instances of the access, use, and sharing of leadership materials as reported by survey respondents. Differences in the calculated means between senior technology leader groups were analyzed using ANOVA as well as Bonferroni and Tukey HSD-Kramer post hoc methods to elucidate any statistically significant differences. The results showed infrequent access, use, or sharing of SLR within any of the senior technology leader groups. The results also showed occasional access, use, and sharing of NSLM by the same groups and statistically significant increases in all three behaviors with leadership span of control. The results inform leadership researchers, information scientists, leadership development service providers, and others interested in the transfer of leadership research to technology practitioners about the current effectiveness of such

transfer. The results also inform future research opportunities including the motivators and detractors for senior technology leaders accessing, using, and sharing both SLR and NSLM. Other research opportunities include quantifying the connection between the use of SLR and NSLM by technology leaders to organizational outcomes as well as how college and university technology degree programs might better prepare technologists to access and use leadership materials.

CHAPTER 1: INTRODUCTION TO THE STUDY

Leaders guide followers in their organizations to achieve goals, often including the delivery of competitive products and services. Leadership practitioners and researchers widely agree on the importance of leaders contributing to organizational outcomes (Day & Lord, 1988). Though business success is typically linked to competitive offerings of goods or services, successful business process improvements are also key to success (Christin Jurisch et al., 2014; Terziovski, 2010). Situational leadership theory (Hersey, Blanchard, & Natemeyer, 1979) claims the effectiveness of a leader stems from their ability to adapt to changing situations.

Leader decisions may account for many complex business factors including trade policies, labor laws, access to natural resources, union rules, social trends, energy costs, and taxation rules to name a few. Business globalization and new technologies across many disciplines are shifting demands on already complex leadership skills (Mendenhall, 2006). Understanding how to leverage multi-cultural and diverse employees to improve innovation and business results makes leadership even more complex (Wang et al., 2019; Zaccaro & Klimoski, 2001). Executives at companies generally try to identify, hire and develop leaders with high potential (Avolio & Hannah, 2008; Bowness, 2017). Technology executives also try to hire and develop leaders who have comprehensive views of technology risks that could otherwise jeopardize business results (Barnier, 2012). Part of developing leaders to adapt to changing circumstances is ensuring they have access to leadership information tools and resources (Bowness, 2017). Leadership information is available from scholarly and non-scholarly sources to assist leaders in navigating complex business factors with diverse teams.

Study Background/Foundation

Leaders get information about leadership from many sources. Leaders may use their intuition, personal experience, formal and informal training, inputs from others, or even game-based simulations (Lussier, 2016; Susskind, 2017; Terrell & Rosenbusch, 2013). The study provided counts of the absolute and comparative use of scholarly leadership research (SLR) and non-scholarly leadership materials (NSLM) by three senior leader groups, grouped by spans of control, in physical sciences technology companies in the USA to inform their leadership decisions and improve business results. SLR includes leadership materials resulting from rigorous pedagogical methods, typically being peer-reviewed and published in academic journals. NSLM includes leadership-focused materials sourced from professional leadership development programs (LDP), government and corporate publications, non-academic journals, magazines, consumer books, and dissertations on leadership. The term non-scholarly does not imply a lack of veracity or usefulness of NSLM but does imply a lack of scholastic rigor or peer review in validating NSLM content.

Current State of the Field in which the Problem Exists

Leaders produce better organizational outcomes when they make decisions informed by leadership research (Booker et al., 2008). Prospective hires into leadership roles either already have information gathering skills or their skills require further development. Many companies have processes for identifying prospective leaders among internal or external job applicants including measuring historical leadership results, recommendations, stakeholder feedback, and executive evaluations (Bowness, 2017; Philpot & Monahan, 2017; Santora, 2003). Some executives have preferences for hiring leaders who are already fully fit to lead as opposed to developing their leadership potential (Bottger & Barsoux, 2012). Some companies also have leader development programs (LDP) including degree programs, instructor-led leadership training, mentorship of leaders by higher seniority leaders, job rotations, and periodic reviews of 360 feedback to leaders from customers, employees, and peers (Solansky, 2010; Terrell & Rosenbusch, 2013). Some companies also hire leadership coaches to work closely with leaders having high potential, but may not assign coaches at all levels of leadership due to cost (Bell, 2021). Couch and Citrin (2018) estimated that companies in the United States of America (USA) spend over US$13B annually on LDPs and that most leadership development tends to be ineffective and concluded that LDPs waste phenomenal amounts of money. Among the various leader development methods it seems reasonable to inspect whether leaders are being provided information about how to lead in certain situations versus being taught about how to find leadership information and apply it to broader situations.

A review of common tools used in LDPs exposes what leaders are taught and perhaps by exclusion, what is not being taught. One common LDP tool is the Myer-Briggs Type Indicator (MBTI). MBTI is used to assess leadership style using leaders' behavioral preferences among four dichotomous trait pairs (Randall et al., 2017). The pairs are introversion versus extraversion, sensing versus intuition, thinking versus feeling, and judging versus perceiving. MBTI is used to help leaders understand their style relative to the personalities of stakeholders around them. Successful leaders operating in various roles tend to have clustered MBTI scores, indicating a capacity of MBTI results to predict a leader's success in similar roles (Kennedy & Kennedy, 2004).

However, teaching leaders how to assess their own MBTI or that of other people, does not appear to be a common LDP objective.

As another example of providing leaders with a leadership tool rather than research skills, some LDP training programs emphasize a tool called emotional intelligence (EI), sometimes referred to as emotional quotient (EQ) or emotional intelligence quotient (EIQ), which has a positive correlation with organizational outcomes (Wilderom et al., 2015). EI encompasses required leadership skills that allow leaders to convey to followers an inspired vision of organizational performance with win-win outcomes and cooperation through trust (Nafukho et al., 2016). EI training addresses how leaders can assess and use feedback from work associates to modify their decision-making (Nafukho et al., 2016; Wittmer & Hopkins, 2018). EI provides leaders with a tool or specific leadership knowledge, however without instructing leaders on how to find new and unrelated leadership information.

Scholarly journals offer diverse insights into primary and secondary data sources often reviewed by peers on a wide range of disciplines related to leadership. Some may be explicitly focused on leadership while others may address leadership within a larger business, education, sociology, or psychology context. Examples include the Academy of Management Journal, the Journal of Management Studies, the Journal of Organizational Change Management, the Organization Development Journal, the MIT Sloan Management Review, and the Strategic Management Journal from a non-comprehensive list of 50 business management journals provided by Kresge Library Services (University of Michigan, 2021). Given the time and resources invested in scholarly leadership research (SLR) content, failure to teach leaders how to access and use SLR implies missed opportunities for leaders to benefit from SLR and improve their leadership decisions.

Many scholarly journals require subscriptions, sometimes called paywalls, which have been identified as access impediments, forming the basis of the open-access literature movement which aims to compensate sources of research information to provide open access without subscriptions (Bjork, 2017; Demeter, 2019; Gershenson et al., 2020; Green, 2018; Ranasinghe & Chung, 2018; Roman et al., 2018; Zhu, 2020). Bypassing paywalls using websites such as Sci-Hub with copyright-infringed research content is common for technologists (Bohannon, 2016; Green, 2017; Himmelstein et al., 2018). There are at least two hurdles between leaders and SLR, the first being that leaders must learn about the existence of SLR along with how and where to find it. Next is the reality of subscription paywalls. What is unclear is the relative significance of the two hurdles in the disuse of SLR.

Colleges and universities worldwide offer undergraduate and post-graduate leadership degree programs and also conduct organizational leadership research. Examples include Harvard Business School, Vanderbilt University, Georgia State University, the Australian Graduate School of Leadership, The Chinese University of Hong Kong, and the University of Oxford among others. The degrees of Ph.D. in Leadership and EdD in Leadership both typically involve original research, though respectively leaning towards pure or organizationally applied research (Nelson & Coorough, 1994). People involved in institutional leadership programs are likely to be involved in research and exposed to sources of scholarly leadership research (SLR) due to frequent literature searches as part of class assignments (Aas et al., 2020; Guillaume, 2021; Hewitt et al. 2014; Osterman et al., 2014). Guldin (2018) found that younger technologists were more inclined to access scholarly technical information sources such as the Journal of the Institute of Electrical and Electronics Engineers, the Journal of Communications Engineering & Systems, or the Journal of Aerospace Engineering & Technology, while older technologists tended to get contact names from articles and make direct contact with authors. Technology research information is also available from online sources such as stackoverflow.com and scholar.google.com with content having varying degrees of scholastic authority (Xu et al., 2020; Yang et al., 2016). Though technologists use scholarly research, the circumstances that may encourage their access and usage of SLR are less evident (Farr & Brazil, 2009; Guldin, 2018).

Innumerable consumer books and textbooks on organizational leadership have been written with varying scholastic authority, the purchases of which may evidence perceived connections between written leadership materials and organizational results. A few bestsellers include: On Becoming a Leader (Bennis, 1989), Good to Great (Collins, 2009), Primal Leadership: Realizing the Power of Emotional Intelligence (Goleman et al., 2002), The 7 Habits of Highly Effective People (Covey, 2004), The Leadership Challenge (Kouzes & Pozner, 1987), How to Win Friends and Influence People (Carnegie, 1937), The Five Dysfunctions of a Team (Lencioni, 2012), and The One Minute Manager (Blanchard & Johnson, 1983). A list of commercially successful books on management and leadership may number in the hundreds, implying that NSLM is actively purchased. However, the purchase of books does not evidence the degree of use of the information contained in them or even if they have been read.

New technologies spawn novel leadership issues implying a need for technology leaders to use leadership materials for guidance (Barnier, 2012; Gritzo et al., 2017). Bleich (2016) presented that leaders should be lifelong learners, needing first to learn how to acquire and then apply leadership knowledge. Bleich found lifelong leadership learning as inconsistent with leadership training short courses and that leaders instead needed to be taught the ongoing process of learning. Technologists may, by the design of their formal training curricula, use technical research, but the ability to conduct technical research does not necessarily imply a reason or ability to locate and use leadership-related research. Nor does the non-use of SLR or NSLM imply for any specific situation that positive outcomes for organizations are not otherwise achieved. Organizational leadership issues may be resolved using shared leadership knowledge, intuition derived from personal leadership experiences, or inputs from leadership coaches (Coate & Hill, 2011; Eling et al., 2014). Insufficient use of leadership materials by technology leaders may reduce the range of guidance and therefore opportunities to improve results for technology organizations (VanVelsor & Guthrie, 1998). The collective investment of time and resources in SLR, collegiate leadership degree programs, LDPs, as well as books and periodicals on the topic of leadership evidences the relevance of studying the counts of instances with which leaders access and use various leadership materials to inform their leadership decisions for the benefit of the companies.

Inspiration to use SLR by technology leaders seems an unlikely consequence of mentorship or 360 feedback. Instructor-led leadership training and collegiate degree programs in leadership are more likely conduits for learning about SLR (Nelson & Coorough, 1994; Shulman et al., 2006). The use of NSLM may be more likely to result from mentorship or 360 feedback since the recommendation of an article or leadership book could be anticipated. Therefore, processes used to identify and develop leaders in physical sciences technology companies in the USA may have the potential to expose leaders to both SLR and NSLM.

Deficiencies in the Evidence

The evidence does not support that technology leaders are taught to use leadership materials or that they use leadership materials. The existence of leadership development programs (LDP) evidences a perceived positive return on investment by organizational executives to improve leader competence and organizational outcomes (Coate & Hill, 2011; Debebe et al., 2016; Geerts et al., 2020; Jeyaraman et al, 2018). Many journal articles in scholarly leadership research (SLR) and non-scholarly leadership materials (NSLM) inform readers about what leaders do, what leaders are, how leaders act, and about leadership styles measurement tools such as the Myers-Briggs Type Indicator or Emotional Intelligence (Johnson, 2007; Panait & Bucinschi, 2018; Nafukho et al., 2016; Northouse, 2015; Randall et al., 2017; Wittmer & Hopkins, 2018). However, joint complexities of business factors, stakeholders, and emergent technologies imply the impracticality of teaching prescriptions for all leadership problems (Chowdhry, 2010). Some leadership issues might be handled using a prescriptive approach taught as part of an LDP while others may require leaders to explore information sources and learn approaches new to them (Fletcher et al., 2010; Versland, 2016). When more narrowly considering technology leaders in the USA, the literature evidences the use of technical research, but not necessarily SLR (Abdalkareem et al., 2017; Guldin, 2018; Himmelstein et al., 2018; Yang, et al., 2016). Evidence shows that some technology leaders bypass journal subscription paywalls to conduct research, but there is insufficient evidence that the research being accessed is related to leadership (Bohannon, 2016; Green, 2017; Himmelstein et al., 2018). Evidence is lacking in the literature regarding the count of instances with which technology leaders in physical sciences technology companies use SLR or NSLM to inform their leadership decisions for the benefit of their companies.

Problem Statement

The general problem is that senior technology leaders at physical sciences technology companies in the USA underutilize scholarly leadership research (SLR) materials (Booker et al., 2008; Pitsis, 2017; Stouten et al., 2018; Wang, 2017). Companies and even nations are continuously reworking their business or operating models to garner competitive advantages. Continuous reworking introduces emergent leadership issues. The information available in SLR might assist leaders in addressing a variety of historical and emergent leadership issues. Disuse of SLR implies lost opportunities to improve organizational outcomes, improve competitiveness, and capitalize on collective investments in SLR.

Audience

The audience for the study includes technology leader-practitioners and leadership researchers. Leader-practitioners include company executives, human resources personnel, or leaders in organizations producing products and services including physical sciences technology companies in the USA. The leader-practitioner audience also includes creators of leader development programs, leader coaches and mentors, and leadership assessment analysts. Researches include collegiate leadership researchers and instructors, students of leadership studies, library scientists, and institutional information management researchers.

Specific Leadership Problem

The specific problem is that by underutilizing scholarly leadership research and non-scholarly leadership materials, senior technology leaders in physical sciences technology companies in the USA miss opportunities for better-informed leadership decisions and improved results for their organizations (Castaldo et al., 2010; Davenport et al., Dayan & Elbanna, 2011; 1998; Wang, 2017; Weiss & Molinaro, 2006). Technology leaders, in addition to having generally lower competence in some aspects of leadership, may encounter higher rates of change in leadership issues due to the impacts of new technologies (Barnier, 2012; Fitzgerald, 2015; Gritzo et al., 2017; Tushman, 2017). One implication is that technology leaders may have more to gain from using scholarly leadership research and non-scholarly leadership materials than leaders in general. An extension is that failure to do so represents greater lost opportunities for improved organizational outcomes at physical sciences technology companies.

Purpose of Study

The purpose of the study was to calculate the means of counts of instances with which senior technology leaders in the USA access, use, and share scholarly leadership research (SLR) and non-scholarly leadership materials (NSLM) to inform their leadership decisions for the benefit of their organizations. A secondary purpose was to analyze the differences in the means of counts of instances between senior managers, directors, and vice presidents (subsequently defined).

Conceptual Foundation

For the study, it was theorized that leaders in physical sciences technology companies in the USA underutilize scholarly leadership research (SLR) (Booker et al., 2008; Wang, 2017). Stouten et al. (2018) found that technology leader-practitioners were more likely to rely on expert advice than on scientifically-based journal articles. A foundation for the theory was that although technologists are often trained to research technical materials, they often found SLR irrelevant, lacking applicability to real situations, and often lagging behind technological advances (Booker et al., 2008). Pitsis (2017) found that leader-practitioners tend to focus on methodology in SLR with less emphasis on supporting literature and having little interest in theoretical foundation. Since the theoretical foundation is a key component of SLR, if leader-practitioners find it to be irrelevant, for them the distinctions between SLR and non-scholarly leadership materials (NSLM) may not be evident (Pitsis, 2017). Booker et al. (2008) found access and use of SLR may be inconsistent with formal training methods for some academic disciplines. The uses of SLR or NSLM seem unlikely to be emphasized in college programs in physical sciences and perhaps are more likely parts of social sciences or business disciplines.

The results-based tasks of technology leaders seem unlikely to compel technologists to engage SLR. Technologists may have many years of experience before becoming technology leaders, developing intuition and leadership context while solving problems of immediate concern which may be antagonistic to long-duration research activities (Wang, 2017). Booker et al. (2008) found disdain for academic researchers among some leader-practitioners who claimed the prior lacked leadership experience or actionable perspectives and also that scholarly research findings were often just common sense. The aggregate reputation of scholarly research was sometimes questioned when the investigation into peer review processes sometimes shows inadequate peer review (Kelly et al., 2014). Concerns were compounded if the scholarly research was found to be academically nonsensical or, in some cases, computer-generated gibberish submitted to journals as a hoax with subsequent publishing (Bartlett, 2021; Tourish, 2020).

If technology leaders at physical sciences technology companies in the USA do not learn about SLR while in college degree programs, do not engage SLR as a typical job function, and do not learn about SLR in leader development programs (LDP), such leaders may be functionally disconnected from SLR, leading to ongoing underutilization of SLR. A lack of use of SLR may engender a lack of familiarity with where and how to access or use SLR. Leader-practitioners may be exposed to NSLM in the form of self-evaluation tools in leader-led training classes or as commercials books on leadership, non-scholarly periodicals, or online videos.

Research Questions

R.Q. 1 What are the calculated means of counts of instances of senior technology leaders at physical sciences technology companies in the USA accessing, using, and sharing scholarly leadership research and non-scholarly leadership materials to inform their leadership decisions to benefit their organizations?

R.Q. 2 Do the calculated means of counts of instances of accessing, using, and sharing scholarly leadership research and non-scholarly leadership materials differ between groups of technology leaders at physical sciences technology companies in the USA, specifically senior managers, directors, and vice presidents?

Methodology and Research Design Overview

The study used a quantitative methodology and a causal-comparative research design enabling analysis of survey responses from three groups of senior technology leaders at physical sciences technology companies in the USA. The sample of leaders was a convenience sample from an existing contact list of industry leaders having authority levels appropriate for the study. The definitions of the members of the three groups are detailed in chapter 3.

Study Limitations

The study had the risk that surveyed leaders did not know the difference between scholarly leadership research (SLR) and non-scholarly leadership materials (NSLM). For this reason, the survey was introduced with explanations of SLR and NSLM with examples. Doing so ensured that the answers from various respondents were aligned on common definitions. The questions in the surveys did not involve sensitive, personal, contentious, or professionally risky subjects, so the risk of getting biased responses was minimized. Since the surveys did not involve any classified, proprietary, private or sensitive information of any parties, there was no risk of intervention by the leaders' companies.

Study Delimitations

The study was specific to senior leaders at physical sciences technology companies in the USA. The results are not transferable outside of the USA or to organizations not involving physical sciences technologies in the USA. The results are also not generalizable or transferable to organizations having leader seniorities different from the three leader groups.

Definitions of Key Terms

ANOVA – analysis of variance – a statistical method in which the variation in a set of observations is divided into distinct components (Knapp, 2017)

calculated means – specific to the study, this is a shortened form of the "calculated means of counts of instances, from survey respondents, of the use of scholarly leadership research or non-scholarly leadership materials by groups of senior technology leaders to inform their leadership decisions for the benefit of their companies"

cultural distance - the extent of novelty or difference between the leader's own national culture and the cultures of other countries he or she has encountered (Chua et al., 2015)

LDP – leadership development program typically consisting of a collection of leader education methods such as collegiate degree programs, leader-led classroom training, mentorship, 360 stakeholder feedback, and role cross-training (Kimball et al., 2021)

leader - a person who is in charge of or commands others in an organization (Durant, 2016)

mentorship – a leader development method wherein a leader is connected for periodic discussions and guidance to one or more supervisors typically having superior authority to the leader being mentored (Shek & Lin, 2015)

NSLM – non-scholarly leadership materials typically consisting of textbooks, consumer books, magazines, online videos, and contents of leader-led classroom leadership training

open-access – a term used to describe free access by everyone, everywhere to cross-discipline research information where governments or organizations pay researchers or distributors for rights to the research or access privileges (Bosc & Dillaerts, 2012)

paywall – a subscription fee required for accessing information from publishers or knowledge management systems such as those providing journal articles (Pattabhiramaiah et al., 2019)

peer review – Peer review is the evaluation of work by one or more people with similar competencies as the producers of the work to maintain quality standards, improve performance, and provide credibility.

physical sciences – professional disciplines involving astronomy, chemistry, computer sciences, engineering, geology, mathematics, and physics excluding any of the life sciences and social sciences (Lipşa et al., 2012)

leader-practitioner – a leader who is accountable for the delivery of products and services specifically excluding educators and those involved exclusively in research (Chaker et al, 2020)

researcher – a person who conducts a systematic investigation into and study of materials and sources to establish facts and reach new conclusions (Hou et al., 2020)

SLR – scholarly leadership research typically consisting of peer-reviewed articles from periodical journals having well respected scholastic integrity

type 1 error - In statistical hypothesis testing, a type I error is the mistaken rejection of a true null hypothesis.

360 feedback – a process with which a person solicits anonymous feedback from a group of others with whom they interact including subordinates, peers, supervisors, and customers among others (Sureda et al., 2021)

Summary

Evidence from the literature shows a connection between leader competency and organizational outcomes (Day & Lord, 1988). The literature evidences the desire of corporate executives to hire and develop competent leaders using many methods and tools and the willingness to pay for leader development programs (Barnier, 2012; Bowness, 2017). A wealth of scholarly leadership research (SLR) and non-scholarly leadership materials (NSLM) are available in the literature representing significant investments of time and money from many sources (University of Michigan, 2021). When leaders access and use SLR, they have a positive impact on their organizations' outcomes (Booker et al., 2008). However, there are significant evidence gaps in showing that technology leaders at physical sciences technology companies in the USA are aware of SLR or access or use either SLR or NSLM to improve their organizational outcomes.

In chapter 2, the conceptual foundation is enhanced and broken into two parts. First, a theoretical foundation is provided and supported by the literature regarding the relevance of competent leadership, the relevance of leadership in technology companies in the USA, the efforts by executives in technology companies to hire and develop competent leaders, and the alignment of the problem statement of the study with prevalent leadership theories. The theoretical foundation supports the theoretical framework which is focused on how leaders learn, the usefulness of scholarly leadership research and non-scholarly leadership materials to technology leaders at physical sciences technology companies in the USA, as well as aids and impediments to technology leaders accessing and using leadership materials. Chapter 3 will then provide details of the study including research methodology, information about the research sample of technology leaders, details of the conduction of the research, and details regarding analysis of data collected in the form of survey responses.

CHAPTER 2: LITERATURE REVIEW

The literature review was used to assess the current state of factors surrounding the specific problem for the study, to evidence the problem as a real problem worth studying, to discover prior attempts and methods used to address the problem and to build a theoretical foundation that guided research. The literature review was conducted primarily using peer-reviewed articles from scholarly and peer-reviewed journals, emphasizing sources within the last seven years. Books may be used to inspect the alignment between leadership theories and the problem statement of the study. The use of web sources or non-scholarly journals was minimal.

Theoretical Foundation

The study was framed on a theoretical foundation derived from the literature addressing several precepts necessary for the problem statement of the study to be meaningful. First was that competent leadership matters to outcomes of organizations. Another was that technology companies are organizations with economically significant outcomes, making competent leadership in technology companies relevant to study. The literature was then reviewed regarding executives in technology companies in the USA hiring and developing competent technology leaders to achieve improved outcomes for their companies. The literature was reviewed regarding the context of leadership within physical sciences technology companies which may indicate certain competencies as more relevant than others for technology leaders. Lastly, alignment is examined between one or more prevailing leadership theories and the development of improved leadership competence of technology leaders.

Competent Leadership Matters

The specific research problem for the study revolved around technology leaders using scholarly leadership research (SLR) to inform their leadership decisions and improve the outcomes of their organizations. If the literature supports the idea that competent leadership matters, then using SLR to further improve leadership also matters. A competent leader may be defined as a leader whose actions are likely to produce improved outcomes for organizations or other stakeholders. In a study about accelerating leader competence development, Avolio and Hannah (2008) found that leaders exhibiting five behavioral precursors were more likely to have accelerated leader development, yielding improved company returns on investments in leader development programs. The five precursors included goal orientation, developmental efficacy, self-concept clarity, self-complexity, and metacognitive ability. Avolio and Hannah found the five competencies exemplified willingness and ability to learn while holding the needs of the organization in higher regard than one's self. Avolio and Hannah also found other components of leader development programs accelerated leader development such as selecting leaders based on testing of leadership style characteristics, collecting performance feedback, and using leader mentorship. The data connected the improved financial returns to enhanced leader competence, thereby demonstrating that leader competence matters. The findings support the general problem statement of the study, that by underutilizing SLR, leaders lose opportunities to improve their leadership competencies and the outcomes of their organizations.

Several ethics theories contain expectations that leaders extend the benefits of their leadership to others outside of their organizations. Johnson (2007) reviewed many leadership ethics theories in the literature applicable to leaders and organizations including utilitarianism (Byskov, 2020), communitarianism (Cowden & Singh, 2017), Rawl's theory of justice (Joseph, 2020), Kant's categorical imperative (Tapek, 2018), and altruism (Calder et al., 2021). A common element among these theories is the need for leaders to provide benefits both inside and outside their organizations. Johnson discussed that failure to address needs outside of one's organization could ultimately harm the organization in various ways such as disaffection of customers, employee turnover, reduce team morale, damaged corporate reputation, and even sabotage. The ethics of leaders' decisions and actions as perceived through the lenses of different ethics theories demonstrate that competent leadership matters due to its potential impact on organizational outcomes. The findings support the general problem statement of the study that by underutilizing scholarly leadership research, in this instance about leadership ethics, leaders lose opportunities to improve their leadership competencies and benefit the outcomes of those inside and outside of their organizations.

Hazy and Uhl-Bien (2015) examined five different aspects of leadership and organizational outcomes associated with each of them. The first aspect was called generative and was associated with an organization being entrepreneurial and adaptive. The second was called administrative and was associated with role orientation, discipline, efficiency, and performance. The next aspect was called community-building and was associated with team motivation, engagement, shared identity, trust, and citizenship. The next was called information gathering and was associated with discourse, data collection, models, and listening. The last aspect was information-using, which focused on process evolution, responsibilities, developing competence and expertise as well as developing accountability. The data showed not only that competent leadership matters but also detailed how it matters in terms of connecting leader competencies to specific outcome types. The findings support the general problem statement of the study, that by underutilizing scholarly leadership research, leaders lose opportunities to improve their leadership competencies and outcomes of their organizations.

Though many leadership theories exist, validation of any theory generally requires testing to see how well predicted consequents of actions match observed consequents. Evidence showing that competent leaders have positive impacts on outcomes for their organizations is foundational for the study. Akar (2018) measured the relationships between ethical leadership and organizational justice, organizational commitment, organizational trust, organizational cynicism, motivation, job satisfaction, and mobbing in educational organizations. The data showed ethical leadership was reflected both positively and negatively in different organizational aspects. The data showed organizational trust in leaders was significantly correlated with job satisfaction, organizational justice, organizational commitment, and motivation. The data also showed a strong negative correlation between organizational trust in leaders and organizational cynicism, demonstrating that ethical behaviors by leaders have consequences on the outcomes for organizations. The findings support the general problem statement of the study, that by underutilizing scholarly leadership research about leadership ethics, leaders fail to improve their leadership competencies and lose opportunities to benefit the outcomes of those inside and outside of their organizations.

Alamir et al. (2019) quantitatively tested two leadership styles, transformational leadership, and transactional leadership, regarding their relationships with the outcomes of job satisfaction and organizational commitment. The testing sample included 502 employees at six higher education institutions and data showed both direct and indirect effects of transformational leadership on both outcome types. The data also showed transactional leadership was related only to job satisfaction. The findings confirmed that leadership style impacts outcomes for organizations and therefore matters. The findings support the general problem statement of the study, that by underutilizing scholarly leadership research on topics such as leadership styles, leaders lose opportunities to improve their leadership competencies and outcomes of their organizations.

In a study involving 438 communications technology workers, Gemeda and Lee (2020) examined the relationships between leadership styles and outcomes for work tasks and innovation behaviors. The data showed that transformational leadership styles were positively correlated with employee work engagements and innovation behaviors. The data also showed that transactional leadership styles were positively correlated with employee task performance and that leaders using a laissez-faire leadership style had a negative correlation with employee task performance. The findings showed that leadership style characteristics are antecedents to organizational outcomes with either positive or negative influences supporting the general problem statement of the study, that by underutilizing scholarly leadership research on topics such as leadership styles, leaders fail to improve their leadership competencies and the outcomes of their organizations.

In another example of leadership practices affecting organizational outcomes, McClean and Collins (2019) examined the relationships between high commitment human resource (HCHR) practices and chief executive officer (CEO) charismatic leadership on voluntary employee turnover and relative performance to peers. HCHR was described as a management system using employee inclusion in a form of shared leadership encouraging organizational affection of employees. HCHR also included employee recruiting and selection based on personal fit with the organization, investment in employee development programs, and compensation connected to company performance. The testing sample included 281 small firms. The data showed that organizations having HCHR practices and CEOs exhibiting charismatic leadership had the highest employee work performances and lowest employee turnovers. The data also showed organizations without HCHR practices or CEOs exhibiting charismatic leadership had the lowest employee work performance and highest employee turnover. The findings supported the use of greater investments in employees, shared leadership, outcome-based financial rewards, and CEOs' charismatic leadership styles to produce positive organizational outcomes. The findings support the general problem statement of the study, that by underutilizing scholarly leadership research on topics such as leadership styles, leaders lose opportunities to improve their leadership competencies and the outcomes of their organizations.

Relevance of Leadership in Technology Companies

The specific research problem for the study revolves around improving leadership in physical sciences technology companies, which is relevant when the outcomes from physical sciences technology companies are economically significant or otherwise meaningful. The economic impact of physical sciences technology companies in the USA is sufficiently large for the study to be significant and relevant. According to Fortune (2021) in 2021 the 500 largest capitalization companies in the USA generated $13.8T US of revenues. There are many physical sciences product companies found within just the top 50 from the list of 500 companies including Alphabet, Amazon, Apple, AT&T, Microsoft, Verizon Communications, Ford Motor, General Motors, Comcast, Dell Technologies, Facebook, General Electric, Intel, International Business Machines, Raytheon, Boeing, and Lockheed Martin. The combined 2021 annual revenues of just these technology companies within the top 50 are approximately USD 1.88T (Fortune, 2021). Without adding the revenues from other physical sciences companies on the list of 500 or those not on the list of 500, USD 1.88T of revenues evidences the economic significance and potential for improving leader competence in physical sciences technology companies. The findings support the relevance of the study, because of the potential improvements to the massive revenues of technology companies in the USA.

Hiring and Developing Competent Leaders

Company executives hire and develop competent leaders, tacitly evidencing significance to business outcomes. Many companies have processes for identifying prospective leaders among internal or external job applicants including measuring historical leadership results, recommendations, stakeholder feedback, and executive evaluations (Bowness, 2017; Philpot & Monahan, 2017; Santora, 2003). Some executives have preferences for hiring leaders who are already fully fit to lead as opposed to developing their leadership potential (Bottger & Barsoux, 2012). However, the literature contains examples of leader development research and guidance (Archambeau, 2021; Dragoni et al., 2014; Hammond et al., 2017; Newstead et al., 2020). The findings are aligned with the general problem statement of the study which addresses the need to improve the competence of leaders for the benefit of their organizations via the use of scholarly leadership research.

According to Gurdjian et al. (2014), companies in the USA spent approximately USD 14B annually on leadership training as one of the top three human capital priorities according to survey responses from human resources executives. Gurdjian et al. also found only 7% of company executives in the United Kingdom believed they properly developed their leaders and 30% admitted they had underperformed on business opportunities due to inadequate leader training. According to Allio (2018), in 2017 companies worldwide spent approximately USD 20B on leadership training. The findings are aligned with the general problem statement of the study which addresses the need to improve the competence of technology leaders for the benefit of their organizations via the use of scholarly leadership research.

Alignment with Leadership Theories

Many leadership theories are accessible in scholarly literature and some may promote the use of scholarly leadership research (SLR) or non-scholarly leadership materials (NSLM) to inform leadership decisions in which case the theories are considered aligned with the problem statement of the study. Some leadership theories may imply, but not promote, the need for leaders to use SLR or NSLM to inform leadership decisions and are considered partially aligned with the problem statement of the study. Some leadership theories may not address SLR or NSLM and are considered not aligned with the problem statement of the study. Lastly, leadership theories contradicting the use of SLR or NSLM are considered misaligned with the research questions of the study. An example of a misaligned leadership theory is the great man theory which states that great leaders have inborne leadership traits or traits that develop very early in life, obviating the need to access SLR or NSLM for personal leadership development (Carlisle, 1841; Northouse, 2015).

Twenty-nine theoretical leadership models were reviewed regarding alignment with the problem statement of the study. The theories included the 3D leadership model (Reddin, 1967), the action-centered leadership model (Adair, 1973), two authentic leadership models (George, 2003; Kelley, 2018), centered leadership (Barsh et al., 2010), charismatic leadership (Shamir et al., 1993), the competing values framework (Cameron & Quinn, 2011), complexity leadership (Uhl-Bien & Arena, 2017), conversational leadership (Hurley & Brown, 2010), eco-leadership (Western, 2010), Fiedler's contingency theory (Fiedler, 1958), five levels of leadership (Collins, 2001), the four framework approach (Bolman et al., 2017), the full range leadership model (Avolio & Bass, 2002), Goleman's six leadership styles (Goleman, 2000), the great man theory (Carlisle, 1841), Kurt Lewin's leadership style (Lewin, 1946), leader-member exchange theory (Graen & Uhl-Bien, 1995), the leadership for collective wisdom framework (Briskin & Erickson, 2009), the managerial grid (Blake & Mouton, 1964), the performance triangle (Michel, 2014), servant leadership (Greenleaf et al., 1996), the skills approach (Katz, 1955; Mumford et al. 2000), situational leadership (Blanchard & Johnson, 1982), the Tannenbaum and Schmidt leadership continuum (Tannenbaum & Schmidt, 1973), trait theory (Stogdill, 1948), transpersonal leadership (Young et al., 2018), visionary leadership (Taylor & Taylor-Machado, 2010), and the Vroom-Yetton-Jago decision-making model (Vroom & Jago, 1988). Leadership theories found to be partially or fully aligned with the problem statement of the study are now addressed. For each leadership theory having alignment or partial alignment with the problem statement of the study, alignment details are provided below. Non-aligned and misaligned theories have no elaboration. Alignment of the general or specific problem statements of the study with canonical leadership theories would evidence that the problem is likely a constituent of leadership issues.

Action Centered Leadership

The action-centered leadership (ACL) model is a seminal work developed while John Adair was lecturing at Sandhurst Royal Military Academy and assistant director and head of leadership at The Industrial Society (Adair, 1973). Adair discussed that leadership is trainable and transferable and involves more than just what the leader is, but also specific skills the leader should possess including time-management, decision-making, and effective communication. In a departure from earlier models, Adair discerned between management and leadership with the prior being primarily about skills and the latter being about abilities and qualities. Five core principles of ACL are planning, initiating, controlling, supporting, informing, and evaluating. The first principle specified the need for collecting information to develop a plan. The controlling principle included a component of decision-making that can use research and prior decision-based evidence to inform decisions. The evaluating principle included the feasibility of ideas which can also be informed by historical research about similar problems and solution approaches. Adair also discussed the need for leader self-assessment methods and tools similar to those found in the literature such as the Myer-Briggs Type Indicator and Emotional Intelligence characterization (Panait & Bucinschi, 2018; Stein, 2017). Two components of the ACL model include developing teams and helping individuals develop their full potential, both of which are further informed by the literature (Crane & Hartwell, 2018; Potnuru et al., 2019). Adair's ACL suggested that leaders may commonly have only half of the required information for decision making with the other half being acquirable as guidance or information from others. ACL is considered partially aligned with the problem statement of the study because it implies the need for leaders to use leadership information sources to inform their leadership decisions without explicitly requiring it.

Leadership for Collective Wisdom Framework

In a book resulting from a collaboration with dozens of contributors from diverse settings and cultures, Briskin and Erickson (2009) described the leadership for collective wisdom framework as leadership relying heavily on information sharing among stakeholders inside and outside of an organization. The framework addressed six primary components which were deep listening, suspension of certainty, seeing whole systems and seeking diverse perspectives, respect for others and deep discernment, welcoming all that is arising, and trusting in the transcendent. The framework is partially aligned with the problem statement of the study for two reasons. First, in the deep listening part of the collective wisdom framework, teams of people pool collective knowledge and are capable of greater results than occur in a top-down hierarchy. A prerequisite identified in the book is that leaders must embrace not knowing everything and be willing to seek other sources of knowledge. One knowledge source is internal team members. Another is external team members and yet another is the knowledge documented in leadership materials. The implication was that for leaders to seek out knowledge, they must be willing to admit their knowledge incompleteness and make efforts to learn more and then lead better. The second was that of seeking diverse perspectives. A leader's connections are a source of diverse perspectives, but the wealth of scholarly and non-scholarly leadership materials extends the opportunity to gain diverse perspectives and inform leaders about understanding a wide range of situational antecedents and resolution approaches. This leadership theory is partially aligned with the general problem statement of the study because it implies the need for leaders to access and use scholarly leadership research to inform their leadership decisions to improve the outcomes for their organizations.

The Performance Triangle

A journal article titled the performance triangle by Nold and Michel (2016) was a study into what allows organizations to be agile when addressing rapidly changing business conditions. The findings were based on 100 corporate case studies spanning ten years including statistical data analyses for 50 of the cases. The data showed that companies are complex and dynamic with rapidly changing business contexts, cultures, leadership, and systems impacting company outcomes. The data showed the critical factor for companies to exhibit adaptability, agility, and resilience was designing organizations to maximize knowledge bases. The findings informing the resulting theoretical model showed the capabilities of leaders and followers were situational and dynamic, requiring constant development of skills and broadening of abilities. The triangle is a graphical representation of a hierarchy, similar to Maslow's hierarchy of needs (Maslow, 1954), with training and skills at the lowest level, supporting higher levels of learning for different skills on the path to efficiently performing teams at the top. The performance triangle is considered to be aligned with the problem statement of the study because some of the knowledge bases indicated to inform leadership decisions are scholarly leadership research and non-scholarly leadership materials.

Skills Approach to Leadership

The skills approach to leadership theory developed by Mumford et al. (2000) extended the three skills approach presented in a seminal book by Katz (1955). The skills approach to leadership stated that effective leaders must develop a variety of leadership capabilities, knowledge, and skills from a variety of situations, often at different leadership levels. The research showed differences between the problems encountered by academics and problems encountered by leader-practitioners which tended to have higher degrees of complexity and novelty. The research showed that access to and use of knowledge was a key skill for successful leader-practitioners to navigate through complex and novel problems. Knowledge was discussed in many forms including knowledge specific to tasks, leadership knowledge from personal experience, knowledge of other stakeholders, and extant or historical knowledge in the form of leadership materials. Information was discerned from knowledge, the latter identified as organizations of facts, structures, principles, and models about characteristics of objects in a domain, the types of knowledge found in the scholarly research literature. One finding was that leaders with different levels of seniority acquired and used knowledge differently based on the totality of their personal experiences. The finding is consistent with the second research question derived from the problem statement for the study. The second research question addresses whether groups of leaders with different spans of control access and use scholarly leadership research and non-scholarly leadership materials with different frequencies. The skills approach is considered partially aligned with the problem statement of the study due to substantial reliance on knowledge acquisition as a key component of leadership skills.

Theoretical Framework

The theoretical foundation evidenced several premises that support the theoretical framework. The premises included that competent leadership matters to company outcomes and outcomes at physical sciences technology companies in the USA are economically significant and relevant to study. The foundation also evidenced that company executives attempt to hire and develop technology leaders through leader development programs to improve company outcomes. The theoretical foundation also showed alignment between four of the 29 leadership theories reviewed and the opportunities for leaders to access and use leadership information to increase their leadership competencies for the benefit of their organizations.

The theoretical framework first addresses how leaders learn and improve their leadership competencies. Among many components of leader learning and development, access and use of scholarly leadership research (SLR) and non-scholarly leadership materials (NSLM) are reviewed in the literature. The focus is then shifted to technology leaders and the applicability of SLR and NSLM to physical sciences technology company outcomes. Thereafter, criticisms and gaps in the literature are reviewed.

How Leaders Learn

In an article about leader learning; based on research in cognitive science, psychology, neuroscience, and biology; Bleich (2016) found five behaviors that improved leader learning. The first was connecting learning about leadership to activities where the learning could be applied. Next was requiring writing skills as part of the learning process which develops different parts of the brain than non-writing activities. Then interleaving different types of reading materials forced leaders to read about concepts, details, theories, and applications, providing better cognition of the interconnectedness of all levels of a problem. The Pomodoro Technique was also found to improve leader learning by compelling them to rank-order tasks by relevance and focus on the most important ones using timers for half an hour to an hour at a time to the exclusion of all interruptions. Doing so allowed for deeper learning which did not occur with frequent interruptions. Lastly, getting sufficient sleep was found to be key while the body repairs itself and develops neural connections to lock in memories and learning. The findings by Bleich helped broaden the view of how leaders learn beyond just the mechanics of accessing information to the enablers or enhancers that apply to many types or categories of leader learning. The findings support the general problem statement of the study by reinforcing the need for leaders to improve their competencies, including by reading materials such as scholarly leadership research, for the benefit of their organizations.

In a quantitative study focused on leadership skills in global corporations, Dragoni et al. (2014) partnered with a global consulting firm to analyze data from a sample of 585 senior leaders in many different industries. The analysis used demographic and career data from all members of the sample. Data were segmented on many leader characteristics including international experience types. Each leader took multiple psychological tests to assess strategic thinking competency and cultural distance, which is the extent of novelty or difference between the leader’s own national culture and the cultures of other countries he or she has encountered. The data showed leaders’ extraversion and openness to experiences had strongly positive correlations with strategic thinking competencies. Leaders had a strongly negative correlation between strategic thinking competency and years of work starting from early career up to 30 years of service. The data also showed more narrowly, a positive correlation between leaders' years of international work experience and strategic thinking competency. The data further showed that leaders' increased cultural distance moderated the strength of the correlation between international work experience and strategic thinking competency. The findings show that leaders learn important strategy skills for global corporations through direct international work experiences. The findings support the general problem statement of the study by reinforcing the need for leaders to improve their competencies for the benefit of their organizations.

Leader development programs (LDP) use a variety of methods to develop leaders, however, Archambeau (2021) found that most companies have LDPs that often fail. The failure reasons were identified as lacking clear objectives, poor program design, off-the-shelf training solutions that are not tailored for the organizational design, conflicts with other short-term objectives, and lack of applicability to specific organizational challenges. Archambeau, who has implemented LDPs while an executive or strategic advisor at IBM, Verizon, Nordstrom, and Roper Technologies among others found executives should treat LDPs as goal-based return-on-investment activities. Archambeau found higher LDP investment returns when developing leaders who demonstrated competence, motivation, and interpersonal skills. Lastly, Archambeau identified mentorship as one of the most important components of leadership development with the mentor filling the roles of advisor, sounding board, change catalyst, naysayer, cheerleader, connector, and closer while also encouraging leaders to take calculated risks and not be afraid of failure. The findings of Archambeau closely mirrored those of Avolio and Hannah (2008) regarding treating LDPs as return-on-investment activities, investing in high-potential leader candidates, and focusing on leader mentorship. Mentorship was also a focus by Coate and Hill (2011) who found that 60% of 300 surveyed companies used mentorship for leader development and that the percentage was rising. Coate and Hill also found from a mixed-methods study of 472 companies that human resources personnel in 78% of the companies found mentorship to be one of the most powerful leadership development tools. Coate and Hill showed that leader mentorship was regarded by human resources professionals as so useful that even during economic struggles and cost-cutting, companies tended to retain their budgets for mentorship. The findings support the general problem statement of the study by reinforcing the need for leaders to improve their competencies for the benefit of their organizations.

In a cross-sectional study of 23 scholarly journal articles about leadership development programs (LDP), Flaig et al. (2020) found that LDPs resulted in several measurable positive outcomes for the companies of leaders in the programs. The LDPs typically included classroom-based training, skills-based training, action learning, mentoring by more senior leaders, coaching, and online training programs. A key finding was that although the reviewed articles guided building or implementing LDPs, there was a dearth of literature regarding the measured effectiveness of LDPs. The implication was that the articles about LDPs were primarily theoretical and unvalidated. Another implication was that there may be differences between mechanisms used to train leaders and methods via which leaders learn. In the absence of validation testing, the distinction was unclear. The findings support the general problem statement of the study by reinforcing the need for leaders to improve their competencies for the benefit of their organizations.

In a study about the effectiveness of leader development in information technology (IT) companies, Hickman and Akdere (2018) conducted a cross-sectional review of the literature and, like Flaig et al. (2020), found a paucity of formal research on the effectiveness of leader development programs (LDP), even before narrowing the search to IT leadership. Data from the survey of 485 chief information officers revealed that leadership was widely viewed as the most important soft skill for IT leaders. Hickman and Akdere found no quantitative, peer-reviewed articles on IT leader development, but found roughly a dozen peer-reviewed qualitative studies about IT leadership. Findings included that mentoring and robust feedback were the most important parts of IT LDPs. Another was that most implemented LDPs were either off-the-shelf, purchased programs or they were programs based on recent fads in best-selling books that did not focus on the specific needs of organizations, leading to substantial financial waste on non-applicable training. Yet another finding was the need for leader training to consider the level of the leaders being trained due to different leadership needs. The finding was consistent with the second research question of the study which is to calculate the means of counts of instances with which leaders, having different levels of authority, access and use scholarly leadership research and non-scholarly leadership materials to inform their leadership decisions for the benefit of their companies.

Some tenets of leadership may be prescriptive such as praising employees in public and counseling them in private. Other leader learning such as how to listen or how to communicate while coaching may be situationally dependent based on the leader's or the other person's interaction style according to Kennedy and Kennedy (2004) who discussed the Myers-Briggs Type Indicator (MBTI) as a leadership development tool found in many LDPs. The MBTI was presented as a means for leaders to become aware of their interaction styles and how they will likely interact with other people having a wide range of styles. The MBTI informs leaders about their styles using behaviors among four dichotomous trait pairs. The pairs are introversion versus extraversion, sensing versus intuition, thinking versus feeling, and judging versus perceiving. Data showed that successful leaders operating in various roles tended to have clustered MBTI scores, indicating a capacity of MBTI results to predict a leader's success in similar roles. One implication was that a leader may use MBTI to understand their traits and which jobs they are best aligned to pursue. However, caution was levied that there was insufficient evidence to conclude that MBTI was able to fully predict the performance of any leader and that it should not be used as a basis for hiring or promotion decisions exclusively. The MBTI is an example of how leaders learn about themselves and regulate their interpersonal interactions versus learning about discrete facts or leadership methods. The findings support the general problem statement of the study by reinforcing the need for leaders to improve their competencies for the benefit of their organizations.

In a qualitative phenomenological study about the development of global leaders, Terrell and Rosenbusch (2013) interviewed leaders from six companies with global operations in different industries. Findings included the use of common leader training methods for non-global leaders such as formal education, leader-led training, 360 feedback, executive coaching and mentoring, job rotation, and special project assignments. However, the findings also showed that global leaders experienced additional learning mechanisms, developed through first-hand cross-cultural and global leadership experiences. What the global leaders collectively identified as their most significant learning experiences were on the job, not from LDPs. Next, global leaders learned the importance and value of cultural sensitivity, relationships, and networks. Third, global leaders required a unique set of global leadership competencies to effectively fulfill their roles, chief among them cultural awareness and sensitivity and a global mindset or perspective. Lastly, global leaders developed and learned intuitively, dynamically employing ad hoc learning approaches to developmental experiences. As opposed to formalized LDPs, global leaders developed from overseas assignments, assignments to international teams and task forces, international training programs, international meetings and forums, and international travel. The conclusions were that in addition to learning from LDPs, global leaders develop through first-hand global leadership experiences; learn the importance of cultural sensitivity, relationships, and networks; require a unique set of global leadership competencies; are driven by curiosity, openness, and desire to learn; and learn intuitively. The findings support the general problem statement of the study by reinforcing the need for leaders to improve their competencies for the benefit of their organizations.

Transferring Scholarly Leadership Research to Leaders in Industry

The literature was searched for evidence of the application of scholarly leadership research (SLR) to leadership challenges in industry. The literature was also searched for evidence of aids or barriers to connecting SLR to leaders in industry. The literature was lastly searched for evidence of leader-practitioner predispositions or beliefs about the use of SLR or the reputation of SLR which might encourage or discourage leaders' access and use of SLR. A review of applicable literature follows.

In a study about the effectiveness of knowledge management and application to 31 projects across disciplines and companies, Davenport et al. (1998) monitored the creation of knowledge repositories, improvements in knowledge access, enhancing knowledge-supporting environments, and managing knowledge as an asset. Knowledge was distinguished from information with the latter being considered data with minimal actionability. Knowledge was considered an enhancement of the information with human interpretation to make it transferable and actionable. One finding was that knowledge could be used to improve project outcomes when the economic value of enhancing performance was understood by executives. Another finding was improved project outcomes when organizations' infrastructures supported the creation and sharing of information and knowledge. Transferability of knowledge was also enhanced with the use of common knowledge formats. Another finding was that having multiple methods for knowledge sharing enhanced transfer and application to successful project outcomes. The findings are informative in the study of transferring knowledge and information contained in SLR and non-scholarly leadership materials (NSLM) to leader-practitioners, consistent with the general problem statement of the study.

Failures to transfer SLR to leaders in industry may be caused anywhere along the custody chain from research originators, through research repositories, to senders. In a study about transferring SLR from university researchers to leaders in industry, Pitsis (2017) noted an increasing trend in ties between personnel at universities and companies, often in the form of bilateral visits, meetings at conferences, and tailoring of degree programs to address industry needs. The increase was observed to be partially due to pressures from personnel at government agencies to derive value from SLR. However, Pitsis found hesitancies in collaborations between academia and industry due to legal questions such as who owns the resulting SLR. Pitsis found some researchers viewed collaboration with those in industry as likely to infringe on intellectual freedom and perhaps insert bias into research. Pitsis also found differences in the world-views of researchers and leader-practitioners and provided specific examples of journal submissions from leader-practitioners being rejected for not following a prescriptive scholarly format. Conversely, Pitsis found SLR often had limited applicability to real-world problems. The implications were that some causes of failures to transfer SLR to industry included the hesitancy of researchers, the mechanisms and legalities of SLR ownership, and disconnected motives with recipients in industry who seek more timely and directly-applicable knowledge. The findings support the general problem statement and the first research question of the study regarding the means of counts of instances of senior technology leaders accessing and using SLR to inform their leadership decisions for the benefit of their organizations.

In a cross-sectional and longitudinal study regarding the transfer of SLR to industry, Wang (2017) found the differences in goals and work methods between researchers and leader-practitioners caused challenges. Researchers valued designing and conducting rigorous research and disseminating it through academic knowledge distribution systems such as scholarly journals and conferences. Leader-practitioners instead dealt with emergent and constantly changing business challenges while trying to deliver products and services. The fundamental problem was that researchers and leader-practitioners did not have the same goals in the transfer of SLR to industry. The lack of translation of SLR between researchers and leader-practitioners was found to span across many disciplines, was documented by many researchers in the literature, and did not appear to be improving over time. The findings support the general problem statement and the first research question of the study regarding the means of counts of instances of senior technology leaders accessing and using SLR to inform their leadership decisions for the benefit of their organizations.

In an article about bypassing scholarly research subscription fees, referred to by some as paywalls, Bohannon (2016) discussed illegal access to copyrighted research. Paywalls are potential external impediments for leaders to access SLR which may be caused less by the amount of the fee versus the notion of who has to pay for it. Leaders may view subscription fees as obligations of their organizations and executives may consider the fees unwarranted, causing a stalemate. Bohannon used statistical website access information from Sci-Hub's owner and found that 50 million research works were hosted on the Sci-Hub platform with 28 million requested documents downloaded in six months in 2016. Roughly one-third of the downloads were delivered to requestors in China, India, and Iran. The findings support the general problem statement of the study regarding whether and how often leaders access and use SLR and NSLM to improve their competencies for the benefit of their organizations.

Bypassing paywalls using websites such as Sci-Hub with copyright-infringed research content is common for technologists according to Green (2017) who researched the international movement for open access to research, where open access means free to users. Green found copyright infringements with 60 million works on Sci-Hub, an increase of 10 million from the year before as found by Bohannon (2016). Green found the research access models agreed upon in the Budapest Open Access Declaration (BOAI, 2021) 15 years earlier had failed to the point that websites like Sci-Hub were still available for delivery of copyright-infringed research. Green found that worldwide open-access efforts including the Directory of Open Access Initiative (DOAJ, 2021) and European government efforts to expand open access had resulted in roughly half of the worldwide research being open-access. The balance was still behind paywalls. Green also showed that only 8000 research-based books were available through open-access channels while Springer publishing alone hosted over 280,000 book titles. Green found the proportion of research-based books published via open access was less than 2%. In the absence of willingness to subscribe to research repositories, the options are to not access the research or instead to access copyright-infringed copies. The findings support the general problem statement of the study regarding whether and how often leaders access and use SLR and NSLM to improve their competencies for the benefit of their organizations.

Pereira de Costa and Lima Leite (2016) using historical, bibliographic research methods found that the Budapest Open Access Initiative was the first to use the term open-access and that it was transformative as evidenced by a large number of subsequent open-access initiatives and formal papers citing it. Some of the subsequent open-access initiatives included the Berlin Declaration on Open Access to Knowledge in the Sciences and Humanities, the Bethesda Statement on Open Access Publishing, the Valparaiso Declaration for Improved scientific Communication in the Electronic Medium, Washington DC Principles for Free Access to Science, the Brussels Declaration on Open

Access, the Croatian Open Access Declaration, and the Scottish Universities Declaration on Open Access. Besides funded initiatives, Pereira de Costa and Lima Leite found many formal documents from governments and institutions supporting the open-access movement from North America, Europe, and Latin America. The implications from the findings of Green (2017) as well as Pereira de Costa and Lima Leite are that paywalls are a sufficient burden for access to scholarly research that governments and institutions worldwide have formally supported many ongoing worldwide initiatives to make access to scholarly research free for everyone. The findings support the general problem statement of the study regarding whether and how often leaders access and use SLR to improve their competencies for the benefit of their organizations.

In a cross-sectional literature review regarding change management prescriptions and empirical evidence, Stouten et al. (2018) found fragmented literature and a lack of scientific rigor dissuaded leader-practitioners from using scholarly leadership research (SLR) even when they acknowledged SLR may be valuable. Stouten et al. also found that SLR tended to focus on change preparation while giving far less empirical attention to how to keep people motivated and working to solve ongoing change problems. The evidence from both the literature and interviews conducted with leader-practitioners evidenced little translation from SLR to leader-practitioners to effect organizational change. Another finding was that leader-practitioners could not directly use SLR due to the constraints on the research, needing instead to interpret findings in the context of their specific organizational challenges. The findings support the general problem statement of the study regarding whether and how often leaders access and use SLR to improve their competencies for the benefit of their organizations.

In a study about the relevance of scholarly research, Serenko et al. (2011) found that scholarly research was distributed to leaders via direct and indirect paths. The direct path was academic, peer-reviewed journals. The indirect path was via consultants or textbooks that referenced the original journal articles, but with formatting adjusted to be more digestible for readers. Serenko et al. found that books intended for leader-practitioners, referred to as how-to books, used mostly non-peer-reviewed sources including personal research, experts' opinions, personal experience, practitioner magazines, conferences, books, and informal discussions with academics. The data showed a variety of issues hindering medical professionals from using scholarly research materials including a lack of time to research a rapidly growing set of works, a lack of understanding of the format of peer-reviewed works, and a general lack of awareness of scholarly journals. The findings support the general problem statement of the study regarding whether and how often leaders access and use SLR to improve their competencies for the benefit of their organizations.

Relevance of Leadership Materials to Technology Leader-Practitioners

For technology leaders to utilize scholarly leadership research (SLR) to positively affect the outcomes of their physical sciences technology companies, not only does SLR have to be available, the leaders must be willing to search for it, access it, and use it. The literature was searched for information about influences that may encourage or discourage technology leaders regarding accessing and using SLR, even if the hurdles of paywalls are removed. The types of influences considered in search terms were leader awareness of the existence of SLR, SLR trustworthiness and reputation, SLR relevance to technology leaders, or issues related to the time and effort required by technology leaders to access and use SLR.

In a cross-sectional literature review, Kieser et al. (2015) found how leader-practitioners use leadership research materials and how often they use them to be of great concern to the academic community, resulting in a considerable body of literature on the topic. The cross-sectional literature review was hampered by what Kieser et al. referred to as fragmentation across disciplines and lacking scientific rigor. A key finding was that there had been an ongoing debate among academics for many prior years regarding whether highly repetitious SLR, lacking an apparent trajectory towards resolving important questions, was relevant to leader practitioners. Kieser et al. found significant hindrances in translating SLR to leader-practitioners and segmented their findings into several categories. One category was called popularist and was associated with researchers claiming the contents of SLR to be valuable and that translation to industry only required access mechanisms to be fixed. Another category was the institutional view, causing a divide between academics and practitioners due to a lack of practical experience of researchers and a lack of incentives for researchers to care about leadership practice in industry. Another finding was that SLR was too often insufficiently narrow to apply to practical problems and did not account for the uniqueness of organizations. Too often the literature was found to be focused on invented problems rather than real ones. Kieser et al. found a large majority of leadership research pertained to natural sciences organizations and very little about physical sciences organizations. Similarly, Gritzo et al. (2017) found a paucity of SLR regarding the skills and attributes needed for successful technology leadership. Kieser et al. also found that leadership research seldom focused on prescriptive approaches, making the application of knowledge abstract and impractical. This appeared to partially conflict with Stouten et al. (2018) who stated that the literature was replete with prescriptions on organizational change management, but Stouten aligned with Kieser et al. on the issues of SLR being abstract and burdensome to apply to specific organizational contexts. The last finding of Kieser et al. was that leader-practitioners felt researchers took too long to produce outputs that were useful for real problems. The findings of Kieser et al. showed not only why some SLR may appear irrelevant to leader-practitioners, but also evidenced that in many cases, SLR was irrelevant due to leaders' inability to usefully apply it to solve problems for the benefit of technology companies. The findings support the general problem statement of the study regarding whether and how often leaders access and use SLR to improve their competencies for the benefit of their organizations.

In a correlational research design study to establish the relationship between research relevance and organizational performance, Chinwe (2015) studied 380 businesses in Nigeria. One finding was that time-constrained leader-practitioners unanimously found the time required to search through scholarly leadership research (SLR) to be impractical. A commonly found view from leader-practitioners was that the language and logic used in SLR were abstract and unproductive. Another finding was that researchers rarely made contact with leader-practitioners and were not exposed to real problems in organizations, causing their research problems and questions to be misplaced. Chinwe found that leader-practitioners expressed concerns about the operational validity of SLR, which most leaders said they could not translate into reality due to uncontrollable business factors. Lastly, Chinwe found that leader-practitioners were unsatisfied with SLR because it failed to meet their desires for research to be presented with useful recommendations, expressed as prescriptions to solve problems. Many of the findings of Chinwe are quite similar to those of Kieser et al. (2015). The findings support the general problem statement of the study regarding whether and how often leaders access and use SLR to improve their competencies for the benefit of their organizations.

Wolf et al. (2014) studied methods for reducing what they referred to as the relevance gap in SLR. Wolf et al. acknowledged the incongruity between the goals of leadership research and leadership practice, recognized the value of both theoretical and applied research and found that insufficient portions of SLR applied to real-world problems. Wolf et al. found no evidence in the literature that the divide between leadership research and its application to practice was narrowing. Another finding was that most leader-practitioners found SLR to be unhelpful and unappealing to read. The notion of SLR needing to be appealing was also identified as an issue by Bartunek et al. (2006) who studied the characteristics of research papers that make them interesting, leading to increased access and citation. To close the relevance gap, Wolf et al. found key factors such as ensuring research questions reflected the realities of practical problems and not treating uncontrollable business factors as if they are controllable by leader-practitioners. The latter implies that researchers need to understand which business factors are controllable and may expose a fundamental problem of having insufficient operational experience outside of academia. The findings support the general problem statement of the study regarding whether and how often leaders access and use SLR to improve their competencies for the benefit of their organizations.

Gritzo et al. (2017) conducted a survey-based quantitative study of 36,000 leaders in technology companies and found the leadership skills of technology leaders were perceived as inferior to non-technology leaders in 112 out of 115 leadership dimensions. The data showed that technology leaders were regarded as superior only in mastering technical knowledge, creating and innovating, and accepting when others are unavailable for work due to being ill. The data also showed unique opportunities to develop successful technology leaders by maintaining technical insight while expanding interpersonal skills. The implications were that technology leaders have more opportunities to develop leadership skills and benefit from SLR. However, Gritzo et al. found technology leadership research to be sparse, consistent with the same finding by Kieser et al. (2015). The findings support the general problem statement of the study regarding whether and how often leaders access and use SLR to improve their competencies for the benefit of their organizations.

The literature review has thus far shown scant evidence of the translation of scholarly leadership research (SLR) to leader-practitioners and even less to technology leader-practitioners. However, if the literature also evidences that leader-practitioners seldom use any type of research, it might imply the issue is less with SLR than with the mechanisms of transfer or the leader-practitioners. To investigate this possibility, the literature was searched for evidence of technology leaders searching for other types of research materials. In a study about the use of the Stack Overflow website, Abdalkareem et al. (2017) found that software developers and information technology professionals used the service extensively, using keywords to find message flows containing questions and answers from other professionals in related fields. Although the purpose of

Abdalkareem et al. was to use keyword research to optimize the efficiency of Stack Overflow, the key finding was that technology professionals including leader-practitioners use Stack Overflow to conduct research. The implication was that when technology leaders in technology companies in the USA underutilize SLR, it is not likely related to their unwillingness to conduct research. This is related to the specific problem statement of the study which is that by underutilizing SLR, technology leaders in technology companies in the USA lose opportunities to improve their leadership skills for the benefit of their companies.

Stack Overflow is a non-scholarly web service within a family of information exchange web services under the umbrella of Stack Exchange (Stack Exchange, 2021). In addition to Stack Overflow, Stack Exchange hosts similar question-and-answer exchange websites in the categories of technology, culture and recreation, life and arts, science, professional, and business. The total number of websites under the Stack Exchange umbrella is 178 with roughly one-half dedicated to science, technology, engineering, and mathematics (STEM) topics. Stack Exchange shows the oldest of the websites, Stack Overflow has been in service for over 13 years and has provided answers to 22 million questions. Although the Stack Exchange family of websites are not peer-reviewed, scholarly resources, if the level of question and answer activity cited by Stack Exchange is reliable, it evidences that technologists including technology leaders routinely conduct research. The implication is that when technology leaders in physical sciences technology companies in the USA underutilize SLR, it is not likely related to their unwillingness to conduct research. This is related to the specific problem statement of the study which is that by underutilizing SLR, technology leaders in physical sciences technology companies in the USA lose opportunities to improve their leadership skills for the benefit of their companies.

Technology leaders conduct research, but not necessarily for leadership materials according to Guldin (2018) who conducted formal interviews with 66 natural resources professionals in seven focus groups. The study was funded by the US government to investigate how to best distribute research information to natural resources professionals. The data showed three primary information search themes. First, the leaders searched for information using citations, articles, and videos, followed by online reading of articles, e-newsletters, and blogs suggested by the search engines. Next, article citations were used to find and read printed journal articles. Another finding was that technology leaders used social interactions at scientific meetings and direct contact with researchers to find scientific information. Lastly, Guldin found differences in how early-career and late-career professionals searched for information. The prior searched for materials and read the content while the latter searched for materials to identify people they could contact directly with questions. The findings showed that technology leaders search for both scholarly and non-scholarly information, but the mechanisms used are typically not direct searches of scholarly journals. The findings are related to the specific problem statement of the study regarding whether technology leaders use scholarly leadership research to inform their leadership decisions for the benefit of their organizations. The findings are also related to the second research question which addresses how the span of control of technology leaders, perhaps correlated with seniority, impacts the calculated means of counts of accessing and using scholarly leadership research and non-scholarly leadership materials.

If the veracity of any scholarly leadership research (SLR) is questionable, there is a risk of negative impacts on the reputation of all SLR. In a study about ethical practices in the publishing of peer-reviewed journal articles, Atjonen (2018) interviewed 121 researchers from eight universities in Finland. A variety of concerns were found with supposedly scholarly submissions including plagiarism, fabrication of data or results, duplicate publication, improper citation practices, and peer reviewers breaching the norms of good review practices. Atjonen referenced several ethical review standards such as those provided by Datta (2021), resulting from inferior research paper review practices. Although the article by Atjonen was primarily focused on unethical behaviors in peer review, an implication of the findings is that the scholarliness of SLR is questionable if the peer-review process is faulty. By extension, if an unknown subset of the total set of SLR has questionable veracity, all SLR is suspect until one can validate the peer reviews that supposedly separate scholarly and non-scholarly leadership materials. The findings are related to the general problem statement of the study regarding whether technology leaders use scholarly leadership research to inform their leadership decisions for the benefit of their organizations.

In an article about fraudulent paper submissions in the publish-or-perish environment of academia, Herndon (2016) as the editor of the Journal of Marketing Channels discussed multiple real-world examples of research fraud encountered by their review board including plagiarism, data fabrication, data falsification, statistical carelessness, conflicts of interest, unethical authorship, listing fake reviewers, and incongruities between the methods and designs of research and the conclusions. Herndon found that if any scholarly works are defamed by fraudulent practices, it casts a pall over all research as being suspect. A disturbing finding by Herndon was that in the time between 2003 and 2009, the number of article retraction notices grew by six times, but it was unclear whether the retractions were due to increased research fraud or increased ability to detect unethical submissions. Herndon detailed how the publish-or-perish mentality in academia contributes to a variety of unethical behaviors. For the study, the salient points of Herndon's findings are that the veracity of some scholarly is questionable, potentially leading to suspicion about the veracity of all SLR. The findings are related to the general problem statement of the study regarding whether technology leaders use scholarly leadership research to inform their leadership decisions for the benefit of their organizations.

Literature Gaps

In the review of alignment between 29 leadership theories and the specific problem statement of the study, four theories aligned partially: They were action-centered leadership, leadership for the collective wisdom framework, the performance triangle, and the skills approach to leadership. The partial alignments were due to claims in the leadership theories that leaders need to collect information and inputs from others and to use collective wisdom, including previously tested approaches, to solve problems. However, none of the theories explicitly stated that leaders should or needed to use scholarly leadership research to inform their leadership decisions to improve the outcomes of their organizations. If the need for leaders to use scholarly leadership research has been considered by theorists, the lack of explicitly addressing it in their theories implies the theorists have either rejected the idea or simply left it unaddressed as a gap in the literature. Alternatively, the use by leaders of scholarly leadership research may not have been considered by leadership theorists, still leaving a gap in the literature.

While scholarly leadership research presents a wide range of prescriptions for how leaders should lead, cross-sectional reviews of the literature show a lack of empirical research on the effectiveness of leadership approaches (Cameron et al., 2011; Flaig et al., 2020). Scholarly research about technology leadership is also sparse (Hickman & Akdere, 2018; Gritzo et al., 2017; Kieser et al., 2015). Scholarly literature on leadership in the natural sciences, though sparse, is more common than in other scientific disciplines (Kieser et al., 2015). The literature review resulted in dozens of journal articles about leadership development programs, however, reviews of all the returned articles produced no examples of teaching leaders where to access, how to access or how to use scholarly leadership research. Though the literature search for leader development programs cannot be considered exhaustive, it does evidence a gap in the literature.

Summary

The literature supports the specific problem statement of the study with several elements of the theoretical foundation. First, the findings show that competent leadership matters and that part of leadership competence is searching for external information, some of which is in the form of scholarly leadership research (SLR). Next, the findings show that executives in companies in the USA attempt to hire and develop competent leaders through leader development programs (LDP) to improve the leadership outcomes for their companies. However, the findings show that LDPs are often ineffective and show little evidence of specifically teaching leaders how to access and use SLR which may enable underutilization of SLR by leaders. Another finding was that the outcomes for physical sciences technology companies in the USA are of sufficient financial magnitude to support the study as relevant and worth researching. Lastly, the literature shows the partial alignment between four separate leadership theories and the specific problem statement of the study thereby evidencing the likely impact of the problem on leadership outcomes. The partial alignments with leadership theories revolved around the need for leaders to collect, share and use information not only to improve outcomes for their companies but also to develop the effectiveness of individuals and organizations.

The literature review resulted in the construction of a theoretical framework, supported by the theoretical foundation. The framework provides evidence of how leaders learn and that LDPs underemphasize how to access and use scholarly leadership research (SLR). The findings showed a variety of problems with how SLR is transferred to leaders and the impediments to leaders' access and use of SLR which may give rise to underutilization of SLR by leaders. One such transfer problem was research paywalls which gave rise to the international open-access movement to try and improve the utilization of SLR by leaders. Technology leaders were found to frequently research non-scholarly web platforms, showing their underutilization of SLR is likely, not due to a lack of willingness to conduct research, but instead to other access and usage issues. Lastly, the literature review evidenced the relevance of SLR and criticisms of the veracity of SLR that could affect leaders' underutilization of SLR to inform their leadership decisions and improve their organizational outcomes.

In chapter three, the research methodology and design are provided to address two research questions associated with the specific problem statement of the study. The specific problem is that technology leaders at technology companies in the USA underutilize scholarly leadership research (SLR), thereby obviating opportunities for their organizations to benefit from SLR. The first research question is, what are the calculated means of counts of instances of technology leaders at physical sciences technology companies in the USA accessing, using, and sharing either SLR or non-scholarly leadership materials (NSLM) to inform their leadership decisions for the benefit of their organizations? The second research question addresses how the calculated means of counts of instances of accessing, using, and sharing SLR and NSLM are modulated by the spans of control of the technology leaders, specifically senior managers, directors, and vice presidents. The instruments of research and data analysis will also be covered.

CHAPTER 3: METHODOLOGY

Research Method

The study used a quantitative methodology involving online surveys of senior technology leaders at physical sciences technology companies in the USA. The research results informed answers to two research questions.

R.Q. 1 What are the calculated means of counts of instances of senior technology leaders at physical sciences technology companies in the USA accessing, using, and sharing scholarly leadership research and non-scholarly leadership materials to inform their leadership decisions to benefit their organizations?

R.Q. 2 Do the calculated means of counts of instances of accessing, using, and sharing scholarly leadership research and non-scholarly leadership materials differ between groups of technology leaders at physical sciences technology companies in the USA, specifically senior managers, directors, and vice presidents?

Qualitative and mixed-methods research methodologies were excluded because the survey questions were to be answered exclusively with quantitative measures. No attempt was made to use any survey responses to inform the answers to any other questions. To inform an answer to the first research question, the calculated means of counts of accessing and using scholarly leadership research and non-scholarly leadership materials by senior technology leaders were quantified from survey responses. To inform an answer to the second research question, the sample of surveyed senior technology leaders was segmented into three senior technology leader groups by the numbers of workers and managers within leaders’ spans of leadership control. The span of leadership control of a technology leader included all personnel whose higher chain of reporting leadership included the senior technology leader. Numerical responses from senior technology leaders were used to directly address the first research question and ANOVA was used to determine if there were statistically significant differences between the three senior leader groups and between which pairs of groups.

Research Design

The study used a quantitative methodology and causal-comparative design with a convenience sample of senior technology leaders at physical sciences technology companies in the USA. The sample of leaders was segmented into three groups; senior managers, directors, and vice presidents respectively defined as having 10-25, 26-50, and 51-1000 workers within a senior technology leader's span of leadership control. Management titles may imply different spans of control at different companies, so titles were not used to segment the sample into groups. However, management titles were used to identify candidates for the sample who were likely to have spans of control within the three specified ranges. Workers included employees, consultants, or contractors who were physical sciences technology workers and managers as well as project managers, finance and accounting personnel, administrative personnel, and other personnel not specifically conducting physical sciences work, but still supported a physical sciences technology organization.

Quantitative research designs other than causal-comparative design were excluded from the study. Other quantitative research methods include survey research, experimentation, correlation, and topological or morphological descriptive studies. Survey research could have been an appropriate choice for the first research question, but the second research question directly required the comparative component of causal-comparative design. Quantitative research methods may be longitudinal (observed over time), cross-sectional (observed across a range of non-temporal variables), both, or neither. The study was designed to answer the two research questions only. The first research question required numerical counting and calculation of means. The second research question required analysis of means of counts between three groups comprising the sample, without a control group. There was no requirement to determine the causation of any effects or correlation between any variables. There was no need to compare observations over time or describe any topological or morphological characteristics. Cross-sectional variables were constrained to senior technology leaders at physical sciences technology companies in the USA. Lastly, there was no need to experiment via the modification of input variables or environmental constraints or boundaries to determine or predict changes to outputs. A causal-comparative design appeared ideal for collecting the data necessary to answer the two research questions.

Sample Description

The three groups of senior technology leaders comprising the sample were from the total population of senior technology leaders at physical sciences technology companies in the USA. The sample was a convenience sample, derived from the LinkedIn professional networking service and not a random sample from the population. LinkedIn is owned by Microsoft Corporation and is not limited to technology professionals or leaders although only technology leaders were considered as candidates for the sample. The senior leaders comprising the convenience sample had varying demographics, geographic distribution within the US, technical fields of expertise, company affiliations, and depths of training in an attempt to reasonably reflect the characteristics of the population of all senior technology leaders at all physical sciences technology companies in the USA. A senior leader's span of control was defined to be the highest span of control the leader had within the last three years. Leaders may temporarily change their spans of control due to company reorganizations, job changes, or retirement. However, for the study, each leader's highest span of control within the most recent year was considered most relevant to answering research question two, addressing the comparisons of the use of leadership materials between leaders having different spans of control.

Using LinkedIn for the convenience sample potentially induced bias, since all respondents use LinkedIn. However, LinkedIn is a widely used professional networking service that is non-selective regarding who can join. Those who do not use computers or the internet would be disinclined to join LinkedIn however, the lack of the use of computers and the internet is expected to be uncommon for technology leaders. Bias in the convenience sample seems constrained to persons in the population who choose to not use professional networking services.

The sample size was the total number of survey respondents for all three groups of surveyed senior technology leaders combined. Estimating the sample size appropriate for comparing the calculated means of numerical data from survey responses may assume idealized characteristics of the data. For instance, the statistical variation in the calculated means of the data may be assumed as Gaussian-distributed, also referred to as normally distributed or Laplace-Gauss distributed. Other assumptions typically include homogeneous variances among the distributions being compared, equal distribution sizes, and a 2-sided test (Allen, 2011).

Methods for calculating sample size are dependent on the construct of the problem. For instance, when estimating the mean value from a single set of data points, the required sample size, n, is sometimes calculated as $n = (Z\sigma/E)^2$. Z is the value from the standard Z-distribution table corresponding to (1 – confidence level)/2. For example, a confidence level in the estimated mean of 0.9 yields (1-0.9)/2 = 0.05 corresponding to a Z-value of 1.645. The value σ is the standard deviation of the data in the calculated mean. E is the allowed error in the estimated mean. To be 90% confident a calculated mean is within an error of 2 units for a data set having a standard deviation of 5 units a sample size of $n = (1.645*5/2)^2 = 16.9 \approx 17$ is required.

The sample for the study had three groups of senior technology leaders of equal sizes. The second research question required comparisons of the calculated mean values among the three groups for various survey questions. As discussed in the data analysis section, the comparisons of calculated means were performed with F-testing using ANOVA and post hoc methods. A prevailing method for calculating the sample size for problems of this type was discussed by Cohen (1988). Cohen discussed effect size which is the difference in the mean values of two or more data distributions normalized by the standard deviation of the data. As the difference between the calculated means of two data distributions increases, it is easier to detect the difference. However, as the variance in the data increases, the difference is more difficult to detect. Cohen called the ratio of the difference between the calculated means to the expected standard deviation the effect size and identified it as an important factor for calculating sample size.

Cohen also introduced the idea of statistical power when calculating sample sizes. Statistical power is the probability of correctly rejecting a null hypothesis that assumes data distributions have the same mean values when they do not. For a fixed sample size, statistical power increases with effect size in the data. If there is no difference in the calculated means of the data distributions, the effect size is zero and statistical power is also zero. As effect size shrinks, the sample size must grow to detect it for a given data standard deviation. Before data collection, the effect size is unknown and may be zero implying an infinite sample size in an attempt to detect the non-existent difference in the means of the data distributions. One cannot arbitrarily calculate sample size to detect an unknown effect size. Instead, the sample size is based on an effect size that is prescribed. The prescribed effect size is synonymous with allowable error in estimating the mean of one data distribution. If the true effect size is smaller than the prescribed effect size, it is not detectable and a null hypothesis claiming the calculated means of the data distribution are the same may not be rejected.

Based partially on Cohen's statistical power approach, a software program used to estimate sample size for three equal-sized data sets using F-tests in ANOVA is the G*Power program made available from Heinrich Heine University in Dusseldorf, Germany. G*Power can be used for many types of statistical analyses and one of them is categorized as the F-test, ANOVA fixed effects, omnibus, one-way test. This specific test is used to estimate the sample size for the study. The assumptions used as inputs are an effect size of 0.4, $\alpha = 0.1$, $(1-\beta) = 0.8$, and number of groups = 3. The false-positive rate of α is the probability that the null hypothesis cannot be rejected when it is factually incorrect (Allen, 2011). The false-negative rate β is the probability that the alternative hypothesis is accepted when it is factually incorrect (Allen, 2011). With these input parameters, the G*Power software automatically computes a required sample size of 51 or 17 in each of the three groups. An interesting observation is that this is the same count per group as was estimated in the single distribution example provided above using the same confidence level and the same ratio of error size to data standard deviation which is mathematically equivalent to effect size. The statistical power, (1-β), is estimated by G*Power to be 0.818 which means there is an 81.8% probability of correctly rejecting the null hypothesis of equal means of the data if the calculated means are different by at least the effect size. The computed sample size using G*Power is 51, and a 10% added margin brought the sample size for the survey to 56 which is rounded up to 19 for each of the three groups of senior technology leaders or a total sample size of 57.

The survey sample was the set of senior technology leaders who participated in the survey as opposed to the number invited or the number who agreed to participate. The sample of senior technology leaders included at least 19 senior technology leaders for each of the three senior technology leader groups. Each senior technology leader was employed by one of 33 physical sciences technology companies in the USA.

The convenience sample was derived from no fewer than 820 professional connections on the professional social networking website Linkedin. Approximately 300 of the professional connections were senior technology leaders meeting one of the segmentation definitions for the three senior technology leader groups. Senior technology leaders' profiles on LinkedIn typically include their current job titles and current or recent places of employment. The convenience sample is not easily re-established to reproduce the study results. The list is derived from almost 40 years of creating personal contacts with senior technology leaders. However, there are no regulatory or other specific barriers to creating a comparable sample. Other technologists with extensive industry experience would likely be able to approximate the sample without extraordinary efforts.

LinkedIn profiles were used to identify senior technology leaders for participation in the survey. The total number of companies or organizations self-identified by the survey respondents was 33. For each survey group of senior technology leaders, a list of 100 candidates was created. Each candidate was associated with a group of senior technology leaders based on their employment title available on LinkedIn. Each candidate was contacted and invited to participate in the survey via email, adhering to COVID 19 protocols as recommended by the US Centers for Disease Control (CDC).

Instruments

The questions in the survey directly addressed one or both of the two research questions of the study. The following survey questions were asked of each senior technology leader respondent. The first question enabled each survey respondent to be placed in one of the three senior technology leader groups or excluded, meaning the respondent's answers will not be used in data analysis. The responses from senior technology leaders to questions 2 through 7 were exclusively numeric and were used in data analysis. Question 8 allowed survey respondents to confirm their leadership roles in physical sciences technology companies. If not, their answers were excluded from data analysis. Question 9 allowed each respondent to identify their employing organization to verify a sufficient representation of respondents from organizations across the USA.

Question 1 - From the five numeric ranges provided below, please select the one that includes the highest total number of employees, contractors, and consultants having you above them in their leadership hierarchy at any single time within the last three years. (0-9), (10-25), (26-50), (51-1000), (1000+)

Question 2 - How many times within the last year that you were actively employed as a technology leader did you access scholarly leadership research to inform your leadership decisions?

Question 3 - How many times within the last year that you were actively employed as a technology leader did you use scholarly leadership research to support a specific positive outcome for your organization?

Question 4 - How many times within the last year that you were actively employed as a technology leader did you share scholarly leadership research with others in your organization?

Question 5 - How many times within the last year that you were actively employed as a technology leader did you access non-scholarly leadership materials to inform your leadership decisions?

Question 6 - How many times within the last year that you were actively employed as a technology leader did you use non-scholarly leadership information to support a specific positive outcome for your organization?

Question 7 - How many times within the last year that you were actively employed as a technology leader did you share non-scholarly leadership information with others in your organization?

Question 8 – Please select the category below that best describes the company where you were during your last year working as a leader. (physical sciences, engineering, or computer technology), (social sciences), (non-scientific), (other)

Question 9 – Please provide your employing organization.

After each group of senior technology leaders achieved at least 19 respondents, the survey was closed to more respondents. The same tool will also provide a means to collect all scored survey results, segregated into the three senior technology leader groups in preparation for data analysis.

Several steps were taken to enhance the reliability and reproducibility of survey responses. First, the study involved diverse respondents from no fewer than five physical sciences technology companies in the USA. Respondents were provided statements of confidentiality and their right to withdraw from participation at any time. Definitions of key terms used in the survey were provided to ensure common understanding among the survey respondents when answering questions. The first question in the survey allowed each leader to confirm their span of leadership control and job titles were not used to assume spans of control. The sample size for each surveyed group of senior leaders was computed to ensure findings are numerically within the stated confidence interval. If more survey responses are available than the required sample size, the additional responses were used to enhance the reliability and reproducibility of the findings. Validity of outcomes would apply if a model to predict outcomes was being tested, which is not the case for the study.

Data Collection

Emails sent to senior technology leader candidates included a clickable link to an online survey using Survey Monkey (Survey Monkey, 2021). The surveys required an average time of fewer than 5 minutes to complete including time to read definitions and disclosures of ethics-related information. As part of the survey service, survey responses are retained and automatically counted. Though some survey analysis features were available, all analysis was performed on raw responses from respondents. All responses were anonymous, but internet protocol addresses were used by the SurveyMonkey service to ensure no respondent made multiple submissions from the same address.

Once the candidate list for each group of senior technology leaders had 100 candidates, links to the online survey were emailed to each candidate. The survey included definitions of terms used in the survey to ensure survey responses were based on a common understanding of the terms used in the questions of the survey. The terms defined for the senior technology leaders were scholarly leadership research, non-scholarly leadership materials, and span-of-control. Senior leaders in all three groups were presented with identical questions. Once 19 survey responses were collected for each of the three senior technology leader groups, data analysis was initiated.

Data Analysis Methods

Data analysis had two parts. For questions two through seven, the means of counts of numerical responses were calculated for the sample and each of the three senior technology leader groups. Next, for each of the questions two through seven, F-testing using ANOVA (tool for analysis of variance) as described by Verma and Abdel-Salam (2019) was used to determine if differences in the calculated mean counts were different at the $p=0.10$ level of significance. The assumptions associated with ANOVA were that the numerical responses to survey questions two through seven are Gaussian distributed with homogeneous variances and that the three survey groups are the same size. Research by Blanca et al. (2017) manipulated input data conditions and showed that ANOVA is robust to non-normality of data sets as well as other factors including unequal group sample sizes, coefficient of sample size variation, unequal shapes of the group distributions, and pairing of group size with the degree of contamination in the distribution. Blanca et al. (2017) also found that Type I error in the F-test was robust in 100% of the cases studied, independently of the manipulated conditions. The calculated sample size using the G*Power tool was 51, 17 per group. However, the sample size was increased by 10% to 19 anticipating the data may not conform fully with the assumptions. F-testing using ANOVA is appropriate for three or more sampled groups and can be used to determine if at least one group has a significantly different mean, though not specifically which one (Salkind, 2017).

For survey questions two through seven, data analysis first consisted of calculating the means of the numerical responses from the survey respondents in each of the three senior technology leader groups. Then, for each survey question two through seven, a null hypothesis (H0) and an alternate hypothesis (H1) were F-tested using ANOVA. The symbol μXY is the calculated mean of numerical responses for question X and from senior technology leader group Y. If F-testing with ANOVA indicated rejection of H0 for any question, additional post hoc tests were used as elaborated below.

For Question 2 - How many times within the last year that you were actively employed as a technology leader did you access scholarly leadership research to inform your leadership decisions?

Null Hypothesis (H0): The mean number of times all three groups of senior technology leaders accessed scholarly leadership research during the last year they were actively employed as leaders are equal. $\mu 21 = \mu 22 = \mu 23$

Alternative Hypothesis (H1): The mean number of times all three groups of senior technology leaders accessed scholarly leadership research during the last year they were actively employed as leaders are not equal. $\mu21 \neq \mu22$ or $\mu21 \neq \mu23$ or $\mu22 \neq \mu23$

For Question 3 - How many times within the last year that you were actively employed as a technology leader did you use scholarly leadership research to support a specific positive outcome for your organization?

Null Hypothesis (H0): The mean number of times all three groups of senior technology leaders used scholarly leadership research to support a specific positive outcome for an organization during the last year that each was actively employed as a leader are equal. $\mu31 = \mu32 = \mu33$

Alternative Hypothesis (H1): The mean number of times all three groups of senior technology leaders used scholarly leadership research to support a specific positive outcome for an organization during the last year that each was actively employed as a leader are not equal. $\mu31 \neq \mu32$ or $\mu31 \neq \mu33$ or $\mu32 \neq \mu33$

For Question 4 - How many times within the last year that you were actively employed as a technology leader did you share scholarly leadership research with others in your organization?

Null Hypothesis (H0): The mean number of times all three groups of senior technology leaders shared scholarly leadership research with others in their organization during the last year that each was actively employed as a leader are equal. $\mu41 = \mu42 = \mu43$

Alternative Hypothesis (H1): The mean number of times all three groups of senior technology leaders shared scholarly leadership research with others in their organization during the last year that each was actively employed as a leader are not equal. $\mu41 \neq \mu42$ or $\mu41 \neq \mu43$ or $\mu42 \neq \mu43$

For Question 5 - How many times within the last year that you were actively employed as a technology leader did you access non-scholarly leadership materials to inform your leadership decisions?

Null Hypothesis (H0): The mean number of times all three groups of senior technology leaders accessed non-scholarly leadership materials during the last year they were actively employed as leaders are equal. $\mu51 = \mu52 = \mu53$

Alternative Hypothesis (H1): The mean number of times all three groups of senior technology leaders accessed non-scholarly leadership materials during the last year they were actively employed as leaders are not equal. $\mu51 \neq \mu52$ or $\mu51 \neq \mu53$ or $\mu52 \neq \mu53$

For Question 6 - How many times within the last year that you were actively employed as a technology leader did you use non-scholarly leadership information to support a specific positive outcome for your organization?

Null Hypothesis (H0): The mean number of times all three groups of senior technology leaders used non-scholarly leadership materials to support a specific positive outcome for an organization during the last year that each was actively employed as a leader are equal. $\mu61 = \mu62 = \mu63$

Alternative Hypothesis (H1): The mean number of times all three groups of senior technology leaders used non-scholarly leadership materials to support a specific positive outcome for an organization during the last year that each was actively employed as a leader are not equal. $\mu61 \neq \mu62$ or $\mu61 \neq \mu63$ or $\mu62 \neq \mu63$

For Question 7 - How many times within the last year that you were actively employed as a technology leader did you share non-scholarly leadership information with others in your organization?

Null Hypothesis (H0): The mean number of times all three groups of senior technology leaders shared non-scholarly leadership materials with others in their organization during the last year that each was actively employed as a leader are equal. $\mu71 = \mu72 = \mu73$

Alternative Hypothesis (H1): The mean number of times all three groups of senior technology leaders shared non-scholarly leadership materials with others in their organization during the last year that each was actively employed as a leader are not equal. $\mu71 \neq \mu72$ or $\mu71 \neq \mu73$ or $\mu72 \neq \mu73$

If ANOVA showed statistically significant differences between the calculated means of counts of survey responses among the three groups existing for any of survey questions two through seven, Bonferroni and Tukey HSD-Kramer post hoc methods were used to discern which pairs of groups had significant differences. The Bonferroni post hoc method, though the simplest, may not yield the most reliable results. The three sampled group sizes were kept approximately equal to mitigate the need for Gabriel's or Hochberg's GT2 approaches which are preferred in cases of substantially unequal group sizes. When the analyzed groups have approximately equal variances and the sampled group sizes are within 20%, which is one-half the effect size of 0.4 used to estimate the sample size, the Tukey HSD-Kramer post hoc method is applicable. With any three arbitrary groups (A, B, C), three group pairings can be made (A-B, A-C, B-C) for the post hoc analyses. When ANOVA showed significant differences in the computed means of numerical responses between groups, two-tailed t-tests were run as part of the post hoc analysis.

Trustworthiness

To ensure reliability and reproducibility of outcomes, the study included at least 57 respondents sampled from senior technology leaders at physical sciences technology companies in the USA. Respondents' survey responses were confidential. The count and diversity of the respondents support the transferability of results to USA companies having similar size, physical sciences technology, and demographic profiles. Survey respondents were employed by 33 companies, ensuring a distribution of responses without over-concentration in a small number of companies. The respondents were senior technology leaders grouped by the number of people within their reporting hierarchies including multiple levels of subordinates. Each respondent, via answers to survey questions one and eight will confirm their span of control and that their leadership is within a physical sciences technology organization.

The validity of a study applies if a model to predict outcomes is being tested, which was not the case for the study. However, sampled population bias should be minimized and finite risks exist that senior technology leaders who used LinkedIn could have different survey responses from those who did not. Further, the senior leaders who chose to not participate in the survey had different access, usage, and sharing profiles of scholarly leadership research and non-scholarly leadership materials than otherwise implied in the results.

Limitations

The study had a risk that surveyed leaders do not know the difference between scholarly leadership research and non-scholarly leadership materials. Therefore, the survey was introduced with an explanation of both, with examples. Doing so helped ensure the answers from respondents were aligned with common definitions. The questions in the surveys did not involve sensitive, private, or contentious questions, so the risk of getting biased responses was minimal. The survey respondents were not at risk of intervention by the leaders' companies. The research was conducted in compliance with the rules of the U.S. Department of Health and Human Services Title 45 CFR 46 Subparts A, B, C, and D as well as the doctrines of the Declaration of Helsinki on human subjects research. There was a sufficiently large pool of available contacts to gather required responses for various groups of senior technology leaders having different spans of control.

Delimitations

The study was specific to senior technology leaders in physical sciences technology companies in the USA. The findings are not generally transferable outside of the USA or to companies not involving physical sciences technology in the USA. The results are not generalizable or transferable to organizations with substantial demographic deviation from the surveyed groups. Also, the outcomes would not be transferable to leadership seniority level groups not represented in the sample. I ensured that candidates for the survey included all contacts who were qualified for the survey without regard to sex, race, religion, ethnicity, or national origin. I assert that the candidate pool contained substantial diversity across these characteristics, but did not attempt to confirm or quantify the degree of diversity in the pool.

Summary

The purpose of the study was to address the problem of leaders in physical sciences technology companies in the USA underutilizing scholarly leadership research (SLR) and non-scholarly leadership materials (NSLM). The quantitative methodology and causal-comparative-designed study answered two research questions related to the problem by surveying a sample of at least 57 senior technology leaders segmented into three groups having different spans of control and also from at least five physical sciences technology companies in the USA. Counts of numeric responses from the surveyed sample regarding the counts with which they access, use, and share scholarly leadership research and non-scholarly leadership materials were used to calculate the means of counts of survey responses. Significant differences in the calculated means of counts for survey questions two through seven were tested using ANOVA. If statistically significant differences were found among the three groups of senior technology leaders, Bonferroni and Tukey HSD-Kramer post hoc analyses were used to investigate differences between pairs of senior technology leader groups.

Chapter 4: RESULTS

Survey invitations were sent to 300 of my existing contacts by email and a messaging function with the LinkedIn.com social media website. Job titles and employer names were used to identify candidates for the survey who appeared to conform to the boundaries of the study. Specifically, each candidate needed to be working in the USA as a technology leader for an organization where they were likely to be involved in physical sciences roles with spans of control between 10 and 1000 people including employees, contractors, and consultants. The candidates contacted appeared to me to be diverse in terms of sex, race, age, and national origin though no attempt was made to confirm any of these characteristics by me or via self-identification by the respondents. Survey responses were collected via the SurveyMonkey web service until each of the three leader groups (senior managers, directors, and vice presidents) contained at least 19 respondents having the required spans of control and who also confirmed their roles as leaders in physical sciences technology organizations within the last three years.

Presentation of Results

A total of 82 respondents took the survey and the responses from 18 were rejected due to having spans of control below 10 or greater than 1,000. Of the remaining respondents, 21 were senior managers having spans of control between 10 and 25, 20 were directors with spans of control between 26 and 50, and 23 were vice presidents with spans of control between 51 and 1000. Respondents claiming job roles other than physical sciences technology leadership were rejected bringing the counts of valid respondents for senior managers, directors, and vice presidents to 21, 20, and 22 respectively. The final set of respondents self-identified 33 different organizations as their employers including AT&T Inc., Verizon Communications, Oracle Computer Technology Corporation, Qualcomm Inc, Northrop/Grumman Corporation, Commscope Inc., LM Ericsson, Dish Wireless, Cox Communications, the United States Army, and the United States Social Security Administration. None of the 33 employing organizations had fewer than 500 employees.

The survey included nine questions. The first and eighth questions were multiple-choice selections regarding each respondent's span of leadership control and type of employing organization. Responses to questions one and eight were used exclusively to filter candidates who were not valid for the boundaries of the study. The ninth question allowed each respondent to identify their employing organization to ensure respondents from a minimum of five companies were included in the sample. The remaining six survey questions, two through seven, were quantitatively analyzed for hypothesis testing and answering the two research questions of the study.

R.Q. 1 What are the calculated means of counts of instances of senior technology leaders at physical sciences technology companies in the USA accessing, using, and sharing scholarly leadership research and non-scholarly leadership materials to inform their leadership decisions to benefit their companies?

R.Q. 2 Do the calculated means of counts of instances of accessing, using, and sharing scholarly leadership research and non-scholarly leadership materials differ between groups of technology leaders at physical sciences technology companies in the USA, specifically senior managers, directors, and vice presidents?

Responses to survey questions two through seven were grouped by senior leaders' spans of control into three groups and then analyzed using single-factor ANOVA within Microsoft Excel with an alpha level of 0.10. ANOVA provided the means and standard deviations for each group as well as the computed level of significance, the p-value. When the computed p-value was less than the alpha level, the null hypothesis that was associated with the corresponding survey question was rejected in favor of the alternative hypothesis. A computed p-value exceeding the alpha level indicated the null hypothesis could not be rejected.

If the null hypothesis was rejected for any of the survey questions two through seven, post hoc analysis was conducted to discriminate which pairs of the three technology leader groups were significantly different from each other. The three sampled group sizes were approximately equal, mitigating the need for Gabriel's or Hochberg's GT2 post hoc methods which are preferred in cases of substantially unequal group sizes. The Bonferroni post hoc method is the easiest post hoc test to use but is often considered to be less sensitive than the Tukey HSD method or Tukey HSD-Kramer method which is used in cases where the sizes of compared groups of data are unequal (Kramer, 1956). The Bonferroni and Tukey HSD-Kramer post hoc tests were used for survey questions where the null hypothesis was rejected.

When performing post hoc tests, the Bonferroni post host method used two-sided t-tests between three paired groups, senior managers and directors, senior managers and vice presidents, as well as directors and vice presidents. The t-tests yielded p-values which were compared to an alpha level that was adjusted by dividing the original alpha of 0.10 level by three which was the number of t-tests being performed, so the adjusted alpha level was 0.0333. If the p-value computed for any t-test was less than the adjusted alpha level, the null hypothesis was rejected in favor of the alternative hypothesis for the pair of groups tested.

The Tukey HSD, which stands for honestly significant difference, post hoc test method uses a value from a standardized and widely available q-table having a prescribed alpha level of 0.10. Different alpha levels correspond to different q-tables. Inputs to the q-table are the degrees of freedom within the three groups analyzed, which is 60, and the number of groups being compared which was three. The q-value found in the standardized q-table for these inputs was 2.595. The Tukey HSD post hoc test assumes equal-sized groups while the Tukey HSD-Kramer method allows for small differences in group sizes which was the case for the study (Kramer, 1956). Using the Tukey HSD_Kramer method, HSD = q*SQRT(0.5*MS_{w*}(1/n_a+1/n_b): where MS_w was the mean sum of squares for variations within groups as provided in ANOVA results for any of the survey questions. Also, n_a and n_b were the numbers of data values for any two groups being tested. A difference between the means of counts of any pair of groups that is larger than HSD was considered significantly different and the null hypothesis was rejected in favor of the alternative hypothesis.

The second survey question was - How many times within the last year that you were actively employed as a technology leader did you access scholarly leadership research to inform your leadership decisions? The average number of times leaders comprising the sample accessed scholarly leadership research during the last year of being an active senior technology leader was 2.19. To compare the three senior leader groups, the following null and alternative hypotheses were tested.

Null Hypothesis (H0): The mean number of times the three groups of senior technology leaders accessed scholarly leadership research during the last year they were actively employed as leaders are equal.

Alternative Hypothesis (H1): The mean number of times the three groups of senior technology leaders accessed scholarly leadership research during the last year they were actively employed as leaders are not equal.

The input data and ANOVA results are in Table 1. The averages of counts for each leader group are shown. Since the p-value of 0.605 is greater than the alpha level of 0.10, the null hypothesis cannot be rejected and no further post hoc analysis is required.

Table 1

ANOVA Results for Survey Question 2

Groups	*Count*	*Sum*	*Average*	*Variance*
Senior Managers	21	36	1.714	4.614
Directors	20	47	2.350	8.345
Vice Presidents	22	55	2.500	8.833

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	7.379	2	3.689	0.507	0.605	2.393
Within Groups	436.336	60	7.272			
Total	443.714	62				

The third survey question was - How many times within the last year that you were actively employed as a technology leader did you use scholarly leadership research to support a specific positive outcome for your organization? The average number of times leaders comprising the sample used scholarly leadership research during the last year of being an active senior technology leader was 1.19. To compare the three senior leader groups, the following null and alternative hypotheses were tested.

Null Hypothesis (H0): The mean number of times the three groups of senior technology leaders used scholarly leadership research to support a specific positive outcome for an organization during the last year that each was actively employed as a leader are equal.

Alternative Hypothesis (H1): The mean number of times the three groups of senior technology leaders used scholarly leadership research to support a specific positive outcome for an organization during the last year that each was actively employed as a leader are not equal.

The input data and ANOVA results for this question are in Table 2. The averages of counts for each leader group are shown. Since the p-value of 0.700 is greater than the alpha level of 0.10, the null hypothesis cannot be rejected and no further post hoc analysis is required.

Table 2

ANOVA Results for Survey Question 3

Groups	*Count*	*Sum*	*Average*	*Variance*
Senior Managers	21	19	0.905	2.290
Directors	20	28	1.400	6.042
Vice Presidents	22	28	1.273	3.255

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	2.741	2	1.371	0.359	0.700	2.393
Within Groups	228.973	60	3.816			
Total	231.714	62				

The fourth survey question was - How many times within the last year that you were actively employed as a technology leader did you share scholarly leadership research with others in your organization? The average number of times leaders comprising the sample shared scholarly leadership research during the last year of being an active senior technology leader was 0.968. To compare the three senior leader groups, the following null and alternative hypotheses were tested.

Null Hypothesis (H0): The mean number of times the three groups of senior technology leaders shared scholarly leadership research with others in their organization during the last year that each was actively employed as a leader are equal.

Alternative Hypothesis (H1): The mean number of times the three groups of senior technology leaders shared scholarly leadership research with others in their organization during the last year that each was actively employed as a leader are not equal.

The input data and ANOVA results for this question are in Table 3. The averages of counts for each leader group are shown. Since the p-value of 0.525 is greater than the alpha level of 0.10, the null hypothesis cannot be rejected and no further post hoc analysis is required.

Table 3

ANOVA Results for Survey Question 4

Groups	*Count*	*Sum*	*Average*	*Variance*
Senior Managers	21	15	0.714	1.914
Directors	20	18	0.900	2.726
Vice Presidents	22	28	1.273	3.351

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	3.487	2	1.744	0.652	0.525	2.393
Within Groups	160.449	60	2.674			
Total	163.937	62				

The fifth survey question was - How many times within the last year that you were actively employed as a technology leader did you access non-scholarly leadership materials to inform your leadership decisions? The average number of times leaders comprising the sample accessed non-scholarly leadership materials during the last year of being an active senior technology leader was 7.095. To compare the three senior leader groups, the following null and alternative hypotheses were tested.

Null Hypothesis (H0): The mean number of times all three groups of senior technology leaders accessed non-scholarly leadership materials during the last year they were actively employed as leaders are equal.

Alternative Hypothesis (H1): The mean number of times all three groups of senior technology leaders accessed non-scholarly leadership materials during the last year they were actively employed as leaders are not equal.

The input data and ANOVA results for this question are in Table 4. The averages of counts for each leader group are shown. Since the p-value of 0.031 is less than the alpha level of 0.10, the null hypothesis must be rejected in favor of the alternative hypothesis, and post hoc analysis is required to discern which groups have significantly different means. The Bonferroni post hoc method was applied by performing t-tests on all three pairs of group means and using an adjusted alpha level of 0.033 with a significant difference shown between senior managers and vice presidents also shown in Table 4.

The Tukey HSD post hoc analysis was also performed. For comparing senior managers to directors, HSD = 2.595*SQRT(0.5*30.864*(1/21+1/20)) = 3.185 which is greater than the difference in computed means between these two groups. Therefore, the difference in the means is statistically insignificant. For comparing senior managers to vice presidents, HSD = 2.595*SQRT(0.5*30.864*(1/21+1/22)) = 3.110 which is less than the difference in computed means between these two groups. Therefore, the difference in the means is statistically significant. For comparing directors to vice presidents, HSD = 2.595*SQRT(0.5*30.864*(1/20+1/22)) = 3.15 which is greater than the difference in computed means between these two groups. Therefore, the difference in the means is statistically insignificant. The only pair of groups having a difference in means greater than the corresponding HSD was senior managers and vice presidents which aligns with the Bonferroni post hoc method results.

Table 4

ANOVA and Bonferroni Post Hoc Results for Survey Question 5

Groups	*Count*	*Sum*	*Average*	*Variance*
Senior Managers	21	100	4.762	23.290
Directors	20	141	7.050	25.208
Vice Presidents	22	206	9.364	43.195

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	227.578	2	113.789	3.687	0.031	2.393
Within Groups	1851.850	60	30.864			
Total	2079.429	62				

Bonferroni post-hoc test

Groups	P-value	Significant?
1 versus 2	0.145	No
1 versus 3	0.013	Yes
2 versus 3	0.205	No

Alpha

Test	Alpha
ANOVA	0.1
Post-hoc corrected	0.033

Note. Group 1 = Senior Managers, Group 2 = Directors, Group 3 = Vice Presidents

The sixth survey question was - How many times within the last year that you were actively employed as a technology leader did you use non-scholarly leadership information to support a specific positive outcome for your organization? The average number of times leaders comprising the sample used non-scholarly leadership materials during the last year of being an active senior technology leader was 4.016. To compare the three senior leader groups, the following null and alternative hypotheses were tested.

Null Hypothesis (H0): The mean number of times all three groups of senior technology leaders used non-scholarly leadership materials to support a specific positive outcome for an organization during the last year that each was actively employed as a leader are equal.

Alternative Hypothesis (H1): The mean number of times all three groups of senior technology leaders used non-scholarly leadership materials to support a specific positive outcome for an organization during the last year that each was actively employed as a leader are not equal.

The input data and ANOVA results for this question are in Table 5. The averages of counts for each leader group are shown. Since the p-value of 0.011 is less than the alpha level of 0.10, the null hypothesis must be rejected in favor of the alternative hypothesis, and post hoc analysis is required to discern which groups have significantly different means. The Bonferroni post hoc method was applied by performing t-tests on all three pairs of group means and using an adjusted alpha level of 0.033 with a significant difference shown between senior managers and vice presidents as shown in Table 5.

The Tukey HSD post hoc analysis was also performed. For comparing senior managers to directors, HSD = 2.595*SQRT(0.5*13.796*(1/21+1/20)) = 2.129 which is greater than the difference in computed means between these two groups. Therefore, the difference in the means is considered insignificant. For comparing senior managers to vice presidents, HSD = 2.595*SQRT(0.5*13.796*(1/21+1/22)) = 2.106 which is less than the difference in computed means between these two groups. Therefore, the difference in the means is considered significant. For comparing directors to vice presidents, HSD =

2.595*SQRT(0.5*13.796*(1/20+1/22)) = 2.079 which is less than the difference in computed means of these two groups. Therefore, the difference in the means is considered significant. Using the Tukey HSD-Kramer post hoc method, two pairs of groups have significant differences in their computed means, specifically senior managers and vice presidents as well as directors and vice presidents. This does not align with the Bonferroni result for directors and vice presidents, but the Tukey HSD-Kramer method is considered to yield a more conservative result (Kramer, 1956).

Table 5

ANOVA and Bonferroni Post Hoc Results for Survey Question 6

Groups	*Count*	*Sum*	*Average*	*Variance*
Senior Managers	21	50	2.381	12.548
Directors	20	74	3.700	10.958
Vice Presidents	22	129	5.864	17.552

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	133.241	2	66.620	4.829	0.011	2.393
Within Groups	827.743	60	13.796			
Total	960.984	62				

Bonferroni post-hoc test

Groups	P-value	Significant?
1 versus 2	0.226	No
1 versus 3	0.005	Yes
2 versus 3	0.070	No

Alpha

Test	Alpha
ANOVA	0.1
Post-hoc corrected	0.033

Note. Group 1 = Senior Managers, Group 2 = Directors, Group 3 = Vice Presidents

The seventh survey question was - How many times within the last year that you were actively employed as a technology leader did you share non-scholarly leadership information with others in your organization? The average number of times all leaders comprising the sample shared non-scholarly leadership materials during the last year of being an active senior technology leader was 3.302. To compare the three senior leader groups, the following null and alternative hypotheses were tested.

Null Hypothesis (H0): The mean number of times all three groups of senior technology leaders shared non-scholarly leadership materials with others in their organization during the last year that each was actively employed as a leader are equal.

Alternative Hypothesis (H1): The mean number of times all three groups of senior technology leaders shared non-scholarly leadership materials with others in their organization during the last year that each was actively employed as a leader are not equal.

The input data and ANOVA results for this question are shown in Table 6. The averages of counts for each leader group are shown. Since the p-value of 0.045 is less than the alpha level of 0.10, the null hypothesis must be rejected and post hoc analysis is required to discern which groups have significantly different means. The Bonferroni post hoc method was applied by performing t-tests on all three pairs of group means and using an adjusted alpha level of 0.033 with a significant difference shown between senior managers and vice presidents.

The Tukey HSD post hoc analysis was also performed. For comparing senior managers to directors, HSD = 2.595*SQRT(0.5*11.408*(1/21+1/20)) = 1.936 which is greater than the differences in computed means of these two groups. Therefore, the difference in the means is statistically insignificant. For comparing senior managers to vice presidents, HSD = 2.595*SQRT(0.5*11.408*(1/21+1/22)) = 1.891 which is less than the differences in computed means of these two groups. Therefore, the difference in the means is statistically significant. For comparing directors to vice presidents, HSD =

2.595*SQRT(0.5*11.408*(1/20+1/22)) = 1.915 which is greater than the differences in computed means of these two groups. Therefore, the difference in the means is statistically insignificant. The only pair of groups having a difference in means greater than the corresponding HSD was senior managers and vice presidents which aligns with the Bonferroni post hoc method results.

Table 6

ANOVA and Bonferroni Post Hoc Results for Survey Question 7

Groups	*Count*	*Sum*	*Average*	*Variance*
Senior Managers	21	41	1.952	6.548
Directors	20	66	3.300	9.589
Vice Presidents	22	101	4.591	17.682

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	74.799	2	37.400	3.278	0.045	2.393
Within Groups	684.471	60	11.408			
Total	759.270	62				

Bonferroni post-hoc test

Groups	P-value	Significant?
1 versus 2	0.136	No
1 versus 3	0.018	Yes
2 versus 3	0.262	No

Alpha

Test	Alpha
ANOVA	0.1
Post-hoc corrected	0.033

Note. Group 1 = Senior Managers, Group 2 = Directors, Group 3 = Vice Presidents

Summary of Results

In Table 7 the row labeled Overall Sample includes results from all survey respondents in three groups of senior technology leaders at physical sciences technology companies in the USA. The groups comprised senior managers, directors, and vice presidents. The Overall Sample row answers Research Question 1, showing the average counts of instances of senior technology leaders accessing, using, and sharing scholarly leadership research (SLR) as well as non-scholarly leadership materials (NSLM) during their last year as active senior technology leaders.

Table 7

Average Instances of Accessing, Using and Sharing Leadership Materials

	Scholarly Leadership Research			Non-Scholarly Leadership Materials		
	Accessed	Used	Shared	Accessed	Used	Shared
Overall Sample	2.19	1.19	0.97	7.10	4.01	3.30
Senior Managers	1.71	0.91	0.71	4.76	2.38	1.95
Directors	2.35	1.40	0.90	7.05	3.70	3.30
Vice Presidents	2.50	1.27	1.27	9.36	5.86	4.59

Note. Computed means are from self-reported counts by senior technology leaders during their last year of active technology leadership.

Table 7 also shows the averages for accessing, using, and sharing SLR and NSLM for senior managers, directors, and vice presidents within the overall sample. The averages for the three technology leader groups refine the answer to Research Question 1 to the group level and also inform the answer to Research Question 2. To answer research Question 2, one-way ANOVA was used to detect statistically significant differences in mean values between the three groups of senior technology leaders for each of the six columns shown in Table 7 which correspond to questions two through seven of the survey.

ANOVA results showed that among the three groups of senior leaders, differences in the average counts of instances of accessing, using, and sharing SLR were statistically insignificant at the p=0.1 confidence level. For NSLM, ANOVA showed there were statistically significant differences in the mean counts of instances of accessing, using, and sharing NSLM among the three senior technology leader groups at the p=0.01 confidence level. The Tukey HSD-Kramer post hoc analysis method was used to discern which pairs of groups of senior technology leaders had statistically significant differences in mean counts of instances of accessing, using, and sharing of NSLM. In the case of accessing NSLM, there was a statistically significant difference between senior managers and vice presidents who had the higher access averages. In the case of using NSLM to achieve a specific organizational outcome, there was a statistically significant difference between senior managers and vice presidents as well as between directors and vice presidents who had higher usage averages than either of the other groups. In the case of sharing of NSLM, there was a statistically significant difference between senior managers and vice presidents who had the higher access averages.

In chapter 5, I discuss the results of the study and consider the import of the results regarding the problem statement for the study. The discussion also extends to the implications of the results on the discipline of organizational leadership. Lastly, chapter 5 covers recommendations for actions and additional research.

CHAPTER 5: DISCUSSION AND CONCLUSIONS

Discussion of Results and Conclusions

The results show the surveyed senior technology leaders at physical sciences technology companies in the USA seldom use scholarly leadership research (SLR) to inform their leadership decisions for the benefit of their companies. Whether senior managers, directors, or vice presidents, the surveyed senior technology leaders on-average access, use, and share scholarly leadership research only once or twice per year. Many individual survey respondents indicated zero access, use, or sharing of SLR. There were no statistically significant differences in the averages of these behaviors between the three groups of senior technology leaders. The results show the surveyed senior technology leaders in this study are generally disconnected from SLR.

The results also show the surveyed senior technology leaders at physical sciences technology companies in the USA access and use non-scholarly leadership materials (NSLM) to inform their leadership decisions for the benefit of their companies about four times per year on average. Many individual respondents indicated zero access, use, or sharing of NSLM and there were no statistically significant differences between senior managers and directors in these behaviors. However, among survey respondents, vice presidents access, use, and share NSLM roughly twice as often as senior managers and the results are statistically significant at the $p=0.10$ confidence level. Surveyed vice presidents also use NSLM more than directors to inform their leadership decisions for the benefit of their companies. Among survey respondents, senior technology leaders tend to increase access, use, and sharing of SLR and NSLM with an increasing span of control, though the reason is unclear and, when accessing, using, and sharing leadership information, there also appears to be a preference for NSLM over SLR.

Application of Results and Conclusions to the Problem Statement

The specific problem is that by underutilizing scholarly leadership research (SLR) and non-scholarly leadership materials (NSLM), senior technology leaders at physical sciences technology companies in the USA miss opportunities for better-informed leadership decisions and improved results for their organizations. Underutilization is an imprecise term, implying a known, target level of utilization of SLR or NSLM. This is not currently the case. I reviewed the literature and found few references associating leaders' use of leadership materials and organizational outcomes. With physical sciences and technology as additional qualifiers on the leaders of interest, the literature yielded fewer and insufficient results to assert a target amount of usage for either SLR or NSLM. The results of the study show an average of one or two yearly instances of access, use, and sharing of SLR by the survey respondents with many having zero instances. An extrapolation of the results implies the survey respondents might, on average, access between zero and a few dozen articles on SLR during their technology leadership careers. I searched the City University of Seattle online library with the single search term leadership, filtered by scholarly and peer-reviewed, and 232,952 articles were returned. The ratios of access, use, and sharing of SLR to the available count of articles evidence the term underutilization of SLR is an accurate characterization.

NSLM exhibits the same imprecision as SLR in that a target amount of utilization of access, use, and sharing is unknown. However, unlike SLR, the survey results show that NSLM is accessed, used, and shared annually by the survey respondents roughly 7, 4, and 3 times respectively on average. This means the survey respondents seek leadership information from perhaps books, magazines, or content from leadership development courses to inform their leadership decisions. Whether these measures constitute underutilization is unclear. The survey did not for example differentiate access to a book on leadership when looking up a chart, reading a single chapter, or reading an entire book. No attempt was made in the study to gauge the significance of any access or use of NSLM.

From the problem statement, inspection is required around the idea of missed opportunities when failing to use SLR or NSLM. Although Davenport et al. (1998) showed that the use of managed leadership knowledge correlated with improved organizational results at the project level, tradeoffs between the organizational results and the time necessary to search through knowledge repositories were unaddressed. Time spent by anyone doing anything occurs instead of doing something else. If a senior technology leader spends time contacting peers for advice or meets with team members, perhaps organizational results are enhanced even more than by accessing, using, and sharing SLR or NSLM. A more thorough investigation would consider the access, use, and sharing of SLR and NSLM as one type of antecedent in a continuum of leader activities resulting in various organizational outcomes. Such an approach may reveal how the access, use, and sharing of SLR and NSLM are ranked within the continuum of leader activities for improving organizational outcomes.

Application to Leadership

The aforementioned 232,952 search results on the term leadership, filtered by scholarly and peer-reviewed results, demonstrate significant investments by researchers and institutions worldwide to conduct leadership research. Documentation of results implies a target audience. If the target audience consisted exclusively of a closed group of leadership researchers, the influence of the findings outside of the closed group would be obviated. The value of the research stems from its extensible transfer and application outside of the field of research itself.

The results of the study expose a potential nationwide lack of transfer of scholarly leadership research (SLR) and non-scholarly leadership materials (NSLM) to senior technology leaders in physical sciences technology companies in the USA. This result is consistent with the findings of Pitsis (2017) who found the poor transfer of scholarly research to leader-practitioners but also increasing ties between universities and leader-practitioners with the prospect of improving the transfer of scholarly research to industry. Pitsis noted hesitancies in collaborations between academia and industry due to legal questions about ownership of research materials. The study results show the prospects of increased transfer of SLR to industry have not yet been fulfilled among the surveyed senior technology leaders.

Though the results show senior technology leaders seldom access, use, or share SLR, the reasons are unclear. The degree to which senior technology leaders are aware of the existence and methods of accessing and using SLR is uncertain, though many survey respondents self-reported accessing, using, and sharing SLR. Surveyed senior technology leaders who self-reported zero instances of accessing, using, or sharing SLR may be unaware of leadership research as a field of study. Though this notion may seem unlikely to leadership researchers, the work of technologists and technology leaders implies no intersection with leadership research. Although the literature is lean on SLR about technology leaders and even more lean on senior technology leaders in physical sciences technology companies, it seems likely these senior technology leaders have similar organizational issues to those of non-technology leaders. In the absence of using SLR or NSLM to inform their leadership decisions, senior technology leaders either alternately inform their leadership decisions or their leadership decisions are underinformed with unquantified and unqualified effects on organizational performance and outcomes. The study results show insignificant access, use, or sharing of SLR by the surveyed leaders, positing what other vehicles they use to inform their leadership decisions. Options include, but are not limited to NSLM, soliciting advice from other leaders, collecting stakeholder feedback, acting on instinct, or acting with information from their own experiences.

The value of SLR is its extensible transfer and use outside of the leadership research community. The investment in SLR is evidenced by the aforementioned 232,952 scholarly and peer-reviewed articles about leadership. Failure to transfer SLR represents a poor return on investment in SLR. Either the collective community of leadership researchers and leader-practitioners improve the transfer of SLR or investments in SLR will likely continue to be misappropriated.

Recommendations for Action

Improving the transfer of scholarly leadership research (SLR) to leader-practitioners would inspire continued investments in SLR. Technology program developers at colleges and universities may consider offering enhanced leadership training for students who are interested in a technology leadership career path as opposed to a non-management, individual contributor path. A brief online search shows many undergraduate technology management degrees are offered in the USA. Many are business degrees with a minor focus on technology management. What is unclear is the degree to which graduates from such undergraduate business programs are represented within the ranks of senior technology leaders at physical sciences technology companies in the USA. Online search also reveals many post-graduate technology management degree programs that are advertised as management training for persons already possessing undergraduate technology degrees. This is somewhat the opposite of a business degree with a technology minor. What is not immediately evident from online searching is undergraduate technology degree programs from top-tier colleges or universities that are coupled with management and leadership components. Neither of the prevailing approaches, undergraduate business degrees with technology management minors or undergraduate technology degrees coupled with post-graduate management degrees, appears to be facilitating the transfer of SLR from leadership researchers to leader-practitioners. Either the prevailing education approaches are failing to instruct students and prospective technology leaders about the existence, access, and use of SLR, or the benefits of doing so are insufficiently compelling to those leaders. The latter implies that technology leaders have already attempted to access and use SLR without compelling results such that they cease ongoing access and use. However, the results of the study do not support this idea, because senior managers showed little to no use of SLR within their last year of leadership. This infers the lack of training regarding the existence, access, and use of SLR as a likely culprit in the lack of transferability of SLR to leader-practitioners. Therefore, collegiate training should be enhanced in several areas. Educational institutions should ensure students are aware of the content, availability, and methods of accessing SLR. These programs should also address the differences between SLR and non-scholarly leadership materials (NSLM), the risks of using NSLM, and the risks of making less informed leadership decisions. Training leaders about the risks of making less informed leadership decisions implies that such risks are known or predictable which further implies the need for additional research about such risks.

Similar to enhanced leadership training at educational institutions, employers and human resources leaders in physical sciences technology companies in the USA should consider adding training components to internal leader development programs (LDP) to ensure that developing technology leaders learn about accessing and using SLR as well as NSLM. Teaching technology leaders to discern when to use SLR versus NSLM should be considered. LDP service providers should also consider adding training components to teach developing technology leaders about SLR and NSLM. Doing so may also help expose executives and human resources personnel to knowledge gaps about leadership materials and the potential consequences of the gaps. LDPs may be appropriate vehicles for conveying case studies about the negative consequences of underinformed leadership decisions. Such case studies may support the proposition that SLR and NSLM can be useful tools for senior technology leaders to improve outcomes for their companies.

Lastly, the transfer of SLR to senior technology leader-practitioners at physical sciences technology companies should be considered as part of the research process. The defacto lack of transfer, as evidenced by the study results, demonstrates that conducting research and publishing the results in subscription periodicals that may be arcane to physical sciences senior technology leaders is insufficient to ensure the transfer of the information. Research institutions and researchers must consider how the leader-practitioner community is going to be exposed to the findings using communications likely to compel access to the research information. This consideration should be part of the standard research process.

Recommendations for Further Research

The study findings lead to multiple questions that may inspire further research addressing the problem of senior technology leaders underutilizing scholarly leadership research (SLR) and non-scholarly leadership materials (NSLM). All three surveyed senior technology leadership groups access, use, and share SLR between zero and two times annually on average. Further research is recommended to elucidate the results. One research question is if senior technology leaders at physical sciences technology companies in the USA are aware of leadership research as a field of study and the existence of SLR. Another research question is whether the same leaders know how to locate SLR and the degree to which paywalls constitute a hindrance to access. Further research could be conducted around how the same leaders view allocating their time to researching through both SLR and NSLM. I previously mentioned that the access, use, and sharing of SLR or NSLM may be best studied as one type of antecedent among a continuum of leader activities affecting organizational outcomes.

Although much of the discussion of the findings is focused on the actions of senior technology leaders to access and use SLR and NSLM, additional research seems warranted on what might be considered the transfer of SLR rather than just its receipt. Such research could inspect the effectiveness of different methods of making senior technology leaders aware of the existence of SLR and NSLM and the potential value they may receive from using both. Research could focus on the motivations of leadership researchers to successfully transfer their research findings to leader-practitioners. It is not automatically apparent that all leadership researchers consider transfer to leader-practitioners as a significant part of the research process.

I previously mentioned the possibility that the lack of use of either SLR or NSLM could be partially influenced by detractors instead of lacking awareness of SLR or NSLM. Additional research could be conducted to understand detractors for senior leaders to access and use SLR or NSLM. Detractors may include a lack of awareness or training about leadership materials as presented by Serenko et al. (2011) or deprioritization when triaged against pressures to deliver technology products or services as was found by Wang (2017). Another established detractor is that of paywalls for subscriptions to scholarly leadership research as discussed by Bohannon (2016). Though the open access movement to research materials has gotten some traction, the study results do not indicate success in translating SLR to leader-practitioners, so more research is required on this topic. Stouten et al. (2018) found that leaders have perceptions that leadership materials are overly broad and abstract making them non-applicable or that their leadership skills make leadership materials unnecessary. Research should be conducted to learn if senior technology leaders at physical sciences technology companies in the USA, who may have attempted to access and use SLR or NSLM to inform their leadership decisions, may have subsequently abandoned SLR or NSLM in favor of other methods to inform their leadership decisions.

I previously discussed two general paths of technology management training generally offered by colleges and universities in the USA. The first includes business degree programs with a technology management component added. The second includes post-graduate degrees teaching management and leadership skills to persons with undergraduate degrees or training in technology. It is currently unclear if either of these collegiate technology management paths specifically addresses how to access and use SLR or NSLM or if physical sciences technology leaders are clueful about the pedagogical methods used in SLR. A corollary question is which of these two management or leadership training paths is more successful in teaching senior technology leaders to use SLR or NSLM.

Another research opportunity is whether enhanced access and use of SLR or NSLM can be correlated with improved organizational outcomes. Though the literature review yielded measurable improvement examples such as Davenport et al. (1998) finding improvements in project management outcomes with the use of managed leadership knowledge databases, additional supporting research is needed. The association between the use of leadership materials and project management outcomes is insufficiently narrow to garner the breadth of leadership issues and outcomes that drive organizational success. Specifically, research on the use of SLR and NSLM to improve outcomes in hiring, discipline, training, collaboration, time management, coaching, and work satisfaction are but a few of myriad possible drivers of organizational success, just like project management. My extensive reviews of the literature yielded no examples of such prior research. Herein lies a green field for studies to research how the use of SLR and NSLM contribute to improvements in the many components that collectively characterize leadership.

Green (2017) found extensive use of the Sci-Hub website which contained approximately half of the published scholarly research worldwide. However, the study results indicate insignificant use of SLR, so additional research is warranted into what proportion of Sci-Hub articles relate to SLR and how technology leaders access them.

A key finding of the study was that the use of NSLM increased with leader span of control. This finding leads to several possible research questions. Perhaps there are components of NSLM that help technology leaders ascend to higher levels of technology leadership. Perhaps there is a correlation between the types of personalities that are willing to seek input from NSLM and the ability to ascend into higher leadership. Both of these imply precursor factors, but perhaps learning to access, use and share NSLM is acquired over time and therefore more prevalent among increasingly senior technology leaders. Instead of being a behavior acquired with time in leadership, it may be that technologists with higher spans of control are exposed to distinct leadership development training that encourages greater use of NSLM. All of these questions could be researched to elucidate why technology leaders with higher spans of control use NSLM more frequently.

Concluding Statement

The problem of senior technology leaders at physical sciences technology companies in the USA underutilizing scholarly leadership research and non-scholarly leadership materials to inform their leadership decisions for the benefit of their companies was elaborated on using two research questions. First, how often do such leaders use the leadership materials? Second, how do leaders having different spans of organizational control differ in their use of leadership materials? The research results show that on-average senior technology leaders rarely access, use or share scholarly leadership research to benefit their companies. The research also showed that senior technology leaders infrequently accessed, used, or shared non-scholarly leadership materials, but these behaviors increased significantly with a leader's span of control. The results also showed that many such leaders self-reported as never accessing, using, or sharing either scholarly leadership research or non-scholarly leadership materials. The study was not used to elucidate the reasons for the lack of transfer of leadership materials to senior technology leaders.

The collective literature on the study of leadership demonstrates a substantial investment of time and money spanning higher education institutions worldwide. In the absence of transferring leadership materials to technology leaders at physical sciences technology companies in the USA, the return on investment in leadership materials erodes. The literature presents little scholarly leadership research focused on technology leadership, exposing a bilateral disregard between scholarly leadership researchers and technology leaders. Given the significant contribution of technology companies to the gross domestic product of the USA, this gap in the transfer of leadership research likely hinders potential gains in productivity and commercial results.

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