

## The Hidden Link between Motivations Driving Earnings Management and Capital Structure Decisions: A Bibliometric Perspective

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**Abstract.** In this paper, earnings management and capital structure decisions are analysed from a new perspective. Bibliometric analysis of the link between capital structure and earnings management is performed, providing new insights on historical evolution of research in the field. The links between keywords in the research area are analysed and grouped in clusters. Valuable insights on the level of research carried out in the field are presented. Current studies are expanded by adding theoretical background analysis: capital structure decisions and the motives of earnings management are compared in the context of various theories. In this paper, common incentives behind capital structure decisions and earnings management are revealed. Systematic comparison between capital structure decisions and motives of earnings management together with results of bibliometric analysis provide new insights on the topic and can assist in future research.

**Keywords:** capital structure, earnings management, earnings management motives, forming capital structure.

**JEL Code:** M49

### Introduction

Capital structure is one of the key areas in strategical planning as it can impact the company's cash flows in the future, growth rate (Tripathy et al., 2021) and determine the level of risk the company faces (Ross, 1977; Ganesamoorthy, 2016). For these reasons, capital structure and decisions regarding its formation get a lot of attention from the company's stakeholders. Increased attention from stakeholders can encourage the company's management to use earnings management to change the company's capital structure and impact the stakeholders. Thus, it is essential to analyse the link between capital structure and earnings management to improve understanding of earnings management in practice.

Primary research on the topic revealed that not a lot of scientific publications focus on the link between capital structure and earnings management. Therefore, a wider analysis is needed to determine the level of research performed on the topic. This research can reveal if the topic requires more scientific attention, and more research carried out in the field. Based on capital structure's importance in the company's activities and the high interest of stakeholders, further research could provide valuable insights on how to improve the quality of financial information and what actions may indicate earnings management.

The aim of the research is to reveal the possible link between motivations driving earnings management and capital structure decisions and evaluate the level of research carried in the topic.

The objectives of the research are as follows:

- (1) To find common attributes of the concepts by comparing theoretical background of motivations driving earnings management and capital structure decisions,
- (2) To reveal the level of studies carried in the field by analysing the evolution of research on keywords “capital structure” and “earnings management”,
- (3) To analyse the links among keywords researched in the field and evaluate if the link has been sufficiently researched in practise.

The research methods are bibliometric analysis, keyword analysis, data visualization, network analysis, comparative scientific literature analysis, comparison analysis, summary analysis, statistical analysis and descriptive statistics.

## **1. Theoretical foundations for the connection between capital structure and earnings management**

Decisions regarding forming capital structure impact various company's activities – the amount of liabilities, profit or loss, cash flows, financial ratios and risk level. For these reasons, the company's stakeholders actively observe and analyse changes in the capital structure of the company and how they impact the company's activities. Based on the importance of capital structure changes on a company's activity and the high interest of stakeholders, it is important to analyse the theoretical foundations of capital structure.

Theoretical background on capital structure consists of classic and modern capital structure theories. *Classic capital structure theory* was developed by Modigliani and Miller (1958). The main proposition of the theory is that capital structure does not impact a company's value in a perfect market. However, a perfect market is based on assumptions that are hardly possible in reality: there are no taxes in the perfect market, all companies have equal access to the finance market and the ability to borrow unlimited amounts of money with the same conditions, information asymmetry does not exist, and there are no transaction and bankruptcy costs in the perfect market (Modigliani and Miller, 1958). However, it was hard to apply the theory in reality, as these assumptions were rarely met in the real market. For this reason, the authors later enhanced the theory with tax effect and additional financing costs. According to amended theory, companies with a bigger portion of borrowed capital in their capital structure have a higher market value (Khan et al., 2021a), because interests are considered as expenses that reduce taxable profit and the company's income tax, and dividends do not affect company's income tax (Modigliani and Miller, 1963; Alifani and Nugroho, 2013). Later the theory was enhanced by the effects of bankruptcy costs and increased risk. A higher amount of borrowed capital increases bankruptcy risk and potential bankruptcy costs, as a result, the company's value decreases (Modigliani, 1982; Aleknevičienė, 2011). Even with two amendments, classic capital structure theory is criticized for being hardly applicable in practice (Khan et al., 2021a).

Further research brought to light new insights and practical implications. A new set of theories – *modern capital structure theory* – was formed. It consists of tradeoff theory and pecking theory. The main purpose of the *tradeoff theory* is to find optimal capital structure. Based on this theory, the company needs to balance financing costs and bankruptcy risk with the effect of reduced corporate income tax (Kraus and Litzenberger, 1973). Other researchers state that optimal capital structure should result in maximalized company value, and this can be reached by balancing borrowing costs and the effect of reduced taxes (Gajdosikova and Valaskova, 2022). *Pecking theory* provides different insights on capital structure decisions. The main proposition of the theory is that companies tend to keep a consistent capital structure and prefer internal financing sources. If internal sources are not available, companies choose external financing sources. The least preferred source is additional equity emission (Myers,

1984). The preferences are explained by the following reasons: internal financing sources help the company to avoid interest expenses and higher risk (Xiang et al. 2022); external financing sources are chosen due to increased surveillance that results in decreased information asymmetry (Khan et al. 2021b) and due to reduced corporate income tax effect; additional emission of equity is the last option as dividends do not reduce profit and profit income tax.

Capital structure decisions can be analyzed from another viewpoint – using *market behaviour theories*. This set of theories includes market timing theory, signalling theory and agency cost theory. According to *market timing theory*, capital structure decisions are based on events happening in the market: companies pick a timing for new equity emission when the market value of their shares is higher than usual and pick a timing for shares buy-back when the market value of their shares is lower than usual. Thus, companies do not search for optimal capital structure and only seek to take advantage of market conditions that can be beneficial to the company (Fama and French, 2002; Popescu and Visinescu, 2009; Elsas et al., 2014). The other two market behaviour theories focus on the way information about capital structure is used. According to *signalling theory*, companies use information about capital structure to form a prosperous company's image in the market, convince the market about its opportunities to grow and well-managed risks. Companies can also withhold information that could harm their image. As a result, information asymmetry is formed, and it can increase the company's market value. To summarize, it is possible to form the company's image and impact its' market value by changing the company's capital structure (Ross, 1977; Khan et al., 2021a). According to *agency cost theory*, optimal capital structure can be reached only by minimizing conflict of interest among stakeholders, especially the company's management, shareholders and creditors (Jensen and Meckling, 1976). The main goal of the management is to maximize the company's value and profitability; shareholders demand that a company maintain a certain level of risk that would result in a specific amount of return; creditors need to be sure that they will get back borrowed money and will benefit from the loan. Reaching consensus can be difficult and expensive. Therefore some companies avoid external financing sources. Agency cost theory argues that external crediting is more expensive than internal financing due to conflicts of interest among different stakeholders (Khan et al., 2021b). Summarized theories are presented in Table 1.

**Table 1. Theories that explain capital structure decisions**

Group of theories		Theory	The main idea of the theory
Theories of capital structure decisions	Classic	Modigliani and Miller (1958, 1963, 1982) theory	The higher the proportion of debt in capital structure, the higher the company's market value.
	Modern	Tradeoff theory	Optimal capital structure should maximize company's market value.
		Pecking theory	Companies' preferences are arranged as follows: firstly, companies use internal sources of financing, and after that, they choose external debt. Lastly, companies use additional equity emission as a financing source.
Market behaviour theories		Market timing theory	Capital structure decisions are impacted by prosperous timing in the market.
		Signalling theory	Capital structure is used to form company's image in the market and impact company's market value.
		Agency cost theory	Optimal capital structure can be reached only by minimizing conflict of interest among stakeholders.

*Source:* prepared by the authors based on Modigliani and Miller (1958, 1963); Modigliani (1982); Kraus and Litzenberger (1973); Jensen and Meckling (1976); Ross (1977); Myers (1984); Fama and French (2002); Popescu and Visinescu (2009); Elsas et al. (2014); Khan et al. (2021a); Khan et al. (2021b); Gajdosikova and Valaskova (2022)

As can be seen in Table 1, there are a few different theories on decisions that form capital structure. However, while making decisions, the management of the company considers the possible impact on the company's image in the market. They want to meet the expectations of stakeholders and the prognosis of market analysts, as well as maintain a prosperous image of the company. Sometimes it is hardly possible to do it with the current company's capabilities. That is when companies resort to earnings management.

Motivation to use earnings management is usually based on positive accounting theory, agent cost theory, stakeholders' theory and signalling theory. Based on these theories, various motives for using earnings management can be identified (see Table 2).

Table 2. **Motives to use earnings management based on various theories**

Theory	Groups of motives	Motives	
Positive accounting theory	Bonus plan motives	- Management feels motivation to use earnings management when their bonus amount depends on the company's performance	
	Debt covenant motives	- Company uses earnings management to maintain a specific ratio of debt and equity	
	Political costs motives	- Earnings management is used in order to avoid political visibility, strict regulation and additional political costs	
Agency costs theory	Contracts motives	<ul style="list-style-type: none"> <li>- Management compensation</li> <li>- Change of CEO</li> <li>- Management abilities</li> </ul>	<ul style="list-style-type: none"> <li>- Loans</li> <li>- Company characteristics</li> <li>- Corporate governance</li> </ul>
	Capital markets motives	<ul style="list-style-type: none"> <li>- Shares market motives</li> <li>- Securities motives</li> <li>- Initial public offering</li> <li>- Mergers and acquisitions</li> </ul>	<ul style="list-style-type: none"> <li>- Management buy-out</li> <li>- Insider trading</li> <li>- Prognosis of analysts</li> </ul>
	External motives	<ul style="list-style-type: none"> <li>- Industry</li> <li>- Legal regulation</li> <li>- Political environment</li> <li>- Tax environment</li> </ul>	<ul style="list-style-type: none"> <li>- Accounting standards</li> <li>- Competitors</li> <li>- Suppliers, customers</li> </ul>
Stakeholders' theory	Meeting stakeholders expectations	<ul style="list-style-type: none"> <li>- To decrease, postpone or avoid announcing losses</li> <li>- To smoothen profit and guarantee dividends</li> <li>- To create earnings reserve ("cookie jar") for the future</li> </ul>	<ul style="list-style-type: none"> <li>- To avoid losses during mergers and acquisitions</li> <li>- To meet the expectations of suppliers and customers</li> <li>- To meet the expectations of employees</li> <li>- To meet the prognosis of analysts</li> </ul>
	Impact stakeholders' decisions	<ul style="list-style-type: none"> <li>- Impact the decisions of investors</li> <li>- Impact the decisions of creditors</li> <li>- Impact the decisions of shareholders</li> </ul>	
	Staying in the market	<ul style="list-style-type: none"> <li>- To keep up with competitors</li> <li>- To keep in a strictly regulated market</li> <li>- To protect the company from competitors in a market with insufficient regulation</li> </ul>	
	Legal compliance	<ul style="list-style-type: none"> <li>- To meet strict legal regulations</li> <li>- To take advantage of the loopholes in legal regulations</li> <li>- To decrease tax liabilities</li> <li>- To avoid the introduction of new taxes or regulations</li> </ul>	
	Personal benefits motives	<ul style="list-style-type: none"> <li>- To receive higher returns when the CEO's remuneration depends on the company's results</li> <li>- To make future work easier and protect oneself from risks</li> <li>- To manipulate the share's value when part of the CEO's remuneration is received in shares</li> <li>- To buy the company's shares for a cheaper price</li> </ul>	
Signalling theory	Signalling motives	- Earnings management is used to create the image of a successful company's growth, impact the market's decisions and company's share value	

Source: prepared by the authors based on Watts and Zimmerman (1990); Rudžioniene (2012); El Diri (2016); Saleh et al. (2020); Siekelova et al. (2020); Bachtijeva (2021); Bachtijeva and Striupaitytė (2023); Pangaribuan et al. (2023)

Comparing Tables 1 and 2, it can be noticed that both capital structure decisions and motives to use earnings management can be explained using the same theories.

Based on *agency costs theory*, earnings management is used in order to meet the expectations of various stakeholders and satisfy their needs (El Diri, 2016; Siekelova et al., 2020). In the context of capital structure, the main idea of agency costs theory is that in order to reach optimal capital structure, the company needs to minimize conflict of interest among various stakeholders (Jensen and Meckling, 1976). Thus, both concepts can be tied to the problem of satisfying different interests of stakeholders.

Based on *signalling theory*, there is an information asymmetry in the market between the company's management and external stakeholders, and management can decide how much information to disclose to external stakeholders. Companies use earnings management and information asymmetry to maintain the image of a successfully growing company, impact shares' price and influence the market's decisions (Saleh et al., 2020). In the context of capital structure, signalling theory suggests that companies use information about their capital structure in order to maintain a prosperous image regarding their growth opportunities, future cash flows and risk management (Ross, 1977; Khan et al., 2021a). Thus, according to signalling theory, both motivations to use earnings management and capital structure decisions are related to sharing beneficial information about the company (sending signals).

Based on *stakeholders' theory*, management is trying to decrease information asymmetry in the market and meet the expectations of the most influential stakeholders (Gray et al., 1996). However, meeting the expectations of different stakeholders can be very difficult or expensive, therefore some companies resort to using earnings management as a solution for meeting expectations of different stakeholders (Katutyte, 2021; Bachtijeva, 2021), minimizing conflict of interests and creating a positive image of the company. Therefore, motivation to use earnings management based on stakeholders' theory can be linked to capital structure decisions based on both agency costs theory and signalling theory.

Based on the leverage hypothesis of *positive accounting theory*, when leverage increases, the possibility that the company use earnings management also increases. Earnings management is used in order to increase profit, avoid breaching debt covenants, avoid default, bankruptcy and related costs (Watts and Zimmerman, 1990; DeFond and Jiambalvo, 1994; Rudžionienė, 2012; Chamberlain et al., 2014; Al-Mohareb and Alkhalaileh, 2019; Nalarreason et al., 2019). High level of debt is associated with higher financial risk not only due to the capability to return the loan but also due to changes in interest rates. High risk may be an incentive to use earnings management. Similar aspects are analysed by *classical capital structure theory*, which suggests that companies strive to keep a permanent (optimal) capital structure. Increasing the level of debt increases the company's value due to saved taxes but also increases financial risk. Therefore, companies are looking for an optimal capital structure that balances saved taxes and increased risk. When such capital structure is found, companies strive to maintain permanent ratio between equity and debt (Modigliani, 1982; Aleknevičienė, 2011). Thus, motives for earnings management based on the leverage hypothesis of positive accounting theory can be linked to capital structure decisions based on classic capital structure theory. Summarized links between capital structure decisions and motives to use earnings management can be seen in Table 3.

Table 3. **Common attributes between decisions to form capital structure and motivation to use earnings management based on various theories**

Attribute	Decisions to form capital structure	Motivation to use earnings management
Problem of different stakeholders' interests	<u>Agency costs theory:</u> Optimal capital structure can be reached only by minimizing <i>conflict of interest among different stakeholders</i> .	<u>Agency costs theory:</u> Earnings management is used in order to <i>satisfy the interests of different stakeholders</i> .
		<u>Stakeholders' theory:</u> Companies use earnings management to <i>meet the expectations of stakeholders</i> , impact their decisions, and get benefits from their decisions.
Sending prosperous signals to the market	<u>Signalling theory:</u> Capital structure can be used to <i>form the company's image in the market</i> and impact the company's market value.	<u>Signalling theory:</u> Earnings management is used in order to <i>create the image of successful company's growth</i> , influence market's decisions and company's market value.
		<u>Stakeholders' theory:</u> Companies use earnings management to provide information that could influence stakeholders' decisions in a way that would be beneficial to the company. In other words, companies <i>send signals</i> that help the companies <i>manipulate the decisions of stakeholders</i> .
Maintaining permanent capital structure	<u>Classic capital structure theory:</u> The company seeks to <i>maintain permanent (optimal) capital structure</i> because a higher level of debt results in higher financial risks.	<u>Positive accounting theory (financial leverage hypothesis):</u> Companies use earnings management to <i>maintain specific ratio of debt and equity</i> .

Source: prepared by the authors

As can be seen in Table 3, there are attributes common to both theories that explain decisions to form capital structure and theories that explain motivation to use earnings management: the problem of different stakeholders' interests, sending prosperous signals to the market, maintaining permanent capital structure. Theoretical links reveal that both concepts may be related and could be used for the same reasons. To research the link further, bibliometric analysis of the studies was.

## 2. Bibliometric analysis of the link between capital structure and earnings management

Further research involved bibliometric analysis of the link between the concepts to understand the degree of scientific investigation of the topic. For sample identification, we used the built-in analysis tools of the Scopus database (2025): researched terms were entered into the search box, and search parameters included search within article title, abstract and keywords. The terms "capital structure" and "earnings management" were put into the query box for search. To get included in the sample, the publication had to include both of these terms. Using the built-in analysis tools of the Scopus database (2025), a sample of 249 scientific publications was identified. The key parameters of articles (year of publication, authors, title, correspondence address, keywords) were exported from the Scopus database (2025) and analysed using Excel. Figure 1 presents the dynamics of the number of publications by the keywords "capital structure" and "earnings management".

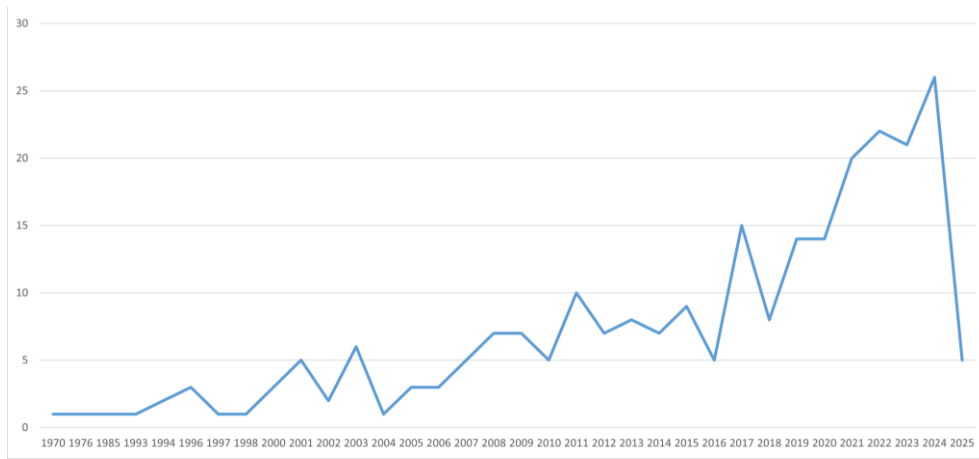


Figure 1. **Dynamics of the number of publications by the keywords “capital structure” and “earnings management” (March 2025)**

Source: developed by the authors based on Scopus database (2025)

The Scopus database suggests that the link between capital structure and earnings management has been researched for over 50 years already (see Figure 1). The first publication featuring both of these terms was released in 1970 by researchers from the United States. However, their research mainly focused on the cost of capital, with capital structure and earnings management being minor factors interacting with the cost of capital (Bierman and Alderfer, 1970). Publications on the topic were infrequent until 2000 and constituted only 4% of total publications in the sample (see Table 4).

Table 4. **Publications grouped by decades of release**

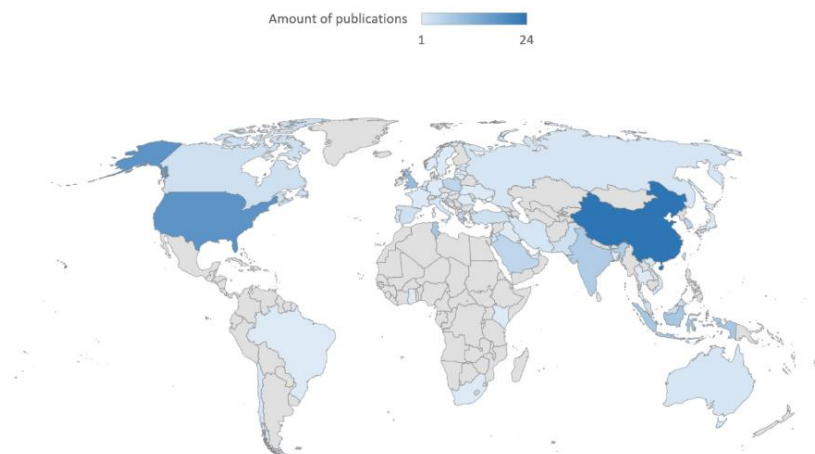
Decade of publication	Total amount of publications	Ratio of publications	Average of publications in a year
1970s	2	0.80%	0.2
1980s	1	0.40%	0.1
1990s	8	3.21%	0.8
2000s	42	16.87%	4.2
2010s	88	35.34%	8.8
2020s	108	43.37%	20.6
<b>Total</b>	<b>249</b>	<b>100,00%</b>	<b>4.5</b>

Source: developed by the authors based on statistical analysis of data from Scopus database (2025)

A significant increase in publications surrounding these terms is observed from the early 2000s onwards, with an average of 4 publications per year in the 2000s, 9 publications per year in the 2010s and 21 publications per year in 2020-2024 (see Table 4). The constant growth of research activity surrounding these terms indicates a growing academic interest in the field.

The main area of publications surrounding these terms has also shifted. The first publications in the 1970s-1980s were released mostly in the United States. If we consider all publications surrounding these keywords released in the period from 1970 to 2025 (see Figure 2), most publications were released by authors from Asia (32.5% of all publications). According to Scopus data, the top 5 countries for research on these terms are China – 24 publications (9.6% of all publications), United States – 18

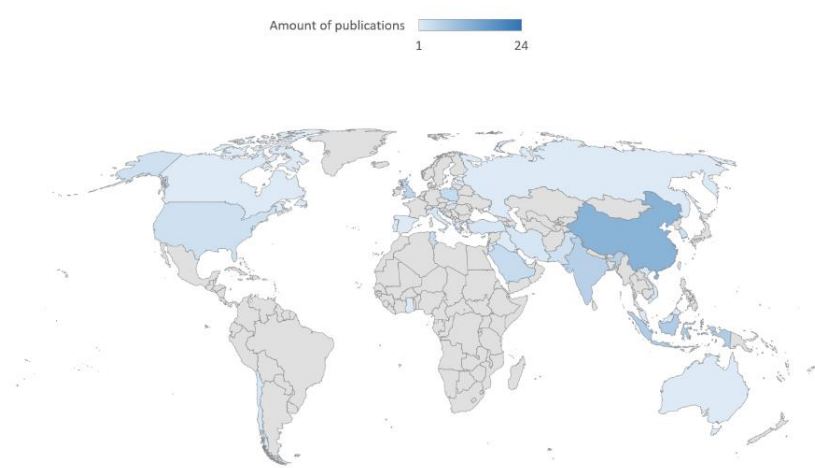
publications (7.2% of all publications), United Kingdom – 10 publications (4.0% of all publications), Indonesia and Tunisia – 8 publications each (3.2% of all publications each).



**Figure 2. Territorial distribution of the number of publications by the keywords “capital structure” and “earnings management” in the period from 1970 to 2025 (March 2025)**

*Source:* developed by the authors based on Scopus database (2025)

Considering the recent popularity of the topic (108 publications were released in the period from 2020 to 2025, 43.3% of all publications), we separated these publications and analyzed them by country as well (see Figure 3).



**Figure 3. The territorial distribution of the number of publications by the keywords “capital structure” and “earnings management” in the period from 2020 to 2025 (March 2025)**

*Source:* developed by the authors based on Scopus database (2025)

According to Scopus data, almost half of publications in the period from 2020 to 2025 were released by authors from Asia (53 publications, 49.1% from publications released in 2020-2025). Authors from Europe released 22 publications (20.4% from publications released in 2020-2025). The top 5 countries for research on these terms in the period of 2020-2025 are China – 12 publications (11.1% from publications released in 2020-2025), Indonesia – 7 publications (6.5% from publications released in 2020-2025), India – 6 publications (5.6% from publications released in 2020-2025), United Kingdom –



5 publications (4.6% from publications released in 2020-2025). The 5th place is shared by Poland, Saudi Arabia and Tunisia with 4 publications each (3.7% from publications released in 2020-2025 each).

Important to notice that only 4 publications were released by authors from Baltic countries that are indexed in the Scopus database (1.6% from publications released in 1970-2025). Searching for the term “Baltic countries” in the title or keywords did not bring any results. This reveals that there is no research on capital structure and earnings management in Baltic countries that are indexed in the Scopus database.

For further analysis, we used VosViewer 1.6.20 software (VosViewer Official Website, 2025) to analyse relationships among keywords and visualise them (see Figure 4).

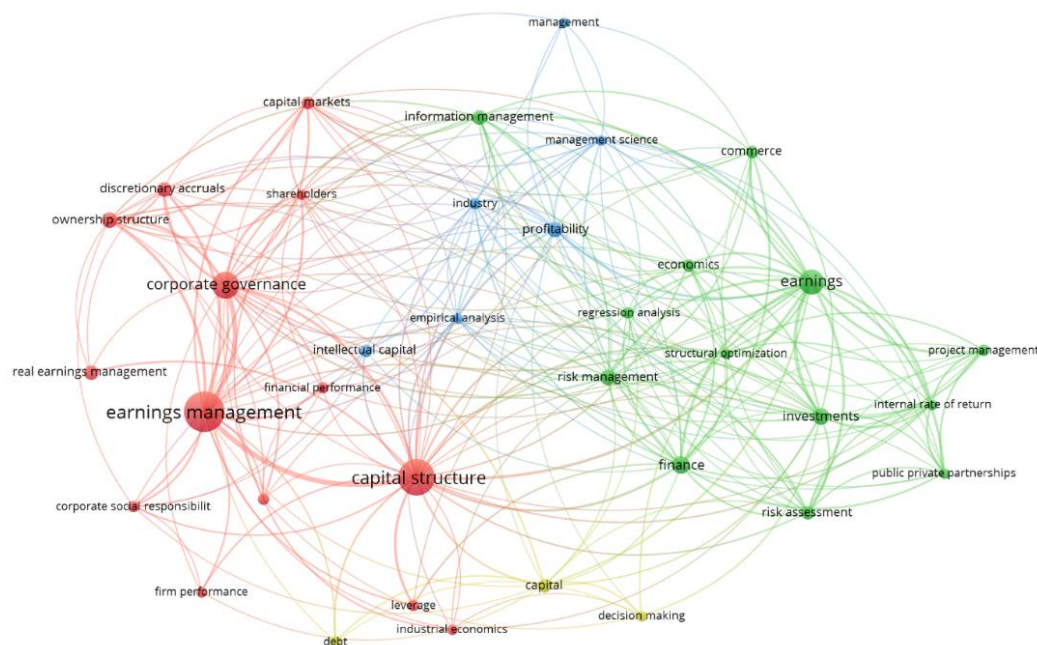


Figure 4. **Links among keywords of publications that included the terms “capital structure” and “earnings management” (March 2025)**

Source: developed by the authors with the help of VosViewer software based on Scopus database (2025)

Analysis in VosViewer revealed 4 clusters (see Table 5). Cluster 1 and Cluster 4 are the closest to investigating the link between capital structure and earnings management, while Cluster 2 focuses on project management and the returns it can bring, and Cluster 3 investigate the links among capital markets, information and company management.

Table 5. **Clusters identified during visual analysis of keywords in publications**

Cluster	Items in cluster	Main research themes in the cluster
Cluster 1	Capital, corporate governance, corporate social responsibility, debt, decision making, earnings management, financial performance, firm performance, industrial economics, industrial management, shareholders	Publications in the cluster investigate the links among capital, debt, earnings management and firm performance

Cluster 2	Earnings, economics, finance, internal rate of return, investments, project management, public-private partnerships, regression analysis, risk assessment, risk management, structural optimization	Publications in the cluster investigate the links among project management, risk management and return of investments
Cluster 3	Capital markets, commerce, empirical analysis, industry, information management, intellectual capital, management, management science, profitability	Publications in the cluster investigate the links among capital markets, information management and company management
Cluster 4	Capital structure, discretionary accruals, leverage, ownership structure, real earnings management	Publications in the cluster investigate the links among capital structure and real earnings management vs. accruals-based

Source: developed by the authors based on analysis performed in VosViewer software

By summarizing the results of the content-contextual block bibliometric analysis, it was noticed that scientific publications of the sample explore a lot of different concepts: capital, capital structure, capital markets, firm performance, investments, project management, risk management, information management, profitability, discretionary accruals, earnings management and real earnings management. The most popular keywords, besides capital structure and earnings management, were corporate governance, earnings, finance, investments, ownership structure and discretionary accruals.

The bibliometric analysis revealed that although the keywords have a long research history starting from 1970, the topic is insufficiently studied – only 249 scientific publications surrounding these keywords have been published. Moreover, only 2 out of 4 clusters of publications could be related to the topic of the link between capital structure and earnings management. The number of publications has significantly increased since the 2000s, showing growing interest in these research areas. However, there is still a research gap in the studies of link between motivations driving earnings management and capital structure decisions: theoretical links presented in Tables 1-3 are not sufficiently researched in practise. Due to the importance of capital structure on a company's performance, the high interest of the company's stakeholders on the topic and insufficient research, further research on the link between capital structure and earnings management is highly recommended and could expand current scientific knowledge in the field.

## Conclusions

1. To understand the link between concepts, the theoretical background of capital structure and earnings management was studied and compared. It revealed that there are attributes common to both decisions to form capital structure and motivation to use earnings management: the problem of different stakeholders' interests, sending prosperous signals to the market, maintaining a permanent capital structure. It means that there is a theoretical background for believing that there is a link between capital structure and earnings management.

2. Research was continued by analysing the level of studies carried on this topic. To analyse the evolution of research on keywords "capital structure" and "earnings management", bibliometric analysis was involved and data extracted from Scopus database (2025) was used. Bibliometric analysis revealed that research surrounding the keywords "capital structure" and "earnings management" has a relatively long history – the first publication was released in 1970. Since the 2000s, the amount of scientific publications has significantly increased. However, the field is still insufficiently researched: only 249 publications including keywords "capital structure" and "earnings management" have been released since the 1970s. Furthermore, most of the publications have been released in Asia and North America, while only 4 publications have been printed in Baltic countries.

3. For further research, data visualization with the help of VosViewer software was performed in order to analyse the links among keywords. Content-contextual block bibliometric analysis revealed that 249 publications can be grouped into 4 clusters. Only 2 of the clusters may be related to the link between capital structure and earnings management. This means that less than 249 publications are related to the link between capital structure and earnings management. Consequently, the field has been researched even less than it seemed after the initial search in Scopus database (2025). The most popular keywords used in publications, besides capital structure and earnings management, included corporate governance, earnings, finance, investments, ownership structure and discretionary accruals. These findings show that there is a lack of empirical research focusing on the link between capital structure and earnings management. Due to importance of the concepts on company's activities and insufficiently researched field, it is highly recommended to perform further research on the topic and test the hypothesis in practise.

#### Authors' contributions

**Milda Striupaitytė:** conceptualization, methodology, investigation, software, supervision, writing - original draft, visualization. **Anastasiia Niesheva:** investigation, visualization, writing - review and editing.

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