

## RESEARCH ARTICLE

# MAPPING THE INVESTMENT EFFICIENCY: A CO-CITATION ANALYSIS

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**ABSTRACT** - This research pioneers a shift in investment efficiency exploration by transcending traditional measurement approaches. The study identifies three main research areas: (1) Factors influencing investment efficiency, (2) Competition, green Research and Development (R&D) and cooperation in the supply chain, and (3) Environmental and renewable considerations in investment efficiency. This is achieved through a document co-citation analysis of 38 highly cited documents. Multidimensional scaling visually maps the intellectual landscape, emphasising the dominance of factors influencing investment efficiency. A 10-year analysis reveals dynamic trends with implications for financial transparency, strategic ownership, social responsibility and technological advancements. The study offers actionable insights for scholars and practitioners, emphasising the necessity of aligning financial goals with sustainability. Despite acknowledged limitations related to data source bias, this research contributes a nuanced understanding of investment efficiency trends, paving the way for future explorations in this vital domain.

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## 1.0 INTRODUCTION

Investment efficiency captures the attention of academics and the industrial world. It involves optimising financial capital, as well as labour and economic resources, to achieve the best outcomes. Research on investment efficiency has been dedicated to understanding and improving investment efficiency (Gao & Yu, 2020). The effectiveness of investment efficiency is measured by how capital is allocated to various assets or projects. Investors and businesses strive to achieve investment efficiency as it enhances optimal financial growth while minimising risks associated with resource allocation and operations (Verbeek et al., 2002). Moreover, attracting low-cost capital resources and allocating capital to highly profitable available projects or assets also determines investment efficiency (R. Chen et al., 2017). Research explores areas such as maximising profit, optimal investments and analysing factors related to or affecting profitability. This includes examining ownership, asset class, behavioural investment and management styles.

In today's complex and interconnected financial markets, investment efficiency plays a vital role in driving financial prosperity, fostering innovation and judiciously allocating resources (Leydesdorff & Vaughan, 2006). Understanding and harnessing investment efficiency have become advantageous for achieving long-term financial goals, sustainable growth and economic stability (McCain, 1990). Investment efficiency has evolved significantly over time, driven by advances in financial theory, technological innovations and changes in the global economic landscape (C. Chen et al., 2010). It encompasses aspects such as diversifying risk across asset classes with low correlation, ensuring asset prices reflect all available information and leveraging powerful computer technology through speedy algorithms and quantitative models (Small, 2003). This has led to various research areas within investment efficiency, including risk management, behavioural finance, operational efficiency, emerging investment assets, technologies and integration of these areas.

This study presents a systematic review of investment efficiency on the measurement of investment efficiency by Feibel (2003) and Gao & Yu (2020), who reviewed and integrated the empirical literature on measuring investment efficiency in accounting and finance. They identified three groups of theory behind the framework: neoclassical theories, agency theory and real options theory. Within neoclassical theories, with Keynes's internal rate of return and Tobin's q theory, Gao & Yu (2020) reviewed the measurement of investment efficiency by comparing investment returns with a benchmark, expanding Tobin's q theory expansion to investment-q sensitivity, exploring excess investment, investigating information asymmetry and considering investment-cashflow sensitivity. These theories relax certain assumptions to measure investment efficiency. The measurement of investment efficiency within agency theory, which acknowledges the presence of information asymmetry, involves the free cash flow theory and expands to address underinvestment and overinvestment. Real options theory introduces relative measures that modify traditional net present value (NPV) theory, incorporating the option to cease investment in unfavourable conditions.

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Gao & Yu's (2020) study is currently the only comprehensive review on the measurement of investment efficiency. However, their review primarily focuses on these measurements, and there still exists scope for exploring trends and key research areas within investment efficiency beyond measurement considerations. To identify the main trends and potential shifts in trends, this study uses data from the Web of Science (WoS) to analyse the main areas of investment efficiency over a specified time period, as well as the most referenced documents in relation to investment efficiency. This study finds that without time constraint, the main research trends of investment efficiency expand over the following six areas. These areas include an exploration of factors influencing investment efficiency (Area 1), an examination of competition, green research and development (R&D), and cooperation in the supply chain (Area 2). Additionally, the study delves into the interplay between investment efficiency, spinoff, divestment, and investment policies (Area 3), the impact of politics on corporate investment (Area 4), the consideration of environmental and renewable aspects in investment efficiency (Area 5), and the relationship between economic growth and carbon dioxide emissions (Area 6).

Consequently, drawing insights from a 10-year timeframe research, the prevailing trends are identified in three main areas. These areas encompass the analysis of factors influencing investment efficiency (Area 1), the exploration of competition, green R&D, and cooperation in the supply chain (Area 2), and a focus on environmental and renewable aspects in investment efficiency (Area 3). The theme of investment efficiency remains an ongoing area of development and innovation because technology and evolving financial market practices continue to affect this theme. Within the identified research areas, Area 1 remains the predominant area of discussion on investment efficiency, containing 26 documents without timeframe limit or 21 documents in the past 10 years. This area primarily focuses on the significant factors that affect a firm's investment efficiency, including the quality of financial reports, accounting principles, auditing, executive and management attributes and shareholder characteristics. As this study primarily utilises the 10-year timeframe to analyse the most recent research trends in investment efficiency, it will focus on this period for the analysis.

The remainder of the study is organised as follows. Section 2 outlines the methods and materials used in this study. Section 3 presents the results and discussion. Finally, Section 4 discloses the limitations and conclusions.

## 2.0 METHODS AND MATERIAL

This research uses document co-citation analysis (DCA), a bibliometric technique focused on collecting, managing and analysing numerical bibliographic data from scientific publications (Verbeek et al., 2002). Co-citation analysis is a prevalent method used to scrutinize the links between articles or authors that contribute to a research field (Di Stefano et al., 2010). Specifically, DCA investigates a network of co-cited references (Small, 1973, 2003). The fundamental assumption is that co-citation clusters reveal the underlying intellectual structures; as such, the study of a co-citation network revolves around understanding a cluster of cited documents and the interrelationships between these clusters (C. Chen et al., 2010). Through this methodology, this study aims to identify the prevailing trends in investment efficiency research. This research seeks to evaluate the primary trends of investment efficiency investigation and their comparative standings by employing the co-citation technique. Particularly, the keyword "investment efficiency" from the WoS produces a list of 72 documents arranged in descending citation frequency order. The WoS is preferred over other sources due to its reputation for its collection of high-ranked publications. The study then proceeds to refine the sample using a co-citation correlation within the set of 72 documents. A series of continuous tests for factor loading and reliability in SPSS enables the elimination of documents with a factor loading of less than 0.6, bringing the final sample to 38 papers. Thus, only these 38 papers form the final sample for analysing the main trends in investment efficiency research. From this co-citation of the sample of 38 documents, a cluster analysis is performed to analyse the relationship amongst the subfields. Additionally, multidimensional scaling (MDS) is applied to create a knowledge map of the investment efficiency research field. MDS, a powerful analytical tool, not only reveals the spatial arrangement of topics but also enhances thematic analysis by visually and dynamically representing the data (Buja et al., 2008), fostering a more intuitive understanding of the interconnectedness within the research landscape.

The process retrieves a co-citation matrix of the 38 most cited documents. As mentioned above, the document list prepared from the keyword "investment efficiency" in the WoS was recorded based on citation frequency. Therefore, the study only considers the most cited documents from the WoS database. Each pair within our 38-paper selection has a co-citation frequency obtained from the WoS to create the co-citation matrix. Studies recommend treating the main diagonal as not applicable or zero, as suggested by McCain (1990) and Ramos-Rodríguez & Ruíz-Navarro (2004). From this co-citation table, a Pearson correlation is converted for further analysis. The Pearson correlation coefficient ( $r$ ) measures the strength of the association between two variables. The closer the data scatter points align with a straight line, the stronger the association between the variables. Ahlgren et al. (2003) and White (2003) established the reliability of the Pearson test. The Pearson correlations continue to serve as the main analytical tool for this study despite some instability found by Ahlgren et al. (2003), which was refuted by White (2003). On the basis of the Pearson matrix, MDS and a two-dimensional map analysis are performed for the primary trend assessment.

For the most recent 10-year period (2013–2023), the document list decreases to 46 papers. Our co-citation correlation testing concludes with 35 of the most frequently cited documents.

### 3.0 RESULTS AND DISCUSSION

#### 3.1 Factor analysis

In DCA, a factor is distinguished when documents achieve loadings beyond the range of  $-0.6$  and  $0.6$  (Hair et al., 2014). This study observes that all 38 documents meet this criterion. The 10-year period filters these down to the most significant 35 papers. Such documents within a region represent certain concepts that are co-cited within the same region and are likely to be categorized under one factor. A subfield belongs to a factor signifies an intellectual trend defined by authors with a loading corresponding to that subfield or factor (Peek & Rosengren, 2000).

Three factors are extracted to summarise the three areas from the 35 most co-cited documents, having a minimum eigenvalue of 2.712 and a maximum of 23.709 (Table 1), in comparison with having no time restraint, which ranges from 1.986 to 17.977. Although both samples explain approximately 90% of data, the eigenvalue indicates a considerably stronger Area 1 in 10 years, thereby emphasizing the importance, strength and clarity of the specific research area. The strength and clarity are illustrated by the volume of documents cited in connection with each trend. However, the significance of each trend underlies its nature, quality and effect on general research into investment efficiency. In this context, Area 1 (Factors of investment efficiency) covers a broad area of the industry and professional field, Area 2 pertains to competition and green R&D and cooperation in the supply chain, and Area 3 relates to environmental and renewable aspects in investment efficiency.

Table 1. Eigenvalue of the main research areas: 10-year period and no time restraint

| Area | Eigenvalue of research areas |                |
|------|------------------------------|----------------|
|      | Last 10 years                | Unlimited time |
| 1    | 23.709                       | 17.977         |
| 2    | 4.828                        | 5.050          |
| 3    | 2.712                        | 3.469          |
| 4    |                              | 3.249          |
| 5    |                              | 2.732          |
| 6    |                              | 1.986          |

Source: Compiled by the authors

*\*Note: The 6 research areas on Investment Efficiency in the unlimited-time frame research articles include: Factors of investment efficiency (Area 1), Competition and green R&D and cooperation in the supply chain (Area 2), Investment efficiency, spinoff, divestment, and investment policies (Area 3), Politics and corporate investment (Area 4), Environmental and renewable aspects in investment efficiency (Area 5), and Economic growth and carbon dioxide emissions (Area 6).*

#### 3.2 Multidimensional Scaling (MDS)

SPSS is used to conduct factor analysis, which generates an MDS analysis. This method identifies correlations between primary variables to create new factors. Factor loadings indicate how strongly a document associates or loads on predetermined factors based on the research questions. Therefore, these factors are considered subfields when the theoretical background is collected to check the documents loaded within a particular factor. The raw co-citation matrix is analysed using an analysis on the key element with varimax rotation (i.e. replacing missing values with the average value) (Nerur et al., 2008). MDS generates a visual chart that demonstrates the relative distance amongst the papers or authors, based on the principle that two similar documents will be located closely (Leydesdorff & Vaughan, 2006). The reliability of the MDS results is measured by low stress and the proportion of variance (R2) because they indicate the solution dimensions. This research employs a two-dimensional solution to illustrate the conceptual distance amongst different research strands (McCain, 1990).

Table 2 presents some statistical features of the data drawn from the 35 analysed documents. On average, a document garners 108 citations from another document sourced from the WoS as of 2023. The median publication year for the selected decade is 2016. Without time constraint, the oldest cited paper is in 2004, and the most recent is in 2014. Thus, these old documents remain the foundation for current trends in investment efficiency research as recorded by the WoS. No documents published post-2016 have enough citations to establish a trend in investment efficiency research. A skewness over 1 suggests an above-average proportion of citations. A kurtosis exceeding 3 illustrates a significant distribution on both tails.

The relationship amongst the three areas of investment efficiency research for the period of 2013–2023 is visually depicted in Figure 1. This two-dimensional visualization map of 35 co-cited documents displays the similarities between the documents. The documents are located on the map based on the proximity in the co-citation matrix. High co-citation scores reflect a high similarity, and this also portrays the theoretical distance between various research topics. The most substantial cluster also represents the primary area of investment efficiency. Stress value, on the contrary, measures the extent to which the original observations are faithfully reproduced in the new dimensional space (Dimension 1 and

Dimension 2). A low Stress value suggests that the PROXCAL model accurately reproduces the data. A stress value under 2 (0.1325) and an R2 value of 0.89282 indicate a good fit for the graph.

Table 2. Descriptive statistic features the data drawn from the WoS

| Area      | 2013–2023          |        | No time restriction |        |
|-----------|--------------------|--------|---------------------|--------|
|           | Citation frequency | Year   | Citation frequency  | Year   |
| Mean      | 108                | 2016   | 123                 | 2014   |
| Median    | 87                 | 2016   | 92                  | 2014   |
| Max       | 330                | 2022   | 1043                | 2022   |
| Min       | 58                 | 2013   | 58                  | 2004   |
| Std. Dev. | 71.73              | 2.82   | 173.22              | 4.63   |
| Skewness  | 1.32               | 0.21   | 3.83                | (0.35) |
| Kurtosis  | 0.86               | (1.22) | 18.20               | (0.59) |

Source: Compiled by the authors

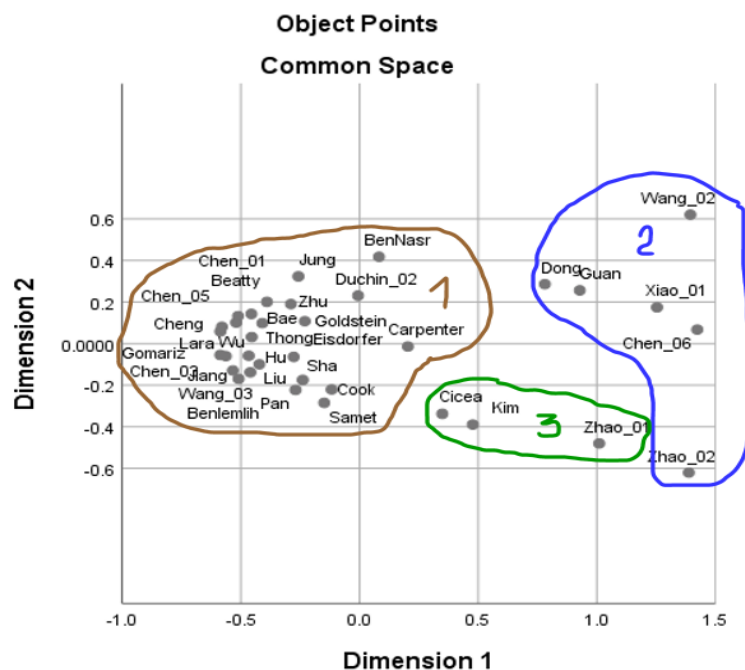


Figure 1. Academic structure of Investment Efficiency research (2013–2023)

Source: Authors' compilation from the WoS (2023)

### 3.3 Main research areas on investment efficiency (2013–2023)

#### Area 1 - Factors of investment efficiency

This area of investment efficiency covers 26 articles across the recent 10 years, whereas only 21 articles are grouped in the mainstream over the unrestricted timeframe. The significantly influential factors affecting investment efficiency can be categorised as accounting financial reporting quality (Bae et al., 2017; Cutillas Gomariz & Sánchez Ballesta, 2014; García et al., 2016), executives and management (Eisdorfer et al., 2013; Hu et al., 2020; Liu et al., 2015), ownership features (R. Chen et al., 2017), market dynamics and stock price informativeness (Ben-Nasr & Alshwer, 2016; Goldstein et al., 2013; Zhu, 2019), individualism versus national culture (Shao et al., 2013) and economic policy uncertainty (Y. Wang et al., 2014).

#### a) Accounting and financial reporting

The central concept of factor accounting and reporting quality is rooted in the positive impact of accounting conservatism on investment efficiency. Accounting quality, encompassing accuracy, reliability, and transparency in financial information presentation, plays a crucial role in shaping investment decisions. High-quality accounting ensures precise and fair representations of a company's financial situation and performance. Accounting quality enhances labor investment efficiency, supported Jung et al. (2013), who found a negative association between abnormal net hiring and accounting quality. Secondly, high-quality accounting reduces information asymmetry, aiding investors in making informed decisions and promoting fair trading, thereby leading to more efficient capital allocation (Jung et al., 2013).

Companies with high accounting quality are likely to attract investments more readily, potentially reducing financing costs and improving investment efficiency, as observed by Cheng et al. (2013). García et al. (2016) further suggest that conservatism in high-quality accounting reports positively impacts investment efficiency through various channels, including reducing adverse effects of information asymmetry and facilitating access to external financing.

Regarding long-term investment decisions, high-quality accounting helps assess a company's viability, reducing the risk of investing in firms with hidden financial problems. Report quality extends beyond financial statements, encompassing clarity, completeness, and timeliness of all information provided to investors. Timely updates and comprehensive reporting contribute to well-informed decisions, enhancing investment efficiency. Ballesta & Gomariz (2012) emphasize the role of financial reporting quality and debt maturity in mitigating overinvestment problems. Transparency, facilitated by quality accounting and reporting, reduces managerial concerns, promoting innovative efforts and efficient R&D capital allocation. Auditor quality is another vital component influencing investment efficiency. Bae et al. (2017) demonstrate that auditors, as part of the management information environment, influence capital investment behaviors, especially for clients with a higher demand for information. Conversely, accounting fraud negatively impacts peer firms in the industry, leading to misleading investment decisions and affecting overall investment efficiency.

In conclusion, accounting and report quality are critical factors shaping investment efficiency. High-quality financial reporting enhances transparency, reduces information asymmetry, and fosters investor confidence, contributing to efficient capital allocation. Conversely, low-quality accounting and reporting can result in misallocation of capital, increased investment risk, and market inefficiencies. Continued emphasis on and enforcement of standards for accounting and reporting quality by regulatory bodies and market participants are essential for promoting efficient investment markets.

#### b) Ownership features and investment efficiency

The exploration of ownership features and their impact on investment efficiency has been a significant trend in recent research, with studies conducted by authors such as R. Chen et al. (2017), Jiang et al. (2018), and Liu et al. (2015). Positive contributors to investment efficiency encompass characteristics such as having significant shareholders, possessing a private or foreign owner, and maintaining board independence. Firms with multiple large shareholders (MLS) demonstrate higher investment efficiency compared to those with a single large shareholder. This is attributed to diversified voices within MLS, providing a fuller governance vision that mitigates potential overinvestment and improves future investment performance. This governance role is crucial in reducing agency costs and information asymmetry in a firm's investment decisions, a point emphasized by Jiang et al. (2018). Their findings indicate that the effect of MLS on investment efficiency remains consistent across firms with varying resource access but is less prominent in those with stronger governance and less information asymmetry.

Conversely, a single significant owner, such as a government or foreign institution, can induce agency costs and information asymmetry. Government ownership, as highlighted by R. Chen et al. (2017), weakens investment-q sensitivity, resulting in higher investment inefficiency, while foreign ownership strengthens it, leading to increased investment efficiency. The impact of foreign ownership is particularly pronounced when governments relinquish control and when country-level governance institutions are weaker. Board management, closely tied to large owners, plays a pivotal role. Liu et al. (2015) demonstrated that independent directors positively influence the operating performance of Chinese firms. This positive relationship between board independence and firm performance is more pronounced in government-controlled firms and those with lower information acquisition costs. Independent directors are seen as instrumental in mitigating insider self-dealing and enhancing investment efficiency.

Cultural background and environmental factors also play a crucial role in investment efficiency. The allocation of capital across risk and long-term assets is influenced by cultural tendencies. Individualistic societies, favoring loosely knit social frameworks and individual pursuit of interests, tend to exhibit a higher propensity for risk-taking and long-term investments. Shao et al. (2013) suggest that firms in individualistic societies are more inclined to allocate excess cash to R&D investments rather than increasing dividends, with R&D decisions being less reliant on internal financing and more responsive to growth opportunities. While improvements in stock market information align with increased investment efficiency, this effect is more pronounced in privately owned firms. Aggregated information provides valuable signals to managers in privately owned firms. The impact of stock market information improvement is less significant in state-owned enterprises (SOEs), reflecting unpredictable subsidies and state-directed investment policies. Notably, evidence from realized returns indicates that Chinese firms face a higher cost of equity capital than US firms, as indicated by Carpenter et al. (2021).

In summary, the aforementioned studies collectively contribute to understanding how various factors, including ownership structure, corporate governance, national culture, and the presence of MLS, influence investment efficiency and firm performance in different contexts.

#### c) Executives and management behaviours

This section delves into the examination of executives and management behaviors and their influence on investment efficiency. Notably, scholars such as Eisdorfer et al. (2013), Hu et al. (2020) and Liu et al. (2015) have contributed to this stream by investigating aspects such as board management towards transparency and the impact of executive

compensation frameworks on capital structure and, consequently, investment efficiency. Eisdorfer et al. (2013) conducted research on the intricate relationship among capital structure, executive compensation, and investment efficiency. They highlighted a significant leverage gap between these factors leading to more investment distortions. Their findings indicated that managers with more debt-like compensation components tend to underinvest, while those with larger equity-based compensation engage more in overinvestment. Furthermore, the study suggested that setting compensation leverage equal to the firm leverage can mitigate underinvestment problems, as it aligns the manager's interests with stockholders, reducing agency costs.

Board reforms play a pivotal role in enhancing board oversight and mitigating agency problems. Hu et al. (2020) examined the global effects of corporate board reforms on stock price crash risk, revealing stronger impacts in firms with more severe ex-ante agency problems. The study suggested that board reforms contribute to reducing crash risk by improving financial transparency and, consequently, investment efficiency. Liu et al. (2015) found that independent directors positively influence firm operating performance in China (22). This positive relationship is more pronounced in government-controlled firms and those with lower information acquisition costs. Independent directors play a crucial role in constraining insider self-dealing and improving investment efficiency.

Cultural aspects, analyzed by Shao et al. (2013), reveal that firms in individualistic countries tend to invest more in long-term and risky assets compared to those in collectivistic societies. This effect is particularly noticeable in the context of R&D projects, where individualistic firms allocate excess cash to R&D investments rather than increasing dividends. Wang et al. (2014) explored how economic policy uncertainty influences corporate investment for Chinese listed companies. The study demonstrated that higher economic policy uncertainty leads to lower investment, but firms with higher return on invested capital, more internal finance usage, and non-state ownership mitigate this negative effect. The findings underscore the importance of transparency and stability in economic policy implementation for improving corporate investment efficiency. Pan & Tian (2020) conducted a natural experiment, demonstrating that the ousting of corrupt politicians and their connected firms significantly affects investment expenditure. The study highlights differing impacts on state-owned and non-state-owned enterprises, with the removal of politicians influencing firm investment decisions more prominently after the recent anti-corruption campaign. Carpenter et al. (2021) noted that the rise in stock price informativeness coincides with an increase in investment efficiency among privately owned firms. However, state-owned enterprises (SOEs) experience a decline in both price informativeness and investment efficiency after the post-crisis stimulus, attributed to unpredictable subsidies and state-directed investment policies. Duchin & Sosyura (2013) investigated divisional managers' connections to the CEO and their impact on capital allocation. The study found that managers with connections receive more capital, and the effects on investment efficiency depend on the trade-off between agency and information asymmetry. Zhong (2018) emphasized the positive impact of transparency on innovative effort, reducing managerial career concerns and enhancing innovative efficiency through its governance role.

In summary, the works of Carpenter et al. (2021), Duchin & Sosyura (2013), Eisdorfer et al. (2013), Hu et al. (2020), Liu et al. (2015) and Zhong (2018) collectively underscore the critical role of board transparency, executive compensation, market aggregation of information, managerial connections, and transparency in influencing investment efficiency. These studies provide valuable insights for corporate governance and strategic decision-making in the realm of executive and managerial behaviors.

#### d) Corporate social responsibility (CSR)

Within the stream of Corporate Social Responsibility (CSR), studies conducted by Benlemlih & Bitar (2018), Cook et al. (2019) and Samet & Jarbou (2017) collectively delve into the intricate relationship between CSR and investment efficiency within firms, offering valuable insights into how CSR practices influence investment behaviors and overall firm performance.

Investment efficiency appears to have an indirectly positive impact on CSR. This relationship operates through two channels: investment efficiency and innovation. Firms with higher CSR performance are found to invest more efficiently, displaying a lower absolute deviation from the predicted investment level and a reduced likelihood of underinvestment or overinvestment. According to stakeholder theory, strong CSR commitments lead to decreased information asymmetry and higher stakeholder solidarity. This suggests that high CSR involvement contributes to reduced investment inefficiency and enhanced investment efficiency. Notably, CSR components directly related to primary stakeholders, such as employee relations, product characteristics, environmental concerns, and diversity, play a more substantial role in reducing investment inefficiency compared to those related to secondary stakeholders. During economic crises, such as the subprime crisis, the impact of CSR on investment efficiency becomes even more pronounced, as emphasized by the research of Benlemlih & Bitar (2018). This underscores the critical role CSR plays in shaping firms' investment behaviors and efficiency.

Cook et al. (2019) conducted a comprehensive investigation into the influence of CSR on investment efficiency and innovation. Their findings indicate that firms with higher CSR performance tend to invest more efficiently, making decisions that avoid projects with negative Net Present Values (NPVs) and favor those with positive NPVs. Moreover, these firms exhibit superior innovation capabilities, generating more patents and patent citations. The authors suggest that CSR contributes to enhanced profitability and firm value through efficient investments and innovation. Cook et al.'s (2019) research highlights the multifaceted advantages of CSR, including improved investment decision-making and

innovation capabilities. Samet & Jarboui (2017) add to this understanding by examining the relationship between CSR and investment efficiency. Their argument revolves around the idea that firms with high CSR performance invest more efficiently by mitigating information asymmetry. Additionally, CSR assists overinvesting firms by addressing investment excess and tackling free cash flow problems. In essence, CSR indirectly contributes to improving firm-level investment efficiency by addressing agency problems and information asymmetry. This study complements previous research by emphasizing how CSR can exert both direct and indirect effects on investment efficiency, contingent on specific circumstances and challenges faced by firms.

In summary, the collective findings of these studies underscore the significant influence of CSR practices on firms' investment efficiency and overall performance. Firms with robust CSR commitments tend to make more efficient investment decisions, reduce information asymmetry, and benefit from improved innovation capabilities. Consequently, CSR emerges as a pivotal factor shaping firms' financial and strategic outcomes.

#### e) Effects of market dynamics and technological development on investment efficiency

The exploration of the effects of market dynamics and technological development on investment efficiency encompasses various aspects, with a particular focus on the explicit technology that underlies real-time data and price informativeness. This specific stream of research evaluates how technological advancements impact investment efficiency, emphasizing optimization measures (Ben-Nasr & Alshwer, 2016; Zhu, 2019). Zhu (2019) empirically investigated the effects of alternative data availability, such as real-time consumer transactions and satellite images, on stock price informativeness and its disciplining effect on managers' actions. The introduction of real-time data had two notable effects on managers: a reduction in opportunistic trading and an increase in investment efficiency. The latter result aligns with the notion that improved price informativeness enhances managers' incentives to invest and divest efficiently.

Contrasting this, Ben-Nasr & Alshwer (2016) delved into the relationship between stock price informativeness and labor investment efficiency. They found that a higher probability of informed trading correlates with lower deviations of labor investment from economically justified levels, indicating higher labor investment efficiency. This positive effect is more pronounced in firms from highly unionized industries and those facing greater financial constraints, while firms relying more on skilled labor are less affected. Goldstein et al. (2013) examined a model where capital providers use a firm's security price to determine investment capital. This market-driven feedback triggers trading frenzies, influencing price pressure and, consequently, impacting firm cashflows. The consequences of these frenzies on real values, such as credit and available cash, have a dual effect on capital provision efficiency. Optimal coordination among speculators during such episodes depends on equilibrium levels and maximizes capital provision efficiency, particularly when price informativeness is highest. Carpenter et al. (2021) observed that stock prices in China have become more informative about future profits, coinciding with increased investment efficiency among privately owned firms. This suggests that the market is aggregating information and providing valuable signals to managers. However, for state-owned enterprises (SOEs), both price informativeness and investment efficiency fall below that of privately owned firms after the post-crisis stimulus, possibly reflecting unpredictable subsidies and state-directed investment policies. Additionally, evidence from realized returns indicates that Chinese firms face a higher cost of equity capital than their US counterparts.

In the field of market dynamics and technology's influence on investment efficiency, Ben-Nasr & Alshwer (2016) scrutinized stock price informativeness and labor investment efficiency in highly unionized industries. Zhu's (2019) study on real-time data emphasized its positive impact on investment efficiency and managerial conduct. Goldstein et al.'s (2013) exploration of trading frenzies unveiled their dual effect on real values and capital provision efficiency. These insights, combined with Carpenter et al.'s (2021) findings on China's stock prices, collectively contribute to a comprehensive understanding of how market dynamics and technology interact to enhance investment efficiency.

Overall, these research trends highlight the multifaceted nature of factors influencing investment efficiency in firms, encompassing accounting practices, governance structures, external market dynamics, and cultural factors. This understanding is crucial for firms and policymakers seeking to improve investment decision-making and overall economic efficiency.

### ***Area 2 - Competition and green R&D cooperation in the supply chain***

This research theme recognises an important area of investment efficiency, namely, the supply chain. It explores the important roles of such various factors as information sharing, technology spillover in competition and cooperation (X. Chen et al., 2019; Dong et al., 2016; Guan et al., 2020; Xiao & Xu, 2013), environmental sustainability and technology efficiency (M. Wang & Feng, 2019; X. Zhao et al., 2016), social performance and investment efficiency in the supply chain. They provide insights into policy implications for improving efficiency, sustainability and coordination in supply chains and industries while mitigating environmental effects and enhancing overall performance. Guan et al. (2020) argued that information sharing enables manufacturers to adjust their wholesale prices and service levels responsively to demand, which can benefit their supply chains if they are efficient in-service investment. Information sharing in one supply chain can also trigger decision adjustments in the other supply chain, which may be beneficial to the first supply chain. Information sharing is more likely to occur when manufacturers are more efficient in-service investment, consumers care more about service or competition is more intense. Particularly, when manufacturers' service investment efficiency or consumers' service attention is sufficiently high, retailers will voluntarily share demand information regardless of competition intensity. They also file a cooperation dilemma where neither supply chain has information

sharing, even though they will be better off if both have. Xiao & Xu (2013) investigated the coordination between the price and service level decisions under vendor-managed inventory (VMI) for a system efficiency. They determined that the interaction between the retail price and the service level may invert the effect of deterioration rate on the retail price. The system efficiency of a decentralised supply chain increases with market scale, price sensitivity, deterioration rate, supplier's cost (including unit production, holding and deterioration costs) and service investment efficiency while decreasing production rate. VMI may invert the effect of the deterioration rate on the unit wholesale price of the decentralised supply chain. In the coordinated setting, the retailer should pay a higher transfer price to the supplier with VMI than that without VMI. Moreover, the transfer price decreases with service investment efficiency, and higher service investment efficiency reduces the transfer price difference. X. Chen et al. (2019) explored firms' green R&D cooperation behaviour where a manufacturer and a retailer initially cooperate to invest in green R&D and then organise production according to a wholesale price contract. The authors argued that the R&D cooperation's improvement of firms' economic performance is mainly determined by firms' own green contribution level, which is dependent on firms' green R&D investment efficiency and spillover, as well as on their relevant power relationship with their supply chain partners. In a Pareto improvement region, green R&D cooperation positively affects firms, customers and the environment. In the case of a non-Pareto improvement region, supply chain coordination can be achieved through a two-part tariff contract.

Similarly, Dong et al. (2016) studied the sustainability investment in sustainable products with emission regulation consideration for decentralised and centralised supply chains. They derived the optimal order quantity (or production quantity) and sustainability investment and found that the sustainability investment efficiency has a significant effect on optimal solutions. The order quantity may increase in the wholesale price due to the effects of the sustainability and emission considerations. Only a sharing contract can coordinate the supply chain, whereas the buyback contract and two-part tariff contract cannot. Zhao et al. (2016) decoupled CO<sub>2</sub> emissions and industrial growth. They reported that investment scale is the most important factor responsible for the increase in CO<sub>2</sub> emissions and the inhibition of decoupling. The investment efficiency effect has a volatile trend and plays the most significant role in reducing CO<sub>2</sub> emissions overall, followed by the energy intensity effect and process carbon intensity effect; whereas the energy mix, carbon coefficient and investment share have marginal effects. Industrial subsectors of raw chemical materials and chemical products, nonmetal mineral products and smelting and pressing of ferrous metals have significant effects on decoupling, thus amongst the top concerns for decreasing CO<sub>2</sub> emissions. M. Wang & Feng (2019) discussed the decoupling relationship between the economy and CO<sub>2</sub> emissions of China's metal industry. They found that potential energy intensity change, investment efficiency decline and production technological progress are three pivotal factors contributing to emission reduction. Industrial structure regulation and energy-saving technology advancement also contribute to emission reduction and decoupling state. Investment scale expansion is the primary factor promoting emission growth and impeding decoupling progress.

In summary, this research area focuses on the integration areas of investment and operation efficiency of supply chains and industries, including cooperation, information sharing and environmental and green sustainability. Understanding their behaviours, their current positions and suitable contract forms is the implication towards investment decisions, technology, contracts and policy measures in shaping economic, environmental and social outcomes. The research conducted in these studies contributes valuable insights for practitioners and policymakers seeking to enhance efficiency and sustainability in various sectors.

### ***Area 3 - Renewable and green factor in investment efficiency***

This trend can be seen as a novel area of investment efficiency because it looks beyond the classical meaning of investment efficiency towards the future to consider the cost of green factor and renewable energy in an investment efficiency context, in other words, the components of efficiency in renewable energy investments (Cicea et al., 2014; Kim et al., 2015; L. Zhao et al., 2021). The effects of various green and renewable components on investment efficiency are initially caused by government subsidies and tax rebates. Particularly, investment efficiency has been investigated from various components: pure innovation efficiency, green productivity, technical efficiency, scale efficiency and total investment efficiency in renewable energy firms. L. Zhao et al. (2021) explored the effective influences of government subsidies and tax rebate policies on renewable energy firms' investment efficiency. At the 16% trust mark, current government subsidies and taxation rebates have dramatically positive effects on pure technological efficiency and total investment efficiency. In addition, government subsidies have stronger positive effects on total investment efficiency and pure technical efficiency than taxation rebates. Furthermore, the ownership concentrations of renewable energy companies greatly encourage pure technological efficiency, size efficiency and total investment efficiency. Moreover, asset returns significantly increase their average degree of total investment efficiency and pure technical efficiency.

As the scale of investment in new and renewable energy has increased, an intriguing issue of the efficiency of the investment has been raised because strategic selection and focused investment allow policy goals to be achieved with limited resources and budget. Particularly, given the various types of renewable energy source, the efficiency of each New and Renewable Energy (NRE) technology must be examined to find suitable technologies for the environments of each target country and eventually realise efficient investments in NRE. Kim et al. (2015) evaluated the investment efficiency of three NRE technologies: wind power, photovoltaic and fuel cells. They used data envelopment analysis method and considered the two policy objectives of public investment, technological development and wider dissemination of NRE in Korea. Their results indicated that wind power is the most efficient renewable energy in Korea



from the perspective of government investment. Cicea et al. (2014) constructed an environmental efficiency index to assess the environmental efficiency of investments in renewable energy at the macroeconomic level. Indicators such as energy intensity, CO2 intensity and gross domestic product per capita and per unit of investment are used to establish a connection between effects and efforts (a prerequisite for studying the efficiency). They found that the two countries investigated have high and low environmental efficiency of investments in renewable energy.

In summary, these studies collectively contribute to the understanding of how investments in renewable energy can be made more efficient. They consider various factors, including government policies, specific technologies and environmental effects, to provide insights into optimising resource allocation and achieving renewable energy goals.

### 3.4 Implications and conclusions

In general, the research has made the following main contributions: On the theoretical front, the study results have provided insights into the research methods used to synthesize the research directions and trends in future research on the investment efficiency topic. The main research areas on investment efficiency have implications on the significant roles of the factors as follows.

**Financial transparency.** The positive effect of accounting conservatism on investment efficiency implies that firms must prioritise accurate, reliable and transparent financial reporting. Incentivising high accounting quality not only aids decision making but fosters a culture of financial transparency.

**Strategic ownership and governance.** The right form of ownership should be able to add value to the firm through effective governance, industry expertise and effective tax shelter where applicable. Strategic ownership is also in line with management and ownership theory. Optimising features such as large shareholders, private and foreign ownership and board independence aligns with a strategic approach to maximise investment outcomes. Along with strategic ownership and governance is cultivating leadership excellence, which significantly maximises investment efficiency. The emphasis on the role of leadership in influencing investment efficiency suggests fostering a culture that encourages positive management behaviours aligned with long-term investment goals. Cultivating leadership excellence becomes a key avenue for organisations seeking to enhance their investment efficiency.

**Integrating social responsibility.** Exploring CSR practices highlights their potential to enhance a firm's reputation and positively influence investment decisions. Integrating social responsibility into business practices emerges not only as an ethical imperative but as a strategic move for optimising investment outcomes.

**Technological advancements in investment strategies.** Staying abreast of technological advancements and integrating real-time data into investment strategies becomes crucial for organisations aiming to optimise returns. The dynamic nature of technology calls for a proactive approach to leverage advancements for improved investment efficiency.

**Strategic collaboration in green R&D.** Recognising the relationship between competition, green R&D cooperation and investment efficiency suggests that businesses should strategically leverage green R&D collaborations. Such collaborations not only contribute to environmental sustainability but also positively influence investment efficiency in the supply chain.

**Aligning financial goals with sustainability.** The exploration of renewable and green factors in investment efficiency signals a growing awareness of the influence of sustainability on financial decisions. Aligning financial goals with environmental responsibility becomes a strategic imperative for organisations navigating the evolving landscape of investment efficiency.

On a practical level, the study offers actionable insights for scholars and practitioners, emphasising the necessity of aligning financial goals with sustainability. Despite acknowledged limitations related to data source bias, this research contributes a nuanced understanding of investment efficiency trends, paving the way for future explorations in this vital domain.

## 4.0 LIMITATIONS AND CONCLUSIONS

This research has certain limitations. Firstly, the main uses only records from the WoS. Although the WoS is a reliable source, its sole use leads to source bias. Secondly, limited source leads to limited documents that are well co-cited. The limited number of documents is suitable for the chosen methodology that is applied in this study. When the sample is larger, it will allow for more methods to analyse the main research areas of investment efficiency. Nevertheless, the applied method offers a robust and reliable test. Another constraint pertains to articles that necessitate time for citation. Consequently, publications released towards the conclusion of our study period may have garnered fewer citations compared to those published earlier, potentially leading to the underrepresentation of recent influential contributions.

In conclusion, the DCA of investment efficiency reveals a dynamic and multifaceted landscape with a predominant focus on various factors influencing investment efficiency. The detailed examination of accounting and reporting quality, ownership features, executive behaviours, CSR practices and technological development provides implications and actionable insights for scholars and practitioners.

Navigating the intricate interplay between these factors suggests adopting a holistic approach. Organisations can enhance their investment efficiency by prioritising financial transparency, optimising ownership and governance structures, cultivating leadership excellence, integrating social responsibility, leveraging technological advancements and strategically collaborating in green R&D. The emphasis on aligning financial goals with sustainability underscores the strategic imperative for businesses to ensure long-term success in the ever-evolving domain of investment efficiency. Last but not least, the future studies may use another software such as VOS-viewer and N-vivo to conduct thematic analysis.

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## 6.0 CONFLICT OF INTEREST

The authors declare no conflicts of interest.

## 7.0 AUTHORS CONTRIBUTION

Hoai Vu Phan (Methodology; Data curation; Formal analysis; Visualisation; Resource)

Cheng-Po Lai (Conceptualisation; Writing – review and editing; Supervisor)

Hsinkuang Chi (Conceptualisation; Methodology; Software)

Hanh Thi My Le (Conceptualisation; Writing – review and editing)

Thi Kim Nguyen (Methodology; Formal analysis; Writing-original draft)

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