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Systematic Review Toward A Definition of Technological Leadership

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Abstract: This article has three interconnected objectives. Firstly, it reviews the recent history of technology leadership research to position the definitions used within the current historical context. Secondly, it compiles a list of definitions and summarizes them through content analysis, providing a comprehensive definition of technology leadership. Thirdly, it presents measurements of technology leadership within an organization. By conducting a systematic review, the study compiles definitions and measurements of technology leadership, emphasizing problem-solving, facilitation, human orientation, interpersonal skills, continuous innovation, organizational support, personal attributes, strategic foresight, and ethical practices. The research provides a comprehensive definition and practical tools for assessing technology leadership, serving as a crucial foundation for future research and organizational strategies.

Keyword: Technology Leadership, Systematic Review, Information Technology, Global Technology Development.

INTRODUCTION

The trend of global advancement by integrating Information and Communication Technology (ICT) into every facet of life has become commonplace, enabling modern society to manage and utilize the surplus of information to solve intricate problems. This is aimed at addressing the continuously evolving developments in the information age (Castells, 2010).

As the future unfolds, there will be an increasing necessity for specialized leadership in technology within organizations (Avolio, Kahai, & Dodge, 2001). Technology leadership will be pivotal in navigating the complexities of the digital era and driving organizational success (Yukl & Mahsud, 2010).

Organizations can develop technological leadership through two main pathways. The first approach prioritizes efficiency, with businesses striving to minimize the required resources to provide a predetermined quantity of specific outcomes. This strategy prioritizes the optimization of processes and resources in order to attain the highest level of production and cost-effectiveness. Important ideas in this area include process innovation, which refers to the act of enhancing and perfecting processes in order to increase efficiency and effectiveness (Ettlie and Reza, 1992; Adner and Levinthal, 2002). Lean manufacturing is a significant idea that focuses on reducing waste and continuously improving to attain operational excellence (Shah and Ward, 2003). Furthermore, incremental innovation is of great importance as it concentrates on creating gradual and continuing enhancements to current products, services, or processes in order to increase performance and sustain competitiveness (Ali, 1994; Coccia, 2017).

The second approach focuses on transformational innovation, when firms strive to undertake revolutionary innovations that redefine industries and establish new markets. This pathway necessitates forward-thinking leadership and an environment that cultivates innovation and willingness to take risks. Transformational innovation frequently entails substantial technology progress and fundamental changes in thinking, compelling firms to venture into unexplored domains and capitalize on fresh prospects. Key concepts in this path encompass disruptive innovation, which refers to inventions that disturb established markets and establish new ones (Christensen, 1997), and radical innovation, which entails the creation of completely new products or services that provide unparalleled value (Chandy and Tellis, 2000).

While transformational innovation emphasizes groundbreaking changes and the creation of new markets through visionary leadership and a culture of creativity and risk-taking, it is important to contrast this with another prevalent strategy in organizational innovation. The lean and mean business philosophy, widely supported by abundant literature, focuses on efficiency and continuous improvement within existing frameworks. This philosophy is particularly recommended for established companies (Acs, 1995) and new ventures adopting the lean startup model (Harms and Schwery, 2020; Ries, 2011). Although both transformational innovation and lean methodologies aim to enhance organizational performance, they do so through distinct approaches. Transformational innovation aligns with radical innovation concepts (McDermott and O'Connor, 2002; Leifer, O'Connor, and Rice, 2001), aiming to redefine industries, whereas the lean approach focuses on maximizing outputs from given inputs, often through incremental improvements (Leonard-Barton, 1992; Morgan et al., 2018; Edvardsson and Olsson, 1996). Despite the apparent similarities in their quest for resource allocation efficiency (Charnes et al., 1994), these strategies reflect fundamentally different philosophies that can complement each other in fostering robust technology leadership and driving sustainable organizational growth.

This article has three interconnected objectives. Firstly, it reviews the recent history of technology leadership research to position the definitions used within the current historical context. Secondly, it compiles a list of 10 definitions and summarizes them through content analysis, providing a definition of technology leadership. Thirdly, it presents measurements of technology leadership within an organization. We hope the given definitions will be invaluable as this form of leadership will continue to evolve and occupy an increasingly pivotal position within organizations in the future.

This research employs the systematic review method as proposed by Tranfield et al. (2003), which elucidates specific principles for conducting systematic reviews in management research. Tranfield et al. argue that systematic reviews enhance the quality of the review process by producing systematic, transparent, and reproducible literature reviews. By adhering to these principles, the research aims to ensure a comprehensive and unbiased synthesis of existing studies. Rigorous systematic reviews aid in discerning scientific contributions and providing clear answers to research questions (Becheikh et al., 2006). This method involves a structured approach to searching, selecting, and critically appraising relevant literature, thereby enabling the identification of patterns, gaps, and future research directions within the field of study.

The significance of this study. This study begins by examining the recent history of research on technological leadership. It places current definitions into a historical perspective, emphasizing how the notion has changed and developed over time. Furthermore, by conducting a thorough examination of the material, the study consolidates a compilation of ten definitions, providing a full and polished definition of technical leadership. This synthesis is essential as it combines various viewpoints and thoughts, offering a cohesive conceptual comprehension. Additionally, the research presents metrics for measuring technical leadership in businesses, providing practical instruments for monitoring and improving leadership efficacy in the digital age. By employing the systematic review approach, this research guarantees a thorough, clear, and replicable review procedure, so bolstering the credibility and dependability of its conclusions. The study establishes a strong basis for future research by following these principles. It identifies patterns, gaps, and directions that can inform and steer the continuous advancement of technological leadership. This complete approach not only provides a clear understanding of the notion, but also emphasizes its crucial role in navigating the challenges of the digital age and promoting sustainable organizational growth.

METHOD

This study employs the systematic review approach proposed by Tranfield et al. (2003), which provides specific guidelines for performing systematic reviews in management research. Advocates argue that systematic reviews enhance the quality of the review process by producing literature reviews that are systematic, transparent, and replicable. Rigorous and systematic evaluations aid in identifying scientific advancements that might effectively address research issues (Becheikh et al., 2006). The systematic review process in management comprises three stages: preparation, implementation, and documentation. The study encompassed various phases, with each phase comprising numerous sequential actions. Nevertheless, the procedures were adjusted to conform to the particular demands of this research. This formula has been implemented and validated by other management research, as evidenced (Khan et al.,2020).

The subsequent stage involves the identification of keywords and the development of search strategies. Scientific publications on technical leadership were retrieved by doing a search in the Scopus database. The choice of Scopus was made due to its comprehensive coverage and the accuracy of its search functionalities (Pascucci et al., 2018). Scopus is a comprehensive electronic repository that encompasses over 18,000 articles sourced from more than 5,000 publishers worldwide. The database encompasses 16,500 scholarly articles across many disciplines including scientific, technological, medical, and social sciences (Phillips et al., 2015). A search technique was developed to determine the maximum amount of relevant research from the chosen database. The plan delineated three distinct search criteria: scope, search technique, and search keywords. The research was conducted exclusively from 2012 to 2022. The initial study that met the selection criteria and garnered

the highest number of citations was authored by Binz et al. (2012) and was published in the Journal of Technological Forecasting and Social Change. The papers from the Scopus database were obtained via the University Learning Center. A search was performed using the phrase "Technological Leadership," which yielded a total of 373 articles.

The third step involves the selection and evaluation of primary studies to determine their quality. In accordance with the parameters set forth by Tranfield et al. (2003) and in keeping with past review studies, the selection of articles adhered to all of the specified criteria as indicated below: Articles published in peer-reviewed academic publications, which focus on technological leadership, written in English, and grouped in the subject areas of Business, Management and Accounting, and Social Sciences.

The fourth phase involves ascertaining the research's relevance by examining titles, abstracts, and full-text documents. 32 papers authored in languages other than English were eliminated from this investigation. At this point, pertinent articles were chosen for examination from the initial pool of 338 articles.

The fifth stage is performing a comprehensive assessment of the quality. The objective of quality evaluation is to evaluate the validity of selected research, present a clear justification, and furnish crucial information to readers in order to ascertain whether this review methodology may be applied to their own study (Christofi and Vrontis, 2017). A significant hindrance in the advancement of the systematic review technique is the creation and execution of investigations that are of superior quality (Tranfield et al., 2003). At the same time, in this stage, the writers cited Burhan and Aini (2021) by choosing papers from Scopus indexed journals. The use of Scopus was justified due to its comprehensive coverage of relevant and high-quality publications. The effectiveness and clarity of the quality criteria used were confirmed (Christofi and Vrontis, 2017). The inspection results were compared with the researcher's evaluation. After establishing a consensus based on defined quality requirements, the number of articles dropped to 46. The final phase entails the retrieval of data. After conducting a comprehensive assessment, the selected research provided the necessary data to investigate human errors and biases (Tranfield et al., 2003).

RESULTS AND DISCUSSION

This part summarizes the conclusions of previously examined research by reviewing the responses to the first research question (RQ1). These findings pertain to the progress of academic publications and the concepts of Technological Leadership as determined by prior research. Information was gathered from multiple scientific papers within the subject field, covering a period of ten years. The initial articles in the review were published in 2012. At first, there were just 2 publications concerning Technological Leadership. However, in 2013, the number of publications rose, although there were some variations. The maximum number of articles was recorded in 2019, with a total of 8. Table 1 presents a list of publications that have published articles on the topic of Technological Leadership. The journals are grouped according to their Scopus Index ranking.

Scopus evaluates the quality of articles by categorizing them into four quartiles: Q1, Q2, Q3, and Q4. The cluster denoted as Q1 is the most prominent in terms of journal quality, with 15 articles. It is followed by Q2 with 4 articles, Q3 with 4 articles, and Q4 with 2 articles. The majority of these journals are published in the fields of technology and management, such as Technological Forecasting and Social Change, International Journal of Technology Management, International Journal of Project Management, Business History, Futures, Journal of Evolutionary Economics, International Journal of Applied Business and Economic Research, and Journal of Technology Management and Innovation. The article authored by Binz et al. in 2012 has received the greatest number of citations, with a total of

92. The cumulative number of citations from the 29 publications that were reviewed is 240, as shown in the Scopus database.

Table 1. List Journal Outlet

Scopus Index	Source Name	Total	
Q1	Technological Forecasting and Social Change	2	15
	Sociological Perspectives	1	
	Educational Technology and Society	1	
	International Journal of Project Management	1	
	International Journal of Technology Management	1	
	International Journal of Bank Marketing	1	
	Science and Public Policy	1	
	Business History	1	
	Eurasia Journal of Mathematics, Science and Technology Education	1	
	Futures	1	
	Mineral Economics	1	
	Electronic Journal of e-Learning	1	
	California Management Review	1	
	Journal of Technology Transfer	1	
Q2	Journal of Evolutionary Economics	1	4
	Journal of Further and Higher Education	1	
	Regional Studies	1	
	World Patent Information	1	
Q3	Quality - Access to Success	1	4
	Managerial and Decision Economics	1	
	Transnational Corporations Review	1	
	Journal of Technology Management and Innovation	1	
Q4	International Journal of Applied Business and Economic Research	2	2

Source: Research Result

The investigation into technological leadership originated during the Industrial Revolution in England at the start of the 18th century and persists up until the present time. The utilization of technology to attain competitive advantages in terms of economic and military dominance during the Industrial Revolution in England has attracted considerable scholarly interest (Kranzberg, 1967; Mokyr, 1990). The iron, cotton, and steel industries made significant progress during the 70-year span of the Industrial Revolution. These advancements played a crucial role in driving additional technological changes in adjacent areas and had a widespread impact as early innovations spread throughout British culture. These technological advancements later resulted in modifications to the economic, political, and social environments. During the Industrial Revolution, England had a significant technological advantage over other countries. This was evident at the Great Exhibition in London in 1851, where visitors, including merchants, engineers, technicians, capitalists, and politicians, were amazed by the advanced British industrial technology on display in the impressive Crystal Palace.

England's scientific and economic strength started to catch the interest of significant European nations, particularly Germany and France. Germany commenced industrialization shortly after England and, following its political consolidation in 1870, likewise accomplished economic consolidation. Germany's recently consolidated banking and monetary systems stimulated industrial expansion, which was further bolstered by the rapid development of German railways that commenced in the 1840s and persisted during the

country's period of political and economic integration (Fohlin, 1999). The movement of technology from the UK to Germany and other parts of Continental Europe was essential in the transfer of technological leadership beyond English boundaries, despite England's attempts to limit it (Allen, 2011). However, in the beginning of the 20th century, the United States had taken over as the global leader in technology, surpassing Europe.

The literature on American worldwide technological leadership is extensive, primarily due to the fact that America's technological advantage, although contested in the previous century, has not been completely replaced. The origins of scholarly debates on American leadership can be traced back to Solow (1957), who recognized technological development as the primary driver of American economic success. Denison and Poullier (1967) emphasized improved technology as one of the elements that contributed to the United States' superiority in total factor production during the 25 years after World War II, a decade after Solow's initial contribution. This disparity was seen not just in total but virtually across all sectors. In 1982, Maddison provided evidence suggesting that the productivity and per capita income of the United States had exceeded that of England in the early 1900s. By 1913, the United States had shown that both productivity and per capita income were considerably higher than in England and continued to surpass those in Continental Europe (Maddison, 1987). Significantly, the American advantage in productivity was mostly due to its superiority in technological innovation.

Chandler (1977) and Lazonick (1988) explained how American firms, particularly in the chemical and electronic industries, created top-tier industrial laboratories after World War I. These laboratories were shielded from immediate corporate demands to address production problems, enabling them to focus on innovation. Both studies demonstrated how this transition was made easier by wider alterations in company governance and organization. In a recent study, Nelson (1990) shown that US firms were at the forefront of global technological advancements over the period from the mid-1940s to the late 1970s. He emphasized that sophisticated technology was a crucial factor in the United States' technical dominance after the war.

The second half of the 19th century was a significant period in American history characterized by extensive research and technological advancements in both consumer and producer products. It was a time when the system of interchangeable components was quickly adopted in many manufacturing sectors. The convergence of these advancements, along with the swiftly expanding US domestic mass market and the growth of railway and communication networks, resulted in the rise of major firms in various sectors, including affordable steel, sewing machines, typewriters, matches, and refrigerated meats. These corporations were the first to use mass manufacturing, which involved the use of enormous factories, strict assembly lines, standardized products, and extended production cycles. They had gained a significant technological advantage over their rivals in England and Continental Europe, which allowed them to exert control over worldwide industry and trade.

Hobday (1995) and Lall (1997) have emphasized that Japan's emphasis on innovation and technological progress has propelled it to a position of leadership among East Asian nations after World War II. Although Japan initially gained technological success by simply copying, emulating, and importing foreign technologies, it became clear that these explanations were no longer sufficient as Japanese products and processes started to surpass those of American and European counterparts in numerous industries. Furthermore, Japan's investment in research and development (R&D) in specific industries, measured as a percentage of its net civilian output, exceeded that of the United States in the 1970s. Additionally, Japan's overall civilian R&D expenditure as a percentage of its gross domestic product (GDP) surpassed that of the US in the 1980s. This quantitative analysis demonstrates

that Japan's strong performance can be attributed to its high level of R&D intensity, particularly in rapidly expanding civilian sectors like electronics.

US patent statistics from the 1980s reveal that Japan's leading electronics companies began to dominate US-based IBM and Bell Laboratories, with the top five Japanese firms filing over 30% more patents than IBM and twice as many as Bell. Further, the rapid development and diffusion of technologies in Japan's electronics sector overtook its foreign rivals in terms of technological sophistication.

However, Japan's relative decline in the 1990s highlighted the pitfalls of excessive reliance on a few high-tech industries, marked by fluctuating global demand, rapid technological changes, and fierce competition from newly industrialized countries. Further, the inefficiencies of Japan's financial and labor markets (due to cultural and institutional factors), which once enabled its technological rise, were now hampering its ability to adjust to the rapid shifts of the global technological landscape.

The literature on technical leadership is limited due to its existence in distinct fields of leadership and technology. Technological leadership became important as businesses started incorporating technology into their business operations. This required the presence of persons or leaders who could effectively guide their employees to make the most use of technology for organizational growth. According to Orlikowski (1992), technology has always played a significant role in organizational theory. She emphasizes two main perspectives on technology: (a) as physical objects or tools, and (b) as the methods, skills, and information used in productive tasks. According to Orlikowski (1992), there are three main areas of research on technology in organizations: (a) viewing technology as a final goal or external influence, (b) studying how humans interact with technology, and (c) examining the role of human actors and organizational context in shaping the impact of technology.

Liker et al. (1999) identified four paradigms for explaining technology in companies, including: (a) technological determinism, (b) technology management, (c) political interests, and (d) interpretivism. These paradigms offer a comprehensive perspective on the interaction between technology and organizational structures and processes. Table 1 displays various definitions of technical leadership, each emphasizing different characteristics of these paradigms. The researchers used the cross-case analysis method to compare and distinguish the ten definitions. The continual comparative approach was employed to compare each successive significant statement (such as a definition or elements of a definition) with the preceding one. This was done to ensure that similar clusters were identified and tagged with the same code. After coding all the statements, the codes were categorized according to their commonalities, and a theme was then found and recorded for each category. This methodological approach guarantees a meticulous and organized combination of the several conceptualizations of technological leadership, resulting in a thorough comprehension that connects the fields of leadership and technology.

Table 2 presents various definitions of technology leadership from different researchers, each highlighting distinct elements that contribute to a comprehensive understanding of the concept. Cech et al. (2015) emphasizes technological leadership as the ability to solve problems within technical systems, positioning leaders as proficient problem solvers in complex environments. Dougherty et al. (2013) focus on enabling others to use, manage, and understand technology effectively, thereby enhancing organizational capability. Celep and Tülübaş (2014) highlight a human-oriented approach, stressing ethics, fairness, equality, and awareness in decision-making and technology use. Chang et al. (2008) argue that interpersonal and communication skills are crucial for technology leaders, as these soft skills are essential for effective technology implementation. Nanjundeswaraswamy and Swamy (2014) link technology leadership directly to service success within organizations, suggesting its critical role in ensuring excellence.

Huang and Sharif (2015) define technological leadership as a function of research and development (R&D), scientific publications, innovation, and patents, underscoring the importance of continuous innovation and scholarly contributions. Wittkop et al. (2018) emphasize that successful technology leadership requires organizational support through policies and procedures, highlighting the need for a supportive infrastructure. The International Society for Technology in Education describes technology leaders as visionary, digital learners, perfectionists, systematic, and possessing digital citizenship, encapsulating the personal attributes and ethical considerations necessary for effective leadership. Ergun et al. (2019) focus on the knowledge and vision required to foresee how technology can influence organizational dynamics, emphasizing strategic foresight. Finally, Januszewski and Molenda (2008) define technology leadership as the ethical practice of facilitating learning and improving performance by creating, using, and managing appropriate technological processes and resources, integrating ethical practices with a focus on education and performance enhancement.

Together, these definitions illustrate the diverse dimensions of technology leadership, encompassing problem-solving, facilitation, human orientation, interpersonal skills, service success, continuous innovation, organizational support, personal attributes, strategic foresight, and ethical practices.

Table 2. Definition of Technology Leadership by Previous Research

Author	Definition	Elements of Definition
Cech, 2015	Technological leadership is an ability such as the ability to solve problems that is very valuable in technical systems	• *Problem Solver* • Technical Systems
Dougherty et al., 2013	Technology leadership, enabling others to effectively and successfully use, manage, assess, and understand the designed technology.	• Using Technology • Managing Technology • Understand Technology
Celep & Tülübaş, 2014	Technological leadership, focused on people, means that decisions and practices in the organization are centered on the needs and expectations of the organization's members. Technology leaders are concerned about ethics, fairness and equality in the use of technology and are alert to issues related to the use of technology.	• *Human Oriented* • Ethics • Justice • Equality • Awareness
Chang et al., 2008	Interpersonal and communication skills are much more important for technology leaders than having technology expertise, as they cannot deliver these skills without these skills	• Interpersonal • Communication
Nanjundeswaraswamy & Swamy, 2014	Technology leadership, in line with technology, leadership plays an important role in the success of services in organizations	• Service Success
Huang & Sharif, 2015	Technological leadership is a function of four factors, namely (1) research and development (R&D), (2) Scientific Publications, (3) Innovation, and (4) Patents.	• R&D • Publication • Innovation • Patent
Wittkop et al., 2018	Technology Leadership can be successful if the organization provides support for a variety of services. Such services must be governed by organizational policies and procedures to ensure excellence in service provision	• Policy Support • Procedure Support
ISTE, 2014	Technology Leaders have the characteristics: visionary, digital learner, perfectionist, systematic, digital citizenship.	• Visionary • Digital Learners • Perfectionist • Systematic • *Digital citizenship*
Ergun et al., 2019	Technology Leadership is a leadership skill that requires	• Technology Vision

Author	Definition	Elements of Definition
	knowledge and vision of technology with the ability to see into the future how technology can influence organizational dynamics.	• Envisage
Januszewski & Molenda, 2008	Technology leadership is defined as the study and ethical practice of facilitating learning and improving performance by creating, using, and managing appropriate technological processes and resources.	• Ethical Practices • Learning • Performance Improvement

Source: Research Result

Based on the analysis of definitions shown in Table 2, we propose a general definition of technological leadership as follows:

Technological Leadership is the capability of a leader to ethically, systematically, and equitably use their technological knowledge and vision with the aim of enhancing organizational performance by creating, utilizing, and optimally managing technological resources.

Technological leadership can be measured using 8 items from Xu et al. (2014) employing a Likert scale (1=strongly disagree, 2=disagree, 3=neutral, 4=agree, and 5=strongly agree). The eight measurement items are:

1. The organization consistently creates/launches technology.
2. The organization frequently introduces technological innovations.
3. The organization always is the first to introduce the latest generation of technology.
4. The organization consistently releases innovative technology to the market ahead of others.
5. The organization continually introduces new online services.
6. The organization frequently innovates in offering online services.
7. The organization offers a wide range of online services.
8. The organization consistently provides a diverse array of service options.

CONCLUSION

This study provides a thorough examination of technological leadership, situating its definitions within a historical context and synthesizing various perspectives to present a cohesive understanding of the concept. The systematic review methodology adopted ensures a rigorous, transparent, and reproducible analysis, which enhances the credibility and reliability of the findings. The research highlights the evolution of technological leadership from the Industrial Revolution to the present digital age, emphasizing the role of specialized leadership in navigating the complexities of modern technological advancements

The definitions of technological leadership reviewed in this study reveal its multifaceted nature, encompassing problem-solving, facilitation, human orientation, interpersonal skills, service success, continuous innovation, organizational support, personal attributes, strategic foresight, and ethical practices. By integrating these elements, the study proposes a comprehensive definition of technological leadership, emphasizing the capability of a leader to ethically, systematically, and equitably use their technological knowledge and vision to enhance organizational performance.

The contribution of this research lies in its systematic consolidation of existing definitions and its provision of practical measurement tools for assessing technological leadership within organizations. This comprehensive approach not only clarifies the concept but also underscores its critical role in promoting sustainable organizational growth and

addressing the challenges of the digital era. As technology continues to evolve, the insights from this study will be invaluable for future research and practice, guiding the development of effective technological leadership strategies in various organizational contexts.

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