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A Framework and Research Agenda on Technological Capability in a Dynamic Market: A Bibliometric Review

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ABSTRACT

Technological capability (TC) is crucial for firms operating in uncertain environments characterised by fierce rivalry, quick changes in the market, and technology. It entails utilizing technology to simplify the transformation of inputs into outputs, manage resources, and adapt to environmental changes—all of which support the potential success of businesses. However, there is no well-defined framework for TCs that fit a dynamic market. To address this, a bibliometric analysis and systematic review were used to create a framework for TC in a dynamic market that integrates TC's existing knowledge with new concepts. The framework shows how businesses' strategic orientations can direct them to build strong TCs that are interwoven with other capabilities like innovation capability, marketing capability, dynamic capability, absorptive capability, and so on, to ensure business success. The provision of comprehensive scientific knowledge about TC in the dynamic market is aided by the presentation of integrative findings on the conceptual relationship of TC with its numerous antecedents and consequences. Therefore, it is suggested that future researchers carry out more investigation and provide clarification on how TCs are linked with various organisational capabilities in a changing market environment. The potential of the above factors as moderators, mediators, or control variables should also be empirically tested. Furthermore, for businesses to derive greater benefit from sophisticated technologies, they must establish a solid knowledge base and possess the capacity to assimilate new information.

Keywords: Technological Capability, Dynamic Market, Framework, Research Direction
JEL Classifications: O32, O33, M14

1. INTRODUCTION

An environment with a high degree of uncertainty is one that is characterised by fierce competition, rapid market change, and turbulent technology. However, we still don't fully comprehend how businesses might align various types of skills with changes in their environment (Wilden and Gudergan, 2015). Technological capability (TC) helps market-oriented businesses receive, analyse, and disseminate information and be more responsive to environmental changes (Eng and Okten, 2011). TC is an organization's ability to use technologies to turn inputs into outputs by managing technological resources, recombining components, methods, processes, and techniques to offer products. According to Lin and Lai (2020), TC can be defined as a core resource and distinctive capability that helps businesses build firm value, acquire a competitive edge, and improve organizational performance. It is a "generative" and "transformative" dimension that influences other inputs in the attainment of valued capabilities and directly enables capabilities (Haenssgen and Ariana, 2018). This TC can help companies grow globally since it makes it possible to build strategic alliances, invest in R&D, share resources, transfer technology, and achieve economies of scale (Guerra and Camargo, 2016). Additionally, innovation capabilities are affected by the regular use of sensing, seizing, and reconfiguring capabilities in a

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highly turbulent environment (Uzkurt et al., 2024), which makes them useful for firms to adapt and improve competitive advantage (Zhang and Bang, 2023).

Earlier studies such as Eisend et al. (2016) have looked at different kinds of capabilities related to specific organizational functional areas, such as marketing, technological, and manufacturing capability. Thus, TC has to be integrated with different capabilities such as dynamic capability (DC) (Wilden and Gudergan, 2015), marketing capability (MC) (Ju et al., 2018), absorptive capacity (AC) (Yang et al., 2019; Wilden and Gudergan, 2014), innovation capability (IC) (Wilden and Gudergan, 2015), and collaborative capabilities (Hillebrand and Biemans, 2004). Moreover, the infrastructure, R&D, personnel, skills, and competences that enterprises accumulate through time are often embodied by TCs (Zahra, 2018). Thus, these capabilities support the TC in enhancing the firm's performance. However, it is still unclear how these capabilities are integrated and commonly enhance the firm's performance. Therefore, this paper seeks to present a comprehensive framework for this rapidly evolving field of study and integrate the TC field's existing knowledge with the different concepts.

The topic of TC is capturing the attention of researchers. Unfortunately, the lack of a comprehensive framework stems from the dissimilar conceptual associations offered by researchers. This limitation arises due to the lack of clarity regarding the relationship between different aspects of dynamic TC in organizations (Gheitarani et al., 2022). This gap needs to be clarified further. First, rather than dynamic TC, most earlier studies have concentrated on static TC (Wang et al., 2019). Thus, there is a need for further investigation into the technological underpinnings of DCs (Gheitarani et al., 2022), as limited attention was given to the impact of these capabilities. Despite some existing literature proposing a relationship between TC and other organizational capabilities, there remains a lack of clarity and consistency (e.g., Ju et al., 2018; Yang et al., 2019). Given that TCs alone are insufficient for attaining market success (Wilden and Gudergan, 2015), it is of utmost importance to demonstrate how TC synergizes with other organizational capabilities to ensure business success. Hence, it becomes imperative for firms competing in the dynamic market to consider TC concurrently with other capabilities such as innovation capability, market capability, dynamic capability, and other organizational capabilities.

Secondly, while certain research endeavours focus on examining the various types of capabilities in isolation, others strive to analyse the integration of TC with MC (e.g., Su et al., 2015) and TC with DC (e.g., Wilden and Gudergan, 2015). Additionally, studies have found controversial findings. For example, market turbulence lessens the relationship between technology turbulence and business performance innovation capability (Gyedu et al., 2021). According to Song et al. (2005), little empirical study has been done on how TCs and MCs interact in high-turbulence environments. However, measuring dynamic capabilities (DCs) and their effect on performance is still difficult, and empirical studies are required to learn how to create and coordinate these skills for optimal performance (Farhana et al., 2020).

Thirdly, the existing gaps in our understanding of TCs in dynamic markets are further highlighted by the necessity to investigate R&D activities as a dynamic system focused on variables including network capabilities, product innovation, and process (Garrido et al., 2020). These gaps highlight the need for further research that delves deeper into the underpinnings of TCs to improve performance and competitiveness in modern businesses. Considering these theoretical gaps, this study collectively highlights these integrative factors as areas for further research to develop comprehensive frameworks for TC in dynamic markets. Fourth, there is no consensus on the antecedents and outcomes of TC in the dynamic market, which has led to overlooking some determinants and outcomes. For instance, technology is a good predictor of product innovation, even though high levels of TC may limit the product from achieving innovation (Yu et al., 2014; Guerra and Camargo, 2016). That is, the degree to which innovation capabilities (ICs) are impacted by the frequent use of sensing, seizing, and reconfiguring capabilities in a highly turbulent environment varies (Uzkurt et al., 2024). Additionally, research has shown interest in how TCs can encourage enterprises to internationalize (Teece, 2014).

Fifth, in the earlier investigations, contentious conclusions were presented on the subject matter. For instance, Su et al.,'s (2015) controversial finding that market instability enhances the performance effect of marketing capability but deters that of TC was one of their main points of contention. In the meantime, as technological advancements continue, market volatility limits marketing advancements. To ease this conflict, more research and explanation of how marketing and technology capabilities are integrated to effectively operate an organization are needed. Additionally, when businesses encounter environmental volatility, good marketing and technology capabilities may turn into liabilities (Leonard-Barton, 1992), particularly if capability gaps develop (Day, 2011; Wilden and Gudergan, 2015). On the other hand, while Zhou and Wu (2010) discovered that high levels of TC may prevent the generation of new products, Renko et al. (2009) found that TC is an effective predictor of product innovation (Guerra and Camargo, 2016). These contentious results show that the current theory is unsatisfactory and needs more research. Above all, these contentious theoretical implications provide fresh problems for our understanding. This motivates future researchers to provide a comprehensive framework that subsequent discoveries will empirically support.

In line with the above gaps, the following research questions have been developed:

- What is the evolutionary productivity and trend of TC in dynamic market research?
- What main factors are integrated into the comprehensive framework of TC in a dynamic market?
- What are the critical areas that require future investigations in the discipline of TC in a dynamic market?

By addressing these research questions, this study provides a broad range of contributions to the research fields. First, by carefully studying and bibliometrically analysing literature, it reveals research trend, influential studies, significant terms,

and concepts in the field of TC in the dynamic market. These bibliometric reviews offer a methodical comprehension of the field's evolution, landscape, and development. This illustrates the diverse contributions made by various TCs and aids in understanding the pattern of TC development. In addition, these reviews improve our understanding of TC in dynamic markets and lay the groundwork for further studies in this area.

Second, scientific mapping was used to organize the integrated framework for further refinement and future research direction by highlighting the gaps and areas left unexplored by earlier research. The framework exemplifies how TC is combined with various techniques, such as market dynamics and other organizational competencies, and how they relate to elements like strategic orientations, commercialization, worldwide market expansion, and corporate success. Using the clusters produced by the keyword analysis, the study provides a thorough investigation of the contributions made by numerous TC-related factors. Moreover, the provision of comprehensive scientific knowledge on TC in the dynamic market is aided by the presentation of integrative findings on the conceptual relationship of TC with its numerous antecedents and consequences, which can be tested by future researchers. This framework could also aid company leaders in considering the various elements when making sensible judgments, in addition to its contribution to future studies.

Third, this study suggests new constructs that were generated by integrating TC with associated constructs. Theoretically, studies have demonstrated the integration of TC and DC (Wilden and Gudergan, 2015), TC and MC (Su et al., 2015), and TC and IC (Wilden and Gudergan, 2015). The study thus demonstrates the need for new constructs, such as market-oriented TC (MoTC) and dynamic technological capability (DTC). Additionally, as an integration, it's not been studied previously how the TC and MC are combined under DCs. By highlighting the significance of this integration, this study advances and provides guidance for future research in the area that requires further investigation. Fourth, the study developed a framework that includes the proposed moderator and mediator variables in addition to the antecedents and consequences of TC. This framework proposes the expected roles of various variables. It is also critical to test how exactly TC integrates with specific types of capabilities, such as absorptive and adaptive capabilities, to have a combined impact on company success.

Fifth, in terms of methodology, this study is one of the first to quantitatively examine a significant amount of data on TC in a dynamic market. This aids in bringing up several TC-related concepts. The study also gives future researchers a clue to quantitatively examine the effect of certain strategic orientations on TC, especially considering dynamic markets. Furthermore, the incorporation of TC and theoretically associated structures broaden the corpus of knowledge that already exists, which future investigators will need to verify. This study sought to bibliometrically review the topic of TC in the dynamic market to offer such contributions. The study also aimed to provide a thorough framework that demonstrates future research directions and integrates the body of knowledge currently known in the TC discipline.

The remaining sections are organized as follows: The second section of this study presents the theoretical foundations of the study. The third section is about the methods and tools of the study, while the fourth section presents the results and findings of the study. Finally, the fifth chapter presents the conclusion and future research implications.

2. THEORETICAL FOUNDATIONS

TC typically entails significant resource commitments, a firm's capacity to produce and use technological resources, among other factors (Cordero et al., 2022). The integration of TC with these factors, as well as the antecedents and outcomes of TC in the dynamic market has been reviewed.

2.1. Antecedents of TC in the Dynamic Market

Strategic orientation, strategic alliances, and research and development (R&D) are anticipated to be critical components in shaping and improving TC within businesses. Firstly, dynamic capabilities (DCs) have a moderating effect on the performance of small enterprises, whereas strategic orientations enhance it (Issa, 2022). Adaptive capability is influenced by strategic orientations, with technological orientation having a greater impact when market demand is unclear (Zhou and Li, 2010). Digital capabilities are driven by these orientations, with technology orientation having a greater effect on new product development success than consumer orientation (Issa, 2022). According to earlier studies, the components of strategic orientation are entrepreneurial, technological, and market orientation (Eng and Okten, 2011). Others consider internationalization, innovation, and learning orientations to be strategic orientations (e.g., Knight and Cavusgil, 2004). According to Pan et al. (2021), strategic orientations that focus on technology and customers are essential for improving a company's TCs in fast-paced marketplaces. In the context of internationalization, research has shown interest in how TCs can encourage enterprises to internationalise (Teece, 2014). In this process, business models can support the commercialisation of these technologies (Gebrekidan et al., 2022) during internationalisation. This process of commercialising technology is a non-linear progression that encompasses multiple stages in the conversion of technology from the laboratory to the dynamic marketplace (Chebo and Wubatie, 2021).

Due to the rapid market shift, most businesses are unable to develop new products effectively using only internal resources (Deeds et al., 2000); as a result, these businesses must collaborate with other stakeholders (Hillebrand and Biemans, 2004). Businesses in high-tech and knowledge-based sectors depend on external networks and interactions to enhance their knowledge domains and produce innovations more quickly and effectively (Castro, 2015). According to Mamédio et al. (2019), strategic partnerships offer a versatile platform for acquiring information, sharing expertise, and gaining access to technology skills, ultimately resulting in the growth of relational DCs within businesses. Furthermore, while short-term technology development tasks are not greatly impacted by R&D capacity, it does have a substantial impact on the enhancement of technology development ability (Park and Shin, 2017). The importance of R&D in helping firms navigate

and prosper in quickly evolving and competitive market settings is highlighted by this emphasis on technological innovation and development (Gusberti and Neumann, 2016).

In conclusion, strategic orientation establishes the direction, strategic alliances supply the means and chances for cooperation, and R&D propels innovation and the development of new technologies. When combined, they provide a potent mix that greatly affects an organization's technological capability. According to Jiang et al. (2020), a firm's business network interacts with strategic orientations to shape the growth of DCs, which in turn impact product innovation. Furthermore, it is crucial to match strategic orientation with TCs for effective international expansion, as evidenced by the moderating effects of strategic orientation on the relationship between TCs and internationalisation (Chung and Yoon, 2020). In general, strategic orientations serve as guiding concepts that mould a company's competitive advantages and technology cycles in a dynamic market environment.

2.2. Integration of TC in the Dynamic Market

Innovation performance is enhanced by internal knowledge integration capabilities in cross-functional decision-making and supplier management, particularly in situations where technological uncertainty is significant (Bengtsson et al., 2013). "Generative" and "transformative" technological objects directly enable capacities and influence other inputs in the attainment of desirable capabilities (Haenssgen and Ariana, 2018). In particular, the integration of TC and DC (Wilden and Gudergan, 2015), TC and MC (Su et al., 2015), and TC and IC (Wilden and Gudergan, 2015), has been theoretically explored. In the context of these integrations, TC is anticipated to be associated with various organizational capabilities. One example of this is the synergistic effects between TC and MC, where their integration can enable firms to effectively respond to environmental turbulence (Su et al., 2013). Internalising newly introduced technologies and resources through technological and marketing innovation synergy results in integrated innovation capability and competency (Xu et al., 2012). Another framework proposed by Eng and Okten (2011) aims to examine the role of marketing and innovative capabilities in developing innovative capabilities, leading to the emergence of TICs. Through knowledge acquisition, integration, and creation abilities, TC is integrated with innovative capabilities; technology uncertainty serves as a moderating factor (Zhao, 2020). Furthermore, the roadmap for developing competitive technological advantages can be established by examining the technological underpinnings of dynamic capabilities, such as sensing, seizing, and deformation (Gheitarani et al., 2022).

Furthermore, TC is combined with other capabilities, including alliance-specific capabilities (Zhang et al., 2021) and absorptive capabilities (Ince et al., 2016). R&D can generally be used to integrate technological and marketing capabilities. DCs, on the other hand, support technological change through strategic managerial decision-making, resource reconfiguration, and continuous learning. Examples of these capabilities are ambidexterity, absorptive capacity, and technology management (Konlechner et al., 2018).

2.3. Consequences of TC in the Dynamic Market

Research emphasizes how crucial TCs are to attaining performance and a competitive edge in quickly evolving contexts (e.g., Muazu and Abdulmali, 2021). TCs have an enormous effect on how well a company performs (Machiri et al., 2023). According to Noerlina et al. (2022), TC has a major impact on how well high-tech manufacturing firms function, which improves their ability to compete in the market. TC, however, affects financial performance differently for high-tech and low-tech companies, with high technical intensity having an impact on the former and low technological intensity on the latter (Park et al., 2021). According to Wilden and Gudergan (2015), MCs have a favourable effect on performance in highly competitive contexts, whereas TCs improve performance in environments that are stable and competitive. Nevertheless, testing the combined effects of TCs and MCs on the performance of the firm in a dynamic market is necessary. This is because, in addition to TCs, DC and IC have significant effects on firm performance and competitive advantage (Ferreira et al., 2020). Besides, sophisticated technological knowledge improves value generation when combined with high levels of prior knowledge and absorptive capacities (Winkelbach and Walter, 2015). Similarly, Denrell and Powell (2016) indicate that TC has a beneficial impact on the performance of SMEs when combined with other capabilities like relational and learning capabilities. The integrated effects of TC and other organizational capabilities on the performance and value generation of the firm must also be objectively tested.

Furthermore, TCs combined with ICs improve the process of knowledge production for a sustained competitive advantage (Yu et al., 2017). Additionally, customer value creation, financial performance, cost minimization, and technology use, all of which can serve as competitiveness indicators, are positively impacted by managerial competencies in customer relationships and marketing innovation (Sánchez-Gutiérrez et al., 2019). Moreover, the use of the TC for promoting new product development (NPD) in the dynamic market context must therefore be made clear. However, when businesses encounter environmental volatility, good marketing and technology capabilities may turn into liabilities (Leonard-Barton, 1992), particularly if capability gaps develop (Day, 2011; Wilden and Gudergan, 2015). Thus, there is a need to differentiate and incorporate the antecedents, dimensions, and outcomes of the TC in the dynamic market.

3. METHODOLOGY

3.1. Study Framework and Approaches

Researchers in business and management disciplines continue to rely on superficial and narrative reviews without a systematic analysis of the literature because there are currently few methodological recommendations for how to gather and arrange reviews accessible in the management sciences (Linnenluecke et al., 2019). Many evaluations leave it up to the reader to determine why certain articles, books, or conference papers were included (or excluded) by the authors in place of others (Tranfield et al., 2003). This study typically combines systematic reviews with bibliometric analysis conducted with VOSviewer software to address these concerns. This is because, to synthesize the body

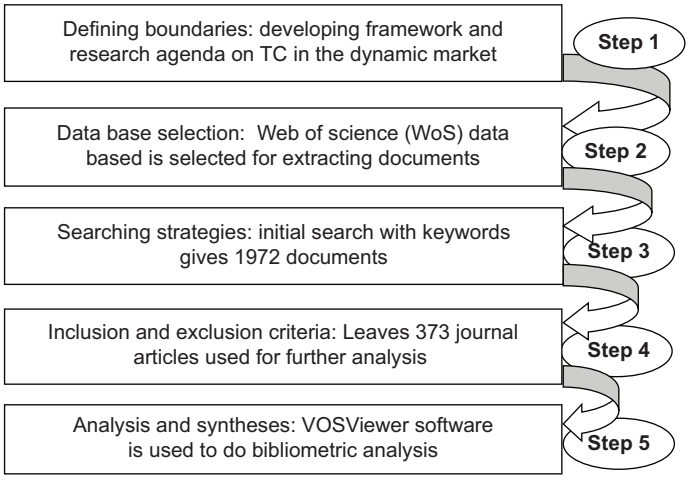
of literature that already exists in an area, systematic literature reviews are becoming a more popular methodology (Kraus et al., 2020); in other words, they utilize a precise technology designed to reduce bias through thorough literature searches (Tranfield et al., 2003). Establishing a context and defining a research problem, seeking theoretical support, separating what has been done from what needs to be done, identifying the main findings, and avoiding fruitless research are other things that systematic literature reviews can help with (Linnenluecke et al., 2019).

There are ethical concerns related to bibliometrics. For instance, rather than concentrating only on precision and accuracy, it is necessary to make sure that the quantitative evaluation of performance using bibliometrics is clear, easy to understand, and transparent. Despite cautions from studies like Post et al. (2020) that many bibliometric studies lack novel theoretical insights, more recent studies like Mukherjee et al. (2022) note that bibliometric studies tend to be more objective and comprehensive in scope than other types of reviews conducted manually (e.g., thematic reviews). Therefore, in addition to a systematic review, business, economics, and social sciences are paying attention to bibliometric analysis, which is utilized for exploring and interpreting huge volumes of scientific data (Donthu et al., 2021). Given this significance, bibliometric analysis was chosen for this study to analyse vast amounts of unstructured data in rigorous ways and draw on the body of scientific knowledge on the TC of the dynamic market. Moreover, we have adopted the stages suggested by Linnenluecke et al. (2019), which include developing research setup, inclusion and exclusion criteria, data cleaning, and data analysis and synthesis, given the relevance of systematic review and bibliometric review as shown in Figure 1. The study used both qualitative (thematic and content analysis) and quantitative (e.g., publication year, top publishing journals, total citations, and disciplines) techniques to analyse the data.

3.2. Databases and Search Strategies

Web of Science (WoS) and Scopus are two of the most popular databases. As the oldest, most popular, and most reliable database of research papers and citations, WoS is significant when compared (Birkle et al., 2020). According to Stuart and Petersen (2022), WoS is regarded as a more dependable and comprehensive resource for bibliometric analyses for these reasons. Thus, to acquire pertinent and trustworthy data for this, we used a typical search approach in the Web of Science (WoS) database. An exploratory search was conducted to assess the topic's applicability and relevance, which was then used to create research questions.

Figure 1: Bibliometric study framework and process (adopted from Hailu and Chebo, 2024)



The search was conducted taking into account the research issues raised on TC in dynamic markets. The terms used were related to technological capability and dynamic markets. Therefore, the terms used were "technolog* capa*" and "dynamic market." In the first search, a total of 1972 articles were retrieved.

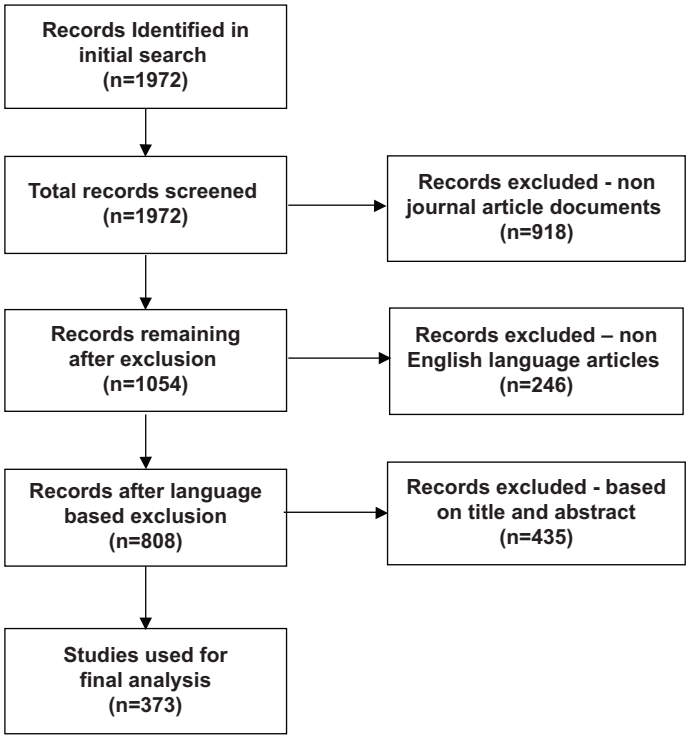
3.3. Inclusion and Exclusion Criteria

After the initial search, articles deemed pertinent to addressing the study topics were chosen using the inclusion and exclusion criteria. Accordingly, the standards pertain to the type of document (i.e., only journal articles) and the language (i.e., English). The inclusion and exclusion criteria were as follows:

- Inclusion criteria: there are no limitations in terms of publication year, country, or academic discipline
- Exclusion criteria: non-journal article documents, articles written in other languages other than English, and articles not related to the specific study (title and abstract-based exclusion).

In terms of the study's exclusion criteria, technical reports, books, editorial letters, and conference papers were excluded. The data included was taken from the title field, keywords, and title and abstract fields using the search phrases. Figure 2 shows that, after all documents other than journal articles were eliminated, 1054 journal articles remained. Next, articles written in a language other than English were excluded to reduce misinterpretation,

Figure 2: Exclusion and inclusion criteria



leaving 808 journal articles. Finally, 435 articles were removed by reading the title and abstract to eliminate unrelated studies. After exclusion, the remaining 373 articles were exported to RIF and CSV formats for further analysis.

3.4. Analysis and Synthesis

Analyses were conducted using both quantitative and qualitative methods. The quantitative analysis considers descriptive factors like the year of publication, the top publishing journals, the field of study, and scientific mapping factors like co-authorship and co-word analysis. Co-authorship and co-word analysis are utilized to visualize research on the topic or defined themes using the VOSviewer software. The researcher can utilize this analysis to pinpoint theories, concepts, and methods that can be used in areas of interest to the researcher (Linnenluecke et al., 2019). Further, the qualitative analysis is content and thematic-based analysis, which has been qualitatively elaborated from the clusters established using the co-word analysis.

4. FINDINGS AND DISCUSSION

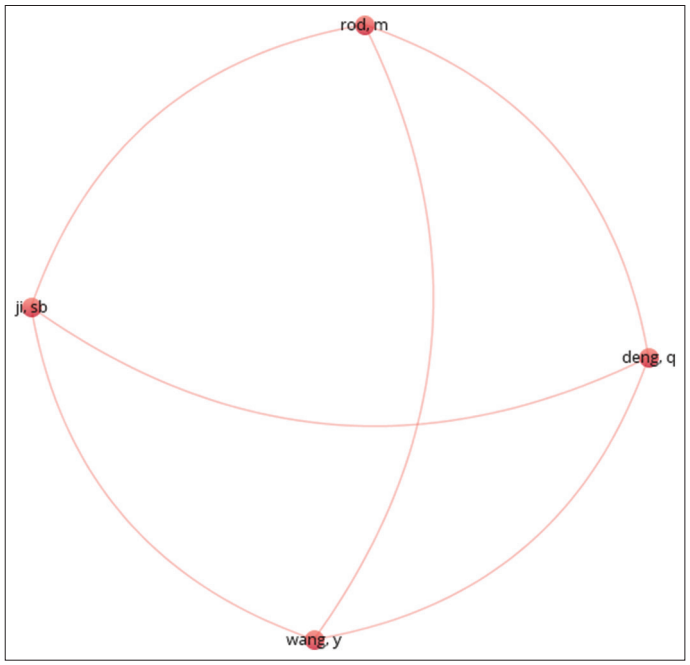
This section provides the results of analysis, which includes both performance analysis and scientific mapping.

4.1. Co-authorship Analysis

A co-authorship analysis was undertaken to study the interactions among scholars in the field of study since collaborations among scholars can lead to improvements in research and contributions from different scholars can contribute to greater clarity and richer insights (Tahamtan et al., 2016). Figure 3 shows the results of co-authorships with author analysis.

The visualized bibliometric network shows the four interconnected authors based on the co-authorships from the initial dataset of 280 authors by selecting two as the minimum number of documents for an author, which leads to 33 meeting the thresholds. These 33 authors were selected for topics addressed and can be reduced to a set of four authors in a cluster (Figure 4). In this particular analysis, fourteen authors are identified as co-authors of two or more articles. Among the 33 authors, Rod M, Ji SB, Wang Y, and Deng Q are the most networked authors, with six total link strengths. All four authors collaborated with each other. These researchers are the most frequent co-authors in the field of technological capability in the dynamic market, having published two articles each. However, only one major group with three coauthors is identified, which indicates the lack of author groups who are contributing to the specific topic of TC focusing on the dynamic market.

Figure 3: Title and abstract based analysis



4.2. Thematic Analysis using Keyword Analysis; Title and Abstract Based Analysis

Thematic analysis is undertaken using key word analysis through title and abstract-based analysis.

Using a minimum number of 10 occurrences of keywords, of the 6,922 keywords, 238 meet the thresholds. For each of the 238 terms, a relevance score was calculated. The default choice of selecting 60% of the most relevant terms is considered, and 143 terms have been selected. By setting the minimum cluster size to 10, five clusters have emerged (Figure 3).

The thematic analysis from the title and the abstract-based analysis show five clusters. The first cluster (red) represents TC and related concepts such as marketing capability, innovation capability, new product development, and performance. The second cluster (green) indicates terms such as change, systems, and opportunity as frequently appearing topics linked to TC. The cluster further indicates the establishment of TC-related systems for exploiting opportunities from the changing market environment in different countries and sectors. The third cluster (blue) represents terms such as experience, information, partners, and alliances. This cluster indicates the necessity of linking TC with learning by allying with partners and exploring information. The fourth cluster (yellow) contains a theme about dynamic capability. It also contains related concepts such as SMEs, business models, and market orientation. Finally, the fifth cluster (purple), knowledge, is related to concepts such as integration, NPD, and competency linked with TC. In general, TC is directly connected with DC, knowledge, and changes, but a weak linkage is established with learning and alliance.

The co-word analysis assumes that words that frequently appear together have a thematic relationship with one another and is further used to predict forthcoming trajectories since the co-word analysis provides a preview of the future of the research field (Donthu et al., 2021). The co-word analysis is used to illustrate the association between keywords in the sample of articles. Figure 5 illustrates the main overlay visualization of occurrences of terms by the keyword, showing the co-occurrences of words in the field of technological capability in the dynamic market.

Using a minimum number of 5 occurrences of keywords, of the 183 keywords, 25 meet the thresholds, and the 25 numbers of terms obtained in the topics addressed can be reduced to a set of four

Figure 4: Network of co-authorship with author's analysis

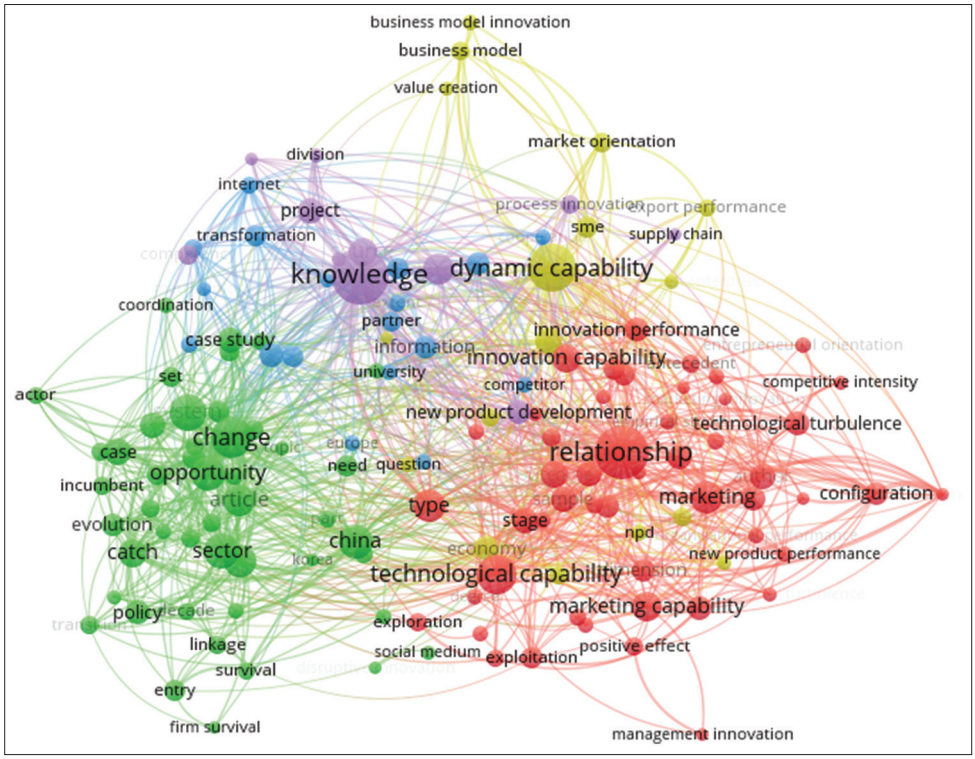
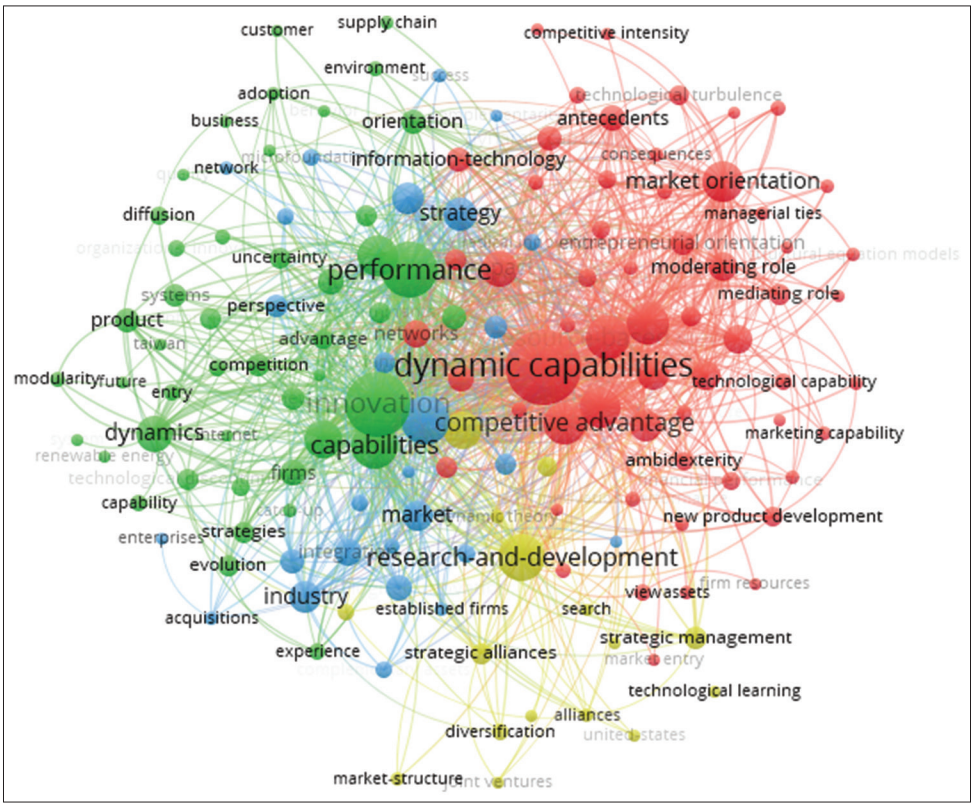


Figure 5: A co-occurrence network of the most frequently used keywords (full counting analysis).



clusters with 25 items. The most widely studied topics related to the technological capability in the dynamic market under each cluster are presented in Figure 5. The first cluster (red) represented by DC contains various themes such as performance, absorptive capacity, RBV, TC, and competitive advantage. The second cluster (green) is about innovation, which contains terms such as performance and growth, capabilities, management, technology, and dynamics. The third cluster (blue) is about knowledge and contains related concepts, including strategy, product development, industry, market, and innovation. The fourth cluster (red) is about R&D,

which also contains firm/organization, strategic management, alliances, market structure, and international expansion.

Based on the themes established above, the following discussions were made:

4.2.1. Strategic orientations for integrating technological capability with other capabilities towards firm performance

Eng and Okten (2011) investigate TC as it is essential to a corporation's innovation strategy and sources of competitive advantage by adopting a capability viewpoint of the resource-based theory of the firm. Existing research indicates that greater performance may result from resource uniqueness, resource reconfiguration and integration, or the ability to react properly to the environment (Song et al., 2005). Franco (2009) stated that the relative benefits of TC will be greater for market pioneers than for responders, meaning that technological "smarts" are more important to market pioneers than to responders. Market pioneering advantages are likely to be more strongly dependent upon the magnitude of the firm's technological capabilities (Franco, 2009).

4.2.1.1. Strategic orientations towards technological capability

The strategic orientations serve as the foundation for the advancement of technological capabilities. Numerous orientations have been extensively researched in the literature as moderators between resources and business performance or as antecedents of capabilities (Byoungho Jin, 2017). Additionally, by examining what businesses do when presented with several possibilities throughout time, we may analyse the effects of businesses' strategic capabilities to anticipate or adapt to changes in technology and the market (Franco, 2009). This strategic focus aids in the creation of TCs that adapt to the turbulent and dynamic environment. This is because quick access to markets and consumers is made easier by strong TCs (Zahra, 2018). As a result, the firm's strategic orientation in terms of technological orientation, market orientation, and entrepreneurial orientation aids in the development of TC that considers market dynamics that are influenced by entrepreneurial activities.

Along with entrepreneurship orientation and technology orientation, market orientation has been considered by researchers as a component of strategic orientation (Eng and Okten, 2011). Additionally, a variety of firm orientations, such as an entrepreneurial orientation (e.g., Rialp et al., 2005), an internationalisation orientation (e.g., Teece, 2014), an innovation orientation (e.g., Knight and Cavusgil, 2004), or a learning orientation (e.g., Rhee et al., 2010), are crucial to improving performance and matching resources with the changing environment (Byoungho Jin, 2017). These strategic focuses are crucial for the advancement of TC, which boosts business performance. For instance, a focus on entrepreneurship aids in allocating technological and other resources for the advancement of TC. By developing TCs, which boost a company's performance, this aspect of strategic orientation helps generate value for the consumer. The TC's ability to provide new values for the newly established market is also a requirement for those engaged in strategically altering their activities. This strategic viewpoint encourages the development of TC that mirrors the learning processes used to experiment with new technologies (Eng and Okten, 2011). In summary, the strategic orientations are thereby helping to develop TCs that improve business performance.

4.2.1.2. Integrating technological capabilities with other organizational capabilities

Even if TC significantly contributes to a company's success, it cannot account for all of it. Technological capability requires support from other capabilities to have a significant impact, including dynamic capability (e.g., Wilden and Gudergan, 2015), marketing capability (e.g., Su et al., 2015; Lisjak and Buhovac, 2008), absorptive capacity (e.g., Yang et al., 2019; Wilden and Gudergan, 2015), and innovation capability (e.g., Jackson, 2017). These elements are crucial since mere ownership of cutting-edge technology cannot be considered a competency alone. Therefore, there is a need to integrate TC with other organizational capabilities to make more contributions towards the enhancement of the firm's performance.

According to Gheitarani et al. (2022), absorptive capacity is further demonstrated as a dynamic capability by the notion that TC is specifically thought of as an ongoing process of developing or absorbing technology. The integration of this absorptive capability with TC enables better performance and helps businesses adapt to changing market conditions. For instance, by utilizing outside expertise, TC might raise the worth of the business (Gheitarani et al., 2022). The integration aims to take advantage of market opportunities in light of better performance. In other words, collaboration with foreign rivals to acquire access to cutting-edge technology and marketing systems is encouraged to hasten technical catch-up (Jackson, 2017). According to Wilden and Gudergan (2014), environmental turbulence may result in a capability gap between a company's current configuration of its MCs and TCs and its value-maximizing configuration in a new environment. This necessitates the fusion of technological and marketing capabilities. But increasing profits in a dynamic market is not an easy task; as it necessitates taking into account market knowledge, utilizing technology, being innovative through learning and R&D, and networking. It is necessary to reconfigure the assets in the form of capabilities to present a comprehensive picture of organizational capabilities. These capabilities might be dynamic capabilities, market capabilities, innovation capabilities, and so on. Then, there is a necessity to integrate these capabilities to provide meaningful organizational capabilities, which are helpful in converting inputs into outputs and exploiting opportunities in the dynamic market.

4.2.1.3. The role of dynamic capability in integrating technological capability and marketing capability

DC is crucial for fusing technology and marketing capabilities to provide competencies that boost a firm's competitiveness and growth. Because consumers' expectations are not reached by either the technology or the marketing aspects alone, more value is generated when technological and marketing capabilities are linked. The way DCs contribute to updating marketing and technological capabilities appears to depend on the level of competitive intensity and the combination of DC dimensions, even though configurations of DC dimensions affect marketing

and technological capabilities (Cordero et al., 2022). Since technological and marketing capabilities operate in an integrated manner in a highly uncertain environment characterised by intense competition, technological turbulence, and quick changes in the market, it is crucial to understand how they can be successfully leveraged (Su et al., 2015). Thus, DC is crucial in the integration of marketing and technology capabilities because marketing capabilities aid in the selection of key technological assets through environmental scanning. Additionally, combining technological and marketing skills through dynamic capability helps businesses, especially when it comes to adapting to a volatile and dynamic market environment. This is so that internal resources and external competencies can be built and rearranged to better suit the needs of a market that is constantly changing in a fast-paced environment. To address these changes in the dynamic market environment and produce better value by utilizing cutting-edge technologies, market capabilities are crucial.

TCs aid in the growth of a firm's use of scientific knowledge and cutting-edge technologies in the creation and provision of new values to customers. However, this will be accomplished by adopting and utilizing marketing capabilities to satisfy the demands of stakeholders in the competitive market. In this situation, DC is crucial to adapting the current technology and marketing capabilities to changing market conditions through the application of innovative technologies. To get a competitive edge in the dynamic market, businesses must develop dynamic capabilities to align technology innovation with market realities. However, the value of technology and marketing capabilities changes in proportion to environmental turbulence, necessitating the identification of the optimal match between technological and marketing capabilities and the specific environmental turbulence conditions (Su et al., 2015). Because not all integrations are equally effective, the outcome may vary depending on the sort of market, the size of the organization, and its character. Clarifying the nature of alignment in various organizational structures as well as in the context of shifting external factors is therefore necessary.

According to Su et al. (2015), marketing and technology capabilities complement one another and have positive implications for a company's performance. Their impact on business performance extends beyond just technological or marketing factors and can have an impact on several organizational outcomes, including fostering future values, raising customer happiness, enhancing the success rates of new products, etc., (Lisjak and Buhovac, 2008). These improvements in customer satisfaction and product success rate are not successful without the help of DCs that merge TC and marketing capability, which supports strengthening its contribution to the firm's success in various ways. In particular, DC demonstrates how the fusion of technological and marketing capabilities aids in the creation of new products that contribute to revenue generation and performance improvement by responding to the uncertain market.

4.2.2. The dynamics of technological innovation capabilities (TIC) management towards firms' growth

The ability to create and use current resources (such as technologies) and capabilities that support innovation initiatives is referred to as having an innovative capability (Eng and Okten, 2011). Businesses should rely on technology-related innovation to preserve a sustainable competitive edge and produce new value (Yang et al., 2019). Industries working on technical advances will offer cutting-edge solutions by routinely monitoring the environment and meeting the shifting wants of their clients. To accomplish this, businesses must equip themselves with the latest technical advancements and industry trends. In today's business climate, the firm's capacity to consistently produce innovations is one of its most crucial capabilities due to the combination of TC with market change (Ellonen and Wikstro, 2009). To improve TIC, creativity must be combined with technological advancements while taking the market's volatility into account.

Current empirical research in this field has generally used a set of TC as a stand-in for an existing body of previous knowledge and has further fostered innovation. Additionally, researchers contend that superior TCs are linked to a better rate of return on innovation (Yang et al., 2019). This suggests that knowledge and R&D capabilities might further contribute to the improvement of a firm's performance and competitive advantage. Thus, it is essential to clarify the process for developing and utilizing technological innovation capabilities in the case of limited resources through collaborations with stakeholders. Because TIC is reflected as an element of IC, which requires further clarification (Dhliwayo and Chebo, 2024). Besides, Narasimhan et al. (2016) emphasized that a firm's R&D competence may be thought of as its ability to transform R&D expenditure (a resource) into innovations. The firm's marketing capability may also be defined as the efficiency with which it translates marketing expenditure (a resource) into measures like sales or customer satisfaction.

4.2.3. Strategies for commercializing technological innovations through market and industry knowledge

Because of the rapid improvements in technology and the current state of the market, businesses are under more pressure than ever to innovate. However, there is potential to commercialize technology in these competitive markets. To foster innovation through the creation of new products, TCs must be combined with other capabilities, such as a blend of R&D capabilities (value creation) and technology commercialisation (value appropriation) (Franco, 2009). To adapt to the changing market environment, the R&D capabilities in this case combine complementary knowledge with technology resources. Besides, the stage of the NPD process where the interaction between technology-related capabilities and marketing-related capabilities is most likely to occur is new product commercialisation (Song et al., 2005). Then, businesses must collaborate with partners to enhance their NPD (Hillebrand and Biemans, 2004). That is, the commercialisation strategies must consider both the integration of internal resource configuration (such as NPD) and external networking with stakeholders. Because rival companies that collaborate on R&D often work on similar projects, the knowledge base of those companies is more relevant. Additionally, co-opetition between competitors can help partners increase their knowledge, skills, and capacity for absorption (Wu, 2014). That is, for the creation of a new product and its commercialisation, technological and market knowledge are essential. Further, the combination of technological knowledge and

innovation produces powerful technological innovation capability, which improves the commercialisation of firms' products.

The knowledge-based view (KBV), a further evolution of the RBV, addresses a synthesis of the value of intellectual capital and encourages a systematic strategy to fully utilise the organisational knowledge base (Ju et al., 2018). The information and know-how components of knowledge must be accumulated to acquire expertise and the dynamic capabilities required to adapt to changing circumstances, according to the OC framework by Shoham (2011). A firm is expected to develop industry expertise in addition to market information. Here, the creation of a new product and its commercialisation depend heavily on industry expertise.

In conclusion, technological know-how is developed through technological innovation supported by R&D and NPD. Moreover, the commercialisation of technologically innovated products would strengthen the developed technological know-how when backed by industry and market knowledge.

4.2.4. The role of strategic management in international market expansion

To enter international markets, it is crucial from a strategic perspective to build clear internal procedures, choose technology and product specifications, form new strategic partnerships, and implement best practices (Teece, 2007). Thus, businesses have organised their internal resources to expand into international markets. To develop dynamic learning and adapt to local technologies, supply networks, users and local research institutes must be established to adapt to local technologies (Gheitarani et al., 2022). Therefore, creating partnerships with rival businesses and other stakeholders is crucial to addressing these challenges. These alliances facilitate resource pooling, technology transfer, cooperative R&D, and operational procedures. Strong TCs are essential for the success of this alliance since they enable businesses to form alliances with other businesses, which makes international expansion simpler and less expensive. Additionally, these qualities are crucial for adapting to shifting customer needs.

Enhancing market capability is essential for creating new products that will satisfy the shifting needs of international consumers. Above all, strategies that incorporate market orientations, internal resource configuration, and building partnerships, while considering the global market are beneficial in obtaining values from TCs. Furthermore, multinational businesses depend heavily on TC for driving NPD due to their technological advantages. Uncertainties in international markets can affect target market selection, posing risks (Ju et al., 2018). Therefore, entering and serving these foreign markets necessitates developing new products tailored to these markets. In this context, TC becomes more critical as businesses with strong TCs tend to internationalise more rapidly (Zahra, 2018). Additionally, it is crucial to evaluate how foreign enterprises rely on marketing skills to nurture NPD in addition to TC (Ju et al., 2018). Thus, the enterprises can expand globally by integrating internal and external elements in developing a strong TC. To enhance international market expansion, this strategic integration requires R&D involvement and external stakeholder networking.

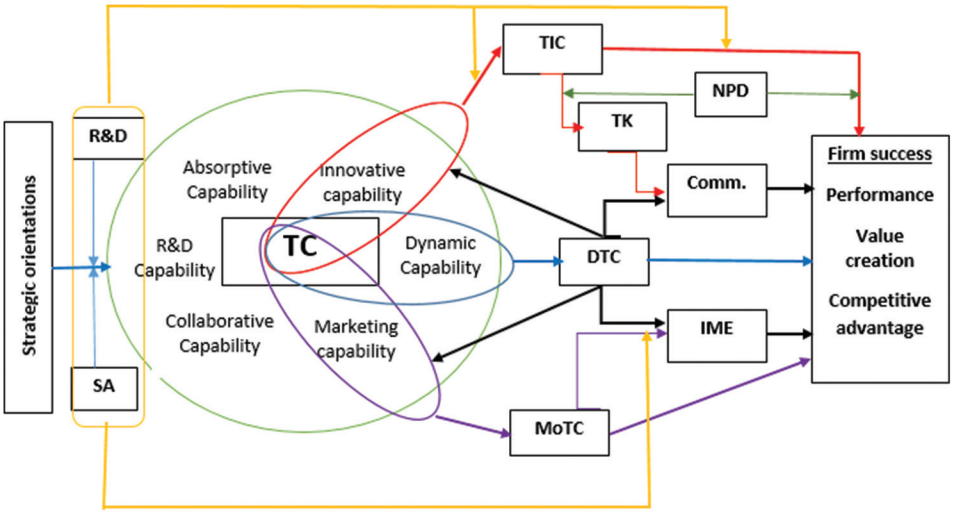
4.2.5. A comprehensive framework

Recent research in strategy has revealed that a firm's performance is a result of interdependent capabilities, highlighting the importance of considering portfolios of resources that are complimentary in nature and enable value generation and appropriation (Franco, 2009). This implies that the performance of a company is influenced by the interaction and combination of several capabilities rather than just the abilities of individuals. This underlines how important it is to consider a portfolio of resources that cooperate to produce value and give an advantage over competitors. From this perspective, a company's strategic orientations, such as its entrepreneurial, market, and technological orientations are crucial for effectively integrating its existing resources with emerging technology in a volatile market. In such markets a company's integration of new technology with its current resources is essential. In other words, a business can create value for its clients and outperform its competitors when it efficiently aligns and configures its resources. This ultimately results in enhanced productivity and prosperity for the organization. To optimize the effect and value of resources across the organization, strategic decisions regarding their allocation must be made.

Studies in this area demonstrate a direct link between the success of a firm's TC and its constituent parts. For instance, TC has been found to impact on the performance of businesses (Shoham, 2011) because it can enable product customization and enable quick responses to shifting market demands (Zahra, 2018). Studies have demonstrated that a company's total capital and each of its constituent parts directly affect its performance. For instance, TC can facilitate quick answers to shifting market demands and product customisation, both of which are critical components of a successful firm. This can be achieved by developing TIC and understanding of industry, market, and current technology. Thus, organizations can obtain a competitive advantage and improve the commercialisation of novel products by creating TIC and broadening their knowledge bases. Winkelbach and Walter (2015) found that a combination of prior knowledge and absorptive capabilities enhances the impact of complex technological knowledge on value creation. This suggests that businesses may extract greater value from sophisticated technological information if they have a solid knowledge base and are able to learn new things. Therefore, developing knowledge in NPD and R&D is crucial for creating value for clients as it allows the company to leverage R&D knowledge in producing easily marketable new products.

The resource-based theory emphasises on a firm's collection of resources and capabilities as sources of developing sustainable competitive advantage (Eng and Okten, 2011; Day, 2011; Ju et al., 2018). According to this idea, the arrangement of technology resources becomes more important when networks are constructed outside, and resources are strategically organized internally. R&D, new product development (NPD), strategic networking, and alliances are critical components that are emphasised in the pursuit of global expansion. In other words, the resource and capability viewpoints emphasise that businesses require a variety of capabilities as they pursue global expansion. This is expected given, a firm's better familiarity with its local market

Figure 6: A comprehensive framework of TC inputs, integrated processes, and outcomes



Key: SA: Strategic alliances, TIC: Technological innovation capability, TK: Technological knowledge, NPD: New product development, DTC: Dynamic technological capability, IME: International market expansion, MoTC: Market oriented technological capability, Comm.: Commercialization

before expansion. As a result, it's important to coordinate the organisation's technology resources and capabilities with its other resources and capabilities. Cordero et al. (2022) further added that new resource allocations may lead to reconfiguration of the company's resource base to address new technological opportunities effectively.

Researchers also noted that the most important factor in sustaining competitive advantage is capacity, or the acquired skills, that allow businesses to coordinate their efforts and allocate resources (Day, 2011; Ju et al., 2018). Nevertheless, while planning the use of technologies and other resources, it is important to take the shifting market conditions into account. Strong obstacles to imitation arise from the embeddedness of business capabilities, firms can preserve their competitive advantage over time (Day, 2011). The ingrained nature of business capabilities are significant barriers to imitation, which enables organizations to maintain their competitive edge over time. This suggests that the characteristics of the VRIN (valuable, rare, unique, and non-substitutable), are crucial in understanding how competitive advantage endures. However, it's insufficient to provide theoretical foundations for a realistic analysis of the success factors of contemporary firms operating in turbulent, uncertain global markets (Sandstr and Virkkunen, 2002). However, integrating technologically integrated capabilities with other capabilities can enhance business operations (e.g., Pisano, 1994). This highlights the importance of integrating TCs with other organizational capabilities for successful international market expansion. To sustain competitive advantage, the framework emphasises the need to coordinating and integrating technological resources with other organisational resources and capabilities. It also highlights the significance of taking market conditions and VRIN qualities into account.

According to the body of research, variations in organizations' DCs account for most variations in innovative performance (Ellonen and Wikstro, 2009). DCs are required inputs when configuring TC with additional capabilities and resources. This suggests that changes in an organization's DCs account for most of the variances in firm performance. Organisations need these capabilities in order to adapt and prosper in changing marketplaces. Therefore, DTC must be established from the TC and DC integration, which improves performance even further. To adapt to the volatile and dynamic market environment, DC is essential in integrating the TC with MCs. This is crucial for meeting a more dangerous, ambiguous, and dynamic worldwide market demand. Because organizations with stronger TCs will have higher degrees of internationalisation, TC is therefore more crucial (Zahra, 2018).

The framework in Figure 6 also emphasizes in the importance of integrating TC with IC. This integration is crucial for the marketing of new products created through R&D and strategic partnerships with other resources. Successful product launches can be achieved by fusing TC and IC into the market. Similarly, TC must be integrated with MCs, to adjust to the dynamic market environment. This integration enables organizations to satisfy the needs of a volatile, confusing, and global market. Strong TCs are crucial for more internationally oriented firms. Overall, the TIC, market-oriented TC, and DTC are crucial in boosting the commercialisation of innovative technology and broadening the global market to respond to the dynamically changing market demand. This achievement further makes organisations successful in terms of value creation, improved firm performance, and enhanced competitive advantage.

5. CONCLUSIONS AND FUTURE RESEARCH IMPLICATIONS

This study aimed to develop a comprehensive framework for the subject of TC in the dynamic market. It also aimed to provide research directions for further studies. The study concludes that there has been a notable recent increase in the number of publications and citations, suggesting a recent phenomenon and

greater scholarly attention that will guide future research in this emerging field. The paper presents a comprehensive framework for understanding the integration of TC with other capabilities including DC, MC, AC, IC It emphasizes the importance of antecedents for improving TC in evolving markets, including strategic alliances, R&D, and strategic orientations. Moreover, the framework displays the outcomes of TC in conjunction with other organizational capabilities. That is, businesses can achieve firm success through resource sharing, R&D investment, strategic alliances, and strategic renewal programs, by integrating TC with other competencies. This will potentially improve performance. Stronger TCs can also lead to higher internationalization, while TIC, market-oriented TC, and DTC help boost technology commercialization and global market expansion. Overall, the study emphasises the need for further research to develop comprehensive frameworks for TC in dynamic markets, address theoretical gaps, and promote a more comprehensive understanding of TC.

First, despite the significant growth of TC research, the causes and consequences of TC remain unclear. The links have not been systematically investigated, in earlier studies. Additionally, research has yielded conflicting results regarding the direction of these relationships. The absence of systematic investigation into the causes, configuration, and effects of TC led to these complex interactions. Besides, there is a need to provide a hint for the researchers for further clarification of the variables related to TC. For instance, while studies have examined the role of R&D in enhancing international market expansion (e.g., De Massis et al., 2012) and the impact of TC on this process (e.g., Zahra, 2018), there are still few studies that demonstrate how TC and R&D can be combined to enhance international market expansion. In other words, this study provides a list of possible effects on TC that will be expanded upon and explained in further investigations. For example, this study clarifies the importance of strategic orientations in creating TCs in a competitive market. However, previous studies have identified entrepreneurial, technological, and market orientations as components of strategic orientation (Eng and Okten, 2011). Others (e.g., Knight and Cavusgil, 2004) also see learning orientation, innovation orientation, and internationalization orientation as strategic orientations. Based on this, the study recommends future researchers create strategic orientation dimensions and use EFA and CFA to analyse the items in each dimension.

Secondly, responding to the dynamic market environment, studies have emphasized the importance of integrating TC with MC (Wilden and Gudergan, 2014). However, there are controversial findings. One of the contentious conclusions made by Su et al. (2015) was that market turbulence advances the performance effect of marketing capability, but hinders that of technological capability. Meanwhile, technological capability improves, but MC is hindered by market turbulence. Thus, further research is essential to clarify how technological and marketing capabilities are combined to successfully run a business.

Thirdly, various capabilities significantly contribute to the performance and competitive advantage of the company. Yet, the integration of these capabilities with TCs and their alignment with the dynamic and uncertain market environment is unclear since the influence is not equally significant. This suggests that it is important to clarify how marketing and technological capabilities fit with other organizational capabilities, such as DC. Future researchers must study the combined impact of TC and other organizational capabilities on value creation, competitive advantages, and performance. Additionally, TC studies need to focus on the turbulent and uncertain market environment.

Fourthly, the integration between TCs and innovation, and how these two elements interact together to benefit the organization is not evident. For instance, Renko et al. (2009) revealed that TC is an excellent predictor of product innovation, while Zhou and Wu (2010) found that high levels of TC may prevent them from producing innovative products (Guerra and Camargo, 2016). Future studies will therefore need to provide more details on this controversial finding. They must examine the reasons why excessive TC harms innovation, in particular. TC is also recognized as one of the most important prerequisites for innovative enterprises developing new products (Yu et al., 2014). However, if innovation is introduced to increase product advantage, this finding might be reversed (Wong, 2012), since new product success may be negatively impacted by innovation (Guerra and Camargo, 2016). To make sense of these conflicting conclusions, it is necessary to empirically clarify the significance of TC in developing new products, and the role of NPD in linking TC with the performance of firms.

Fifth, this study introduces novel constructs developed by amalgamating TC with associated constructs for future scholars. For instance, studies have demonstrated the amalgamation of TC and DC (Wilden and Gudergan, 2015), TC and MC (Su et al., 2015), and TC and IC (Wilden and Gudergan, 2015). Moreover, as an integrated construct, the combination of TC and MC within DCs has not been previously examined. This integration lacks theoretical foundations. Consequently, this investigation substantiates the need for fresh constructs, namely MoTC, TIC, and DTC. This study highlights the need for further investigation into integrating these factors.

Finally, examining the precise manners in which TC is combined with specific types of capabilities, such as absorptive and adaptive capability, to jointly impact business success is also of paramount importance. Future scholars need to conduct empirical investigations of the moderating effect of these specific capabilities. Furthermore, while some theoretical evidence suggests that strategic management influences TC and TC affects performance, the role of TC as a mediator must be examined. Additionally, the scholarly community has not thoroughly investigated the contribution of TC to technological knowledge creation and how this knowledge facilitates TC commercialization and innovation through market and industry knowledge. Future research should assess the potential of the specified factors to function as moderators, mediators, or control variables.

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