UNIVERSIDAD COMPLUTENSE DE MADRID

FACULTAD DE CIENCIAS ECONÓMICAS Y EMPRESARIALES

TESIS DOCTORAL

¿Los ingresos contables predicen o determinan el crecimiento económico? El caso de la República Popular de China

Do accounting earnings predict or determine economic growth? The case of People's Republic of China

MEMORIA PARA OPTAR AL GRADO DE DOCTOR

PRESENTADA POR

Mu Sun

DIRIGIDA POR

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Quotes

“Everything is the best arrangement”

Jia Cuo

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ABSTRACT

In the past decade, there has been an increasing focus on the research pertaining to the usefulness of accounting information. Accounting information plays a pivotal role in the realm of economics by bridging the gap between macroeconomics and microeconomics. Existing literature aims to quantify the relationship between macroeconomic factors and micro-level firms' accounting information, rather than solely concentrating on economic indicators. Several empirical studies have endeavored to explore this relationship in order to ascertain its relevance for decision-making usefulness of accounting information. These studies typically employ aggregate earnings indicators derived from accounting data to establish a connection between accounting information and macro-level GDP.

The literature has established that aggregate accounting earnings data contain information about GDP growth, with the majority of contributions coming from samples in the United States. However, differences in accounting standards across countries result in variations in the treatment of financial statement items, necessitating a thorough discussion from theory to empirical studies on a single sample. Additionally, accounting data derived from GDP components other than aggregate earnings have not been adequately considered. Therefore, this thesis utilizes Chinese listed company data to systematically and comprehensively explore the connection between micro and macroeconomics through an analysis of the GDP growth information contained within accounting information, contributing to the theory of accounting information usefulness. With this main objective this thesis has two subsidiary goals: to conduct a comprehensive bibliometric analysis of existing literature to reveal the intrinsic relationship between accounting returns and

economic growth; and to conduct an empirical analysis of the GDP change information contained in the aggregate-level accounting data.

To establish a comprehensive theoretical framework, this thesis conducts an extensive bibliometric analysis of macro-accounting using the influential databases Web of Science and Scopus. The knowledge map is visualized, and the research trajectory is delineated using information visualization software VOSviewer. Additionally, it examines the recent research trends in macro-accounting on an annual basis and predicts its future development through the neural network PSO-LSTM model. Empirical evidence demonstrates that investigating the relationship between total income and economic growth has emerged as a prominent research focus in recent years. Moreover, Scopus exhibits greater potential for research advancement in this domain compared to Web of Science.

In the empirical section of this thesis, China's data is utilized as a singular sample for analysis. The availability, comparability on an international scale, and adaptability of existing research models are thoroughly examined and verified in light of the current accounting standards in China. This thesis reveals no substantial evidence to support the most critical existing research model on the aggregate earnings. Simultaneously, an aggregate model based on the four components of GDP revenue method is proposed to assess the predictive capability of aggregate-level accounting data concerning GDP. Furthermore, it explores whether other accounting information can provide indications about future changes in GDP by examining accruals at an aggregate level encompassing accrued expenses and accrued income. Additionally, this thesis scrutinizes the predictive

performance of neural network models constructed upon traditional linear regression frameworks.

As found in the results, the present value model and the value-added model both support the notion that accounting information derived from the four components of the revenue-based GDP accounting framework contains relevant data for future GDP. Additionally, our model demonstrates a strong sensitivity to subsequent second-quarter GDP performance. Among these variables, depreciation and income exert the most significant impact, while wages have a relatively minor influence.

Incorporating aggregate-level accruals into the model reveals that taxes, fixed asset depreciation, and aggregate income provide significant insights into current-period GDP and future changes in third-quarter GDP. Moreover, at the aggregate level, accruals offer informative indications of both current-period and next third-quarter GDP changes, whereas individual accruals exhibit lower predictive power. Additionally, multiple empirical tests demonstrate the superiority of neural networks over traditional linear regression models in handling nonlinear data, leading to improved fitting performance of neural network models.

Keywords: Usefulness of Accounting Earnings; GDP; Aggregate Earnings; Aggregate Accounting Information; Accruals; GDP Forecast; Neural Network Model

RESUMEN

En la última década, ha habido un enfoque cada vez mayor en la investigación relacionada con la utilidad de la información contable. La información contable juega un papel fundamental en el ámbito de la economía al cerrar la brecha entre la macroeconomía y la microeconomía. La literatura existente apunta a cuantificar la relación entre los factores macroeconómicos y la información contable de las empresas a nivel micro, en lugar de concentrarse únicamente en los indicadores económicos. Varios estudios empíricos se han esforzado en explorar esta relación para determinar su relevancia para la utilidad de la información contable en la toma de decisiones. Estos estudios suelen emplear indicadores de ganancias agregadas derivados de datos contables para establecer una conexión entre la información contable y el PIB a nivel macro.

La literatura ha establecido que los datos agregados de ingresos contables contienen información sobre el crecimiento del PIB, y la mayoría de las contribuciones provienen de muestras de Estados Unidos. Sin embargo, las diferencias en las normas contables entre países dan lugar a variaciones en el tratamiento de las partidas de los estados financieros, lo que requiere una discusión exhaustiva desde la teoría hasta los estudios empíricos sobre una sola muestra. Además, los datos contables derivados de componentes del PIB distintos de los ingresos agregados no se han considerado adecuadamente. Por lo tanto, esta tesis se utiliza datos de empresas chinas que cotizan en bolsa para explorar de manera sistemática y exhaustiva la conexión entre la micro y la macroeconomía a través de un análisis de la información sobre el crecimiento del PIB contenida en la información contable, contribuyendo a la teoría de la utilidad de la información contable. Con este objetivo principal, esta tesis tiene dos objetivos segundarios: realizar un análisis

bibliométrico integral de la literatura existente para revelar la relación intrínseca entre los rendimientos contables y el crecimiento económico; y llevar a cabo un análisis empírico de la información de cambio futuro del PIB contenida en los datos contables a nivel agregado.

Para establecer un marco teórico integral, esta tesis lleva a cabo un extenso análisis bibliométrico de macrocontabilidad utilizando las bases de datos Web of Science y Scopus. Para ello se visualiza el mapa de conocimiento y se delinea la trayectoria de la investigación utilizando el software de visualización de información VOSviewer. Además, se examina las tendencias recientes de investigación en macrocontabilidad y se predice su desarrollo futuro a través del modelo de red neuronal PSO-LSTM. La evidencia empírica demuestra que la investigación de la relación entre el ingreso total y el crecimiento económico se ha convertido en un foco de investigación destacado en los últimos años. Además, Scopus muestra un mayor potencial para el avance de la investigación en este dominio en comparación con Web of Science.

En la sección empírica de esta tesis, los datos de China se utilizan como muestra singular para el análisis. La disponibilidad, comparabilidad a escala internacional y adaptabilidad de los modelos de investigación existentes se examinan y verifican minuciosamente a la luz de las normas contables vigentes en China. Esta tesis no encuentra pruebas concluyentes para apoyar el modelo de investigación dominante sobre las ganancias agregadas. Al mismo tiempo, se propone un modelo agregado basado en los cuatro componentes del método de ingresos del PIB con el objetivo de evaluar la capacidad predictiva de los datos contables a nivel agregado sobre el PIB. Además, se explora si otra información contable puede proporcionar indicaciones sobre cambios futuros en el

PIB examinando los devengos a nivel agregado que abarcan los gastos y los ingresos acumulados. Esta tesis también analiza el rendimiento predictivo de los modelos de redes neuronales construidos sobre marcos de regresión lineal tradicionales.

Como se obtiene en los resultados, tanto el modelo de valor presente como el modelo de valor agregado respaldan la noción de que la información contable derivada de los cuatro componentes del marco contable del PIB basado en los ingresos contiene datos relevantes para el PIB futuro. Además, nuestro modelo demuestra una fuerte sensibilidad al desempeño posterior del PIB en el segundo trimestre siguiente. Entre estas variables, la depreciación y el ingreso ejercen el impacto más significativo, mientras que los salarios tienen una influencia relativamente menor.

La incorporación de devengos a nivel agregado en el modelo revela que los impuestos, la depreciación de los activos fijos y el ingreso agregado brindan información significativa sobre el PIB del período actual y los cambios futuros en el PIB del tercer trimestre siguiente. Además, a nivel agregado, las acumulaciones ofrecen indicaciones informativas de los cambios del PIB tanto del período actual como del próximo tercer trimestre, mientras que las acumulaciones individuales exhiben un menor poder predictivo. También, múltiples pruebas empíricas demuestran la superioridad de las redes neuronales sobre los modelos de regresión lineal tradicionales en el manejo de datos no lineales, lo que lleva a un mejor rendimiento de ajuste de los modelos de redes neuronales.

Palabras clave: Utilidad de las ganancias contables; PIB; Ganancias agregadas; Información contable agregada; Devengos; Previsión del PIB; Modelo de red neuronal

1

INTRODUCTION

As a crucial determinant of economic performance, macroeconomics exerts a significant influence on enterprises, investors, and even governmental entities. The prediction of a nation's macroeconomic development has consistently been an area of intense academic research. Gross Domestic Product (GDP), as an indicator of national economic accounting, plays a fundamental role in assessing the economic status of a country or region, not only as a statistical measure but also as a lens through which to gauge the vitality and robustness of an economy. Additionally, it offers valuable insights for policymakers to make informed decisions in response to evolving economic conditions (Henderson et al., 2012). In line with the United Nations' guidelines (UNDESA, 2022), the computation of GDP should be rooted in economic theory and employ a comprehensive array of disciplines to evaluate a country's (or region) economic performance during a specific timeframe. The release of GDP data is typically coordinated by the statistical department of the respective country or region on a quarterly basis.

Since the outbreak of the global financial crisis in 2008, there has been significant volatility in global stock markets and the world economy has experienced tremendous upheaval. Against a backdrop of persistent economic uncertainty worldwide, the COVID-19 pandemic unleashed a fresh wave of turmoil, exacerbating an already fragile global economic landscape. According to a report published by the International Monetary Fund

(IMF, 2023), global growth is expected to decline from 3.5% in 2022 to 3.0% both in 2023 and 2024. The pandemic outbreak affected global supply chains, exacerbating inflation in many countries (Gita, 2021). Currently, with the global economy yet to fully recover, events such as the Russia-Ukraine conflict or conflicts in Israel have once again disrupted global economic stability.

Therefore, in the current environment of economic uncertainty, analyzing macroeconomic GDP information embedded in micro-corporate accounting data can facilitate a micro-level observation of the macro-economy and provide novel empirical evidence for theoretical research on accounting usefulness. The theories of the usefulness of accounting for decision-making are critical, as they do not only constitute the theoretical basis of the conceptual framework of the International Financial Reporting Standards (IFRS) in Europe but also of the Financial Accounting Standards Board (FASB) in the US, applied all over the world (Staubus, 2013).

Furthermore, the theory of accounting information usefulness for decision-making has progressively unveiled various insights contained in accounting data, making significant contributions to macroeconomic growth forecasting. Prior research has examined the role of aggregate earnings (AE) as a link between macroeconomics and microeconomics, introducing the concept of examining the macro level from a micro perspective through AE-based market return predictions.

Early research (Kothari et al., 2006) pioneered the use of AE as a proxy for micro-financial data to directly assess its usefulness in macroeconomics and examine its relationship with future market returns. However, some studies (e.g. Cready & Gurun,

2010) have found that AE information is not yet fully incorporated by the market, as evidenced by the consistent negative relationship between AE and market returns even after their announcement. Subsequently, numerous studies have confirmed the direct association between AE and market returns (e.g. Bailey & Lai, 2020; Ball et al., 2009; Choi et al., 2016; Gallo et al., 2016; Gkougkousi, 2014; Kim et al., 2020; Patatoukas, 2014; Son & Jeong, 2022). At the same time, some studies also focus on the impact of AE information on inflation (Cready & Gurun, 2010; Kothari et al., 2006; Patatoukas, 2014; Shivakumar & Urcan, 2014). Building upon this foundation, other researchers have investigated the additional insights on future GDP embedded in aggregate-level accounting data (e.g. Collins & Nguyen, 2022; Son & Jeong, 2022; Sun et al., 2022).

Previous studies primarily focus on examining the association between AE and GDP. Notably, Konchitchki and Patatoukas (2014a, 2014b) have substantiated that AE contains valuable incremental GDP information that can enhance macroeconomic forecasts better than traditional methods. However, in some research, negative accruals within AE offer better explanatory power for changes in GDP (Gaertner et al., 2020; Lalwani & Chakraborty, 2020). Additionally, there are investigations into the incremental information about GDP contained in special items (such as restructuring charges, special executive compensation, asset write-offs, etc.) at an aggregate level apart from AE. Notably, these special items exhibit greater sensitivity towards capturing changes in GDP dynamics (Abdalla & Carabias, 2022).

The estimation of GDP is crucial in the field of economics. Existing forecasting methodologies for GDP can be roughly categorized into either predicting and regressing

GDP indicators via a linear regression forecasting model (Baffigi et al., 2004), or predicting GDP via non-linear models.

Traditional econometric techniques impose stringent assumptions on time series data. When the data is non-stationary, it often requires adjustment to achieve stationarity. For instance, quarterly time series data may exhibit intercepts and trends, which can render traditional methods less suitable for forecasting. However, artificial neural network (ANN) models, which have gained prominence in recent years, can effectively avoid the limitations of linear regression (Feng & Zhang, 2014). ANN models are now extensively employed across various research domains, stemming from their robust parallel processing capabilities, fault tolerance, and high nonlinearity. Principally, they have been utilized for the prediction of macroeconomic indicators. Notable studies such as Panda and Narasimhan (2007) employed ANN to forecast the US dollar exchange rate, while Dunis et al. (2011) utilized a recurrent neural network to predict exchange rates for the euro and dollar. Nakamura (2005) assessed the efficacy of neural networks in forecasting inflation. Smalter et al. (2017) corroborated that neural network models can augment the accuracy of macroeconomic indicator forecasts. Numerous other existing studies have corroborated the efficacy of ANN models for macroeconomic forecasting indicators.

Numerous empirical studies have consistently demonstrated the merits of neural network models in macroeconomic forecasting, particularly in enhancing the accuracy of GDP predictions (Jahn, 2020; Loermann & Maas, 2019; Richardson et al., 2021; Tkacz, 2001). However, it has been observed that ANN models exhibit suboptimal performance when dealing with short-term sample data (Teräsvirta et al., 2005). Furthermore, apart from their efficacy in GDP prediction, ANN models have also exhibited advantages in

forecasting various other macroeconomic indicators such as inflation optimization, GDP and circulation indicators optimization, commodity price forecasts, trade forecasts and interest rate forecasts (Choudhary & Haider, 2012; Chuku et al., 2019; Haider & Hanif, 2009).

1.1 JUSTIFICATION AND OBJECTIVES

In September 2010, the FASB and the IASB jointly issued Concept Statement No. 8 (IASB & FASB, 2010), replacing the original concept statement of Corporate Financial. This new statement determines that the financial reporting provides valuable financial information about the reporting entity. In IAS 1 latest revision (IASB, 2020), it was also noted that the purpose of financial reporting is to provide investors with more helpful information. In today's complex and changeable economic background, the study of accounting information is more practical. Existing related research mainly focuses on the research of accounting information for investors, creditors, and individuals (Brown & Han, 2000; Curtis et al., 2021; He & Narayanamoorthy, 2020; Lev et al., 2010; Rhodes, 2016). However, at the macro-level of the economy, there is a lack of research from an accounting perspective (Ball et al., 2019; Konchitchki & Patatoukas, 2014a).

As the economy main engine, examining the incremental GDP information contained in accounting information is of great significance for predicting future economic growth. Also, when investigating the internal relationship between microeconomics and macroeconomics, most studies focus on how macroeconomics affects microeconomic decision-making (Sun et al., 2022). Examining the correlation between firm-level accounting information and national-level economic growth can contribute to theoretical research on the usefulness of accounting information.

Refining the relationship between company-level accounting information and the macroeconomy is crucial, as company-level activities form an integral part of the macro-economy. Examining the predictive power of future GDP embedded within aggregate accounting information can enhance GDP forecasting accuracy. Although most existing research is centered on earnings-level accounting information, there is a lack of studies examining other aggregate-level accounting information and its relationship with GDP (Sun et al., 2022). The macroeconomic information contained in enterprise accounting micro-information cannot be quantified to be widely used. Moreover, the existing international evidence research on the relationship between GDP and accounting information often lacks a theoretical basis.

Simultaneously, given the differences in accounting standards across countries, it is necessary to conduct an in-depth analysis of each individual sample. As the world's second-largest economy, China is experiencing rapid economic growth. However, with the implementation of China's new accounting system, the National Bureau of Statistics of China has comprehensively revised historical quarterly GDP data. This revision aims to ensure that the quarterly GDP data from 1992 aligns with international standards, thus enhancing its international comparability. This process may involve the re-collection, correction, and adjustment of data to ensure consistency and accuracy (NBS, 2023). Therefore, researchers engaged in macroeconomic studies that include China must acknowledge the potential data discrepancies resulting from changes in accounting methods, which could impact the international comparability of the data. Due to the rapid updates in accounting standards, existing research may struggle to capture accurate financial data. Specifically, China's accounting system underwent a significant

transformation in 2007 with the adoption of new accounting standards aimed at aligning more closely with international standards to enhance the quality and transparency of financial reporting. The old and new standards differ markedly, leading to substantial differences in accounting treatments and disclosures across different periods. As a result, data prior to 2008 is not comparable. Therefore, an in-depth discussion on the international comparability and adaptability of its data is also of practical significance for the study of this topic.

Based on the previous reasons, this thesis aims to enhance and expand existing research in this field by systematically investigating the relationship between micro and macroeconomics through an analysis of GDP growth data within accounting information. It also aims to contribute to the theory of decision-making usefulness of accounting information.

With this main objective in mind, this thesis aims to establish a theoretical framework by employing mathematical and statistical methodologies for quantitative analysis, specifically exploring the influence between micro-level corporate financial information and macroeconomic factors. Consequently, as one of its subsidiary objectives, this research endeavors to uncover the inherent relationship between these variables by conducting a comprehensive bibliometric analysis of existing literature on the impact of accounting earnings on economic growth. Additionally, this study seeks to forecast future trends in this field using a neural network model while simultaneously evaluating the scientific significance of this emerging research direction, thereby providing an essential theoretical foundation for advancing future investigations in this domain.

According to the research objectives of this section, the corresponding research inquiries are delineated as follows:

RQ1: What is the development status of the existing research on accounting earnings and economic development?
RQ2: What trends will the research on accounting earnings and economic development have in the future?

As the second sub-objective, this thesis aims to empirically analyze the information regarding changes in GDP contained within aggregate-level accounting data. Consequently, it not only verifies the performance of models in existing studies on Chinese data, it also proposes a four-factor model based on the GDP income approach. The foundation of this model lies in the System of National Accounts developed by the United Nations Department of Economic and Social Affairs (UNDESA, 1993), as well as the definition of GDP income method. The composition of GDP can be categorized into four elements: employee wages, net production taxes, depreciation of fixed assets, and operating surplus. According to the research objectives of this section, the corresponding research inquiries are delineated as follows:

RQ3: Can traditional aggregate earnings model explain China's economic growth?
RQ4: Does the aggregate-level accounting information based on the GDP income method model contain China's GDP growth information?

Based on the above four-factor model of GDP composition, in this section we first discuss the model's ability to predict GDP. Secondly, accrual accounting standards emphasize the

significance of accrued revenues and expenses in earnings management. Previous studies have confirmed that accruals contain valuable information regarding future accounting earnings and macroeconomic conditions (Son & Jeong, 2022). However, due to variations in accruals caused by divergent accounting standards across countries, a comprehensive discussion is required to explore the incremental information contained within accruals at an aggregate level. Therefore, this research aims to contribute to this this field by incorporating the accrued revenues and accrued expenses items from the quarterly balance sheet into the four-factor model.

Additionally, this research introduces a novel research concept. Drawing on the existing literature concerning aggregate-level accounting information and GDP forecasting and considering the time series data employed in this research, it proposes the application of the backpropagation (BP) neural network model in addition to the traditional linear regression model, to test the predictive capacity of aggregate-level information on future GDP. Furthermore, this research compares the predictive performance of the traditional econometric model and the BP neural network model for GDP, thereby exploring the future GDP change information contained at the aggregate level from a fresh perspective.

Therefore, the corresponding research questions are defined as follows:

RQ5: Can aggregate-level accounting information based on the GDP income method model predict China's GDP?

RQ6: Can the neural network model optimize the GDP forecasting model proposed in this thesis?

RQ7: Do aggregate-level accruals and accruals contain information about future changes in GDP?

In summary, this thesis aims to enhance and expand existing research by systematically investigating the relationship between micro and macroeconomics through an analysis of GDP growth data within accounting information, contributing to the theory of the decision-making usefulness of accounting information. To achieve this, the research has two subsidiary objectives: conducting a comprehensive bibliometric analysis of existing literature to uncover the inherent relationship between accounting earnings and economic growth, and empirically analyzing the information regarding changes in GDP contained within aggregate-level accounting data.

The contributions of this study are as follows:

Firstly, this study conducts a bibliometric analysis of existing literature on related topics to establish a robust theoretical foundation for empirical research, thereby laying the groundwork for future advancements in this field within the scientific community.

Secondly, it critically examines and evaluates the topic's status and significance within the scientific community, thus providing valuable insights to support further advancements in research.

Thirdly, by conducting comprehensive research on the international comparability and adaptability of a single dataset, this study offers valuable references for other related studies while ensuring its own academic rigor.

Fourthly, it presents an innovative GDP forecast model based on the income-based GDP accounting method, providing a novel approach to predicting GDP using comprehensive accounting information.

Fifthly, by expanding upon the four components of the GDP income approach, it deepens our understanding of future economic changes embedded in aggregate accounting information while presenting fresh evidence. Moreover, it offers new insights to researchers in relevant fields.

Sixthly, it explores how incorporating information about future economic growth derived from accumulated accruals enhances the utility of accounting information.

Seventhly, it employs neural network models for testing purposes and contributes to their applicability across different domains.

Lastly, it enriches the literature on macroeconomic usefulness by providing valuable insights into future economic changes.

1.2 RESEARCH STRUCTURE

This dissertation is divided into seven chapters, with the present one introducing the topic, justifying the rationale of the study, and proposing its purpose.

Chapter 2 conducts an extensive bibliometric analysis of macro-accounting using the influential databases Web of Science and Scopus, aiming to enhance the theoretical

foundation of this topic. It also examines the latest research trends in macro-accounting every year and predicts its future development through a neural network model.

Chapter 3 provides details about the research data sources and specific methods for processing the raw data.

Chapter 4 validates existing aggregate profitability research models and then examines sample data performance of GDP components using an income-based approach, drawing interesting conclusions.

Chapter 5 introduces the GDP composition model using the proposed income-based approach for GDP forecasting. It also introduces a neural network model for a comparative study with the traditional linear model.

Chapter 6 further optimizes the GDP composition model based on the income method and tests its prediction effect on GDP by incorporating accounting accruals. It also introduces a neural network model for comparative research.

Finally, Chapter 7, general conclusions are drawn from this thesis along with discussions on limitations and future research opportunities.

2

LITERATURE REVIEW[1]

[1] A section of this chapter has been Published in August 2022:

Sun, M., Urquía-Grande, E., Chamizo-González, J., & del Campo, C. (2022). Accounting Earnings and Economic Growth, Trends, and Challenges: A Bibliometric Approach. *Computational Intelligence and Neuroscience*, 2022(C), 7352160. https://doi.org/10.1155/2022/7352160

This chapter uses the method of bibliometric analysis to comprehensively examine the current research status of macro-accounting and establish the theoretical foundations for this thesis. Simultaneously, it employs a neural network hybrid method to analyze its future development trends. Concretely, it explores two associated theoretical frameworks: the advancement of national economic accounting theory and the international comparability of China's economic data. Furthermore, it reviews the application and development of artificial neural networks and BP neural network models in this field.

The present chapter reveals that this research area pertains to the investigation of earnings usefulness, with a particular focus on micro-level firms' aggregate earnings as the primary indicator. Therefore, it begins with a review of research on earnings usefulness and systematically examines its progress in depth.

2.1 METHODOLOGY AND SAMPLE

This study uses Scopus and Web of Science (WoS) databases, which serve as primary sources for indexing scientific papers and collecting data from numerous articles. Both databases yield dependable and high-quality literature search outcomes (Gaviria-Marin et al., 2019), although there are studies trying to determine which of the two databases is better (Esteban et al., 2022). The aim is to compare and analyze the findings obtained

from these two databases as integrating multiple databases for analyzing scientific data can enhance the reliability of bibliometric analysis results (de Oliveira et al., 2019).

Additionally, this chapter examines Price's law as a mean to enhance the elucidation of the current research status. Price (1986) observed that there consistently exist a selected few individuals who dominate publications within a given field. Therefore, Price's law posits that scientific research progresses through four distinct stages: the precursor stage, characterized by initial developments; the exponential growth stage; the consolidation of knowledge stage; and finally, the decline in production stage.

Accounting information is intricately linked to economic development as it serves as a vital tool for fostering cost-effective economic progress. Hence, the objective of this chapter is to explore the research domain encompassing accounting information and macroeconomics. The indicator "aggregate earnings" epitomizes this subject matter most effectively. However, due to limited existing literature on this topic, this chapter commenced by investigating its preceding dimension: the research on the usefulness of earnings. Employing keywords such as "usefulness" and "earnings," it conducted searches for relevant keywords, abstracts, and topics. In terms of the research line pertaining to "aggregate earnings," despite its scarcity in literature, an independent investigation was undertaken.

After completing the aforementioned preparations, this chapter will utilize the gathered data for bibliometric analysis, as its findings can provide valuable insights into the research capacity and diverse scholarly directions within the academic community pertaining to this particular subject matter.

This study aims to analyze the intricate details of research lines pertaining to the utility of earnings in this domain, based on the findings obtained on this subject matter. It will employ VOSviewer (Vision 1.6.7 for Microsoft Windows 11), an information visualization software, to construct knowledge maps using outputs from both Scopus and WoS databases. By utilizing the co-occurrence mapping technique, temporal changes in research trends can be observed along with the identification of current hot topics within existing research areas. Subsequently, this investigation will scrutinize and compare output data from both databases to assess similarities and differences in research status. Finally, a neural network model will be employed to predict future focal points within the aggregate earnings topic across these two databases.

2.2 BIBLIOMETRIC ANALYSIS

2.2.1. Usefulness of earnings

A) Yearly publication and citation frequency

After manually excluding the completely unrelated fields, 251 publications were obtained on WoS and 282 on Scopus. First a bibliometric analysis of the earnings usefulness research was implemented. This step is to find the position of aggregate earning research in the current academic world and explore its macro development trend. It used the collected data to compare the annual publications (Figure 2.1).

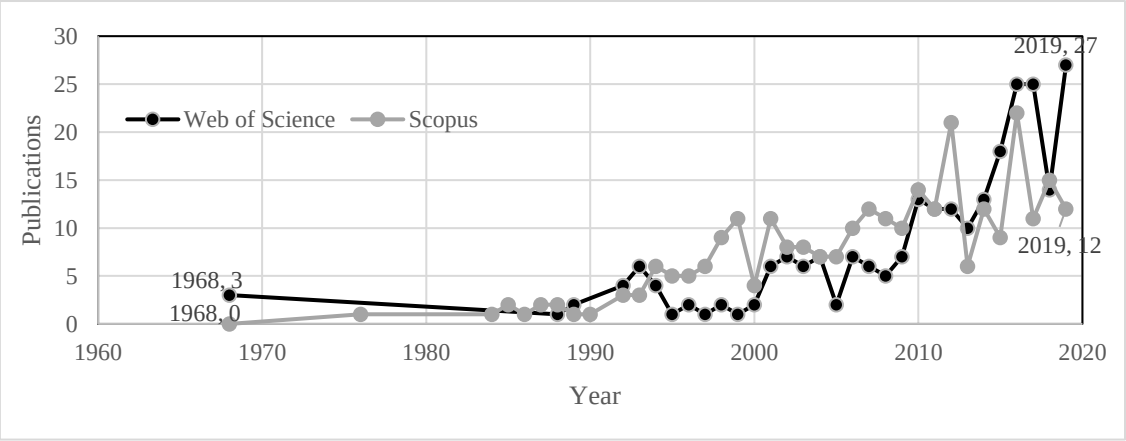


Figure 2.1 The usefulness of earnings yearly number of publications in WoS and Scopus

Figure 2.1 shows that the earliest evidence found on WOS dates from 1968 (with three articles), and until 1990, the research intensity was very low (only one article). The number of papers started to increase in the late 1990s and is still increasing. This is a solid upward trend, with almost identical results for both databases. The reason why the results of the two databases are basically the same might be related to the 2008 global economic crisis as the uncertainty brought about by the economic crisis makes accounting usefulness research even more influential. Simultaneously, although the two databases' results show large fluctuations during 2010-2019, both curves have an exponential upward trend. According to this trend, this research will arrive to the third stage in a few years, which is the consolidation of knowledge stage (Price, 1986)

For the quartiles of these publications in both databases, it was found that more non-impact journal publications are included in WoS than in Scopus, 24% in WOS compared to only 4% in Scopus. Also, the proportion of Q1 journals in Scopus accounts for 52%, while in WoS is only 38%. Among the two databases, papers on this topic published in high-impact Q1 and Q2 journals, account for the majority, 57% in WoS and 81% in

Scopus, proving the importance of this topic (see Table A2 in Appendix A). It should be noted that this thesis's findings are not influenced by recent changes in WoS regarding the assignment of quartiles and impact factors to ESCI (Emerging Sources Citation Index) journals, as the data collection was conducted prior to these changes.

Secondly, the present study examines the annual citation patterns of both databases. Due to variations in document inclusion, Figure 2.2 illustrates significant disparities between the two databases. In Web of Scienc, citations demonstrate a consistent upward trend throughout the entire analyzed period. However, Scopus exhibits high activity levels from 1995 to 2006 followed by a sharp decline thereafter. Additionally, Scopus displays fewer influential papers compared to WoS, indicating a decline in its influence within this field post-2006. This study posits that Scopus research holds untapped potential for further development and suggests that exploring new research directions can provide valuable support for innovation and advancement within the field.

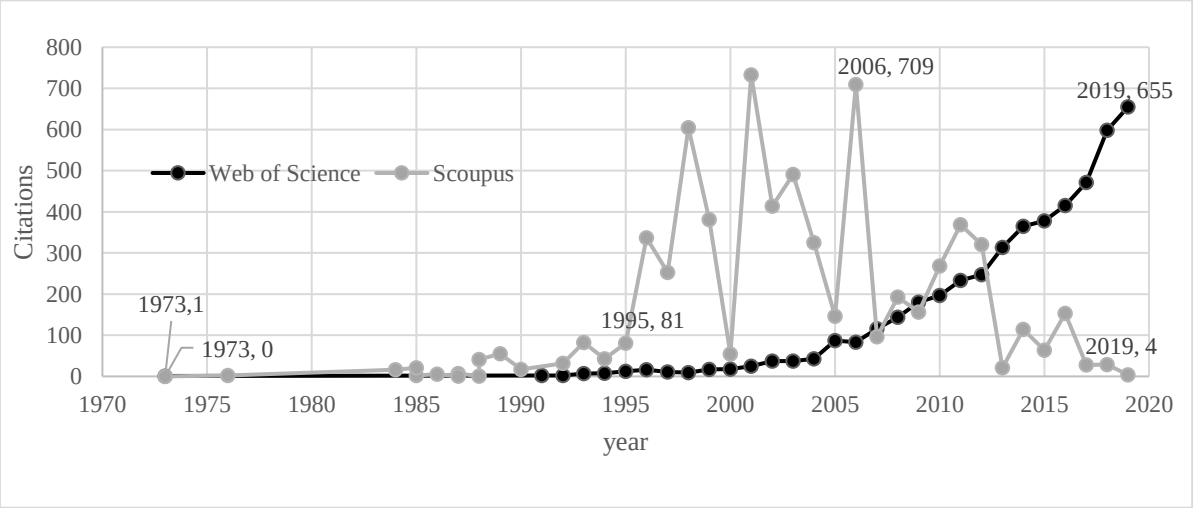


Figure 2.2 The usefulness of earnings yearly number of citations in WoS and Scopus

B) Term co-occurrence maps and research lines

The present section aims to compare and analyze the co-occurrence maps generated using the two databases, providing insights into the most frequently utilized terms in this particular field of study. In this investigation, the co-occurrence threshold was adjusted to tenfold, resulting in 107 matches out of a total of 5,205 WoS terms. Considering VOSviewer's default setting that retains only the top 60% terms, a total of 64 terms were selected for generating maps. Similarly, employing identical parameters for Scopus, data analysis yielded 123 matches from a pool of 5,518 terms. Ultimately, we retained a set of 74 generated terms.

The term co-occurrence maps based on WoS and Scopus results are shown, respectively, in Figure 2.3 and Figure 2.4. According to the threshold, these terms can only be displayed when they occur ten times or more. In other words, when scholars mention them often. The closer terms have a stronger connection, forming clusters. These clusters are the existing research lines in the research area. The map was set to density visualization to better observe the hotspots of terms and their clustering distribution. The results in both databases were determined by VOSviewer and resulted in three clusters.

By comparing the two databases' results, we can find that each cluster in the two databases in Figures 2.3 and 2.4 has its representative terms clustered in three main research lines in the usefulness of earnings research.

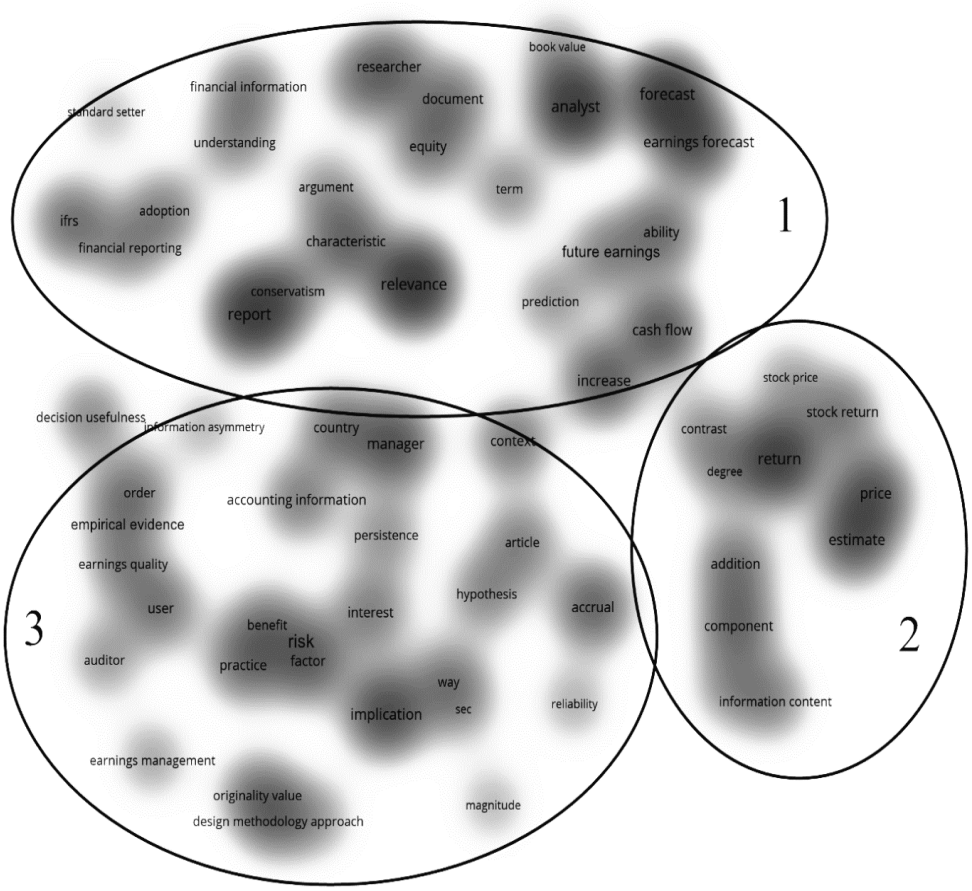


Figure 2.3 WoS term co-occurrence map

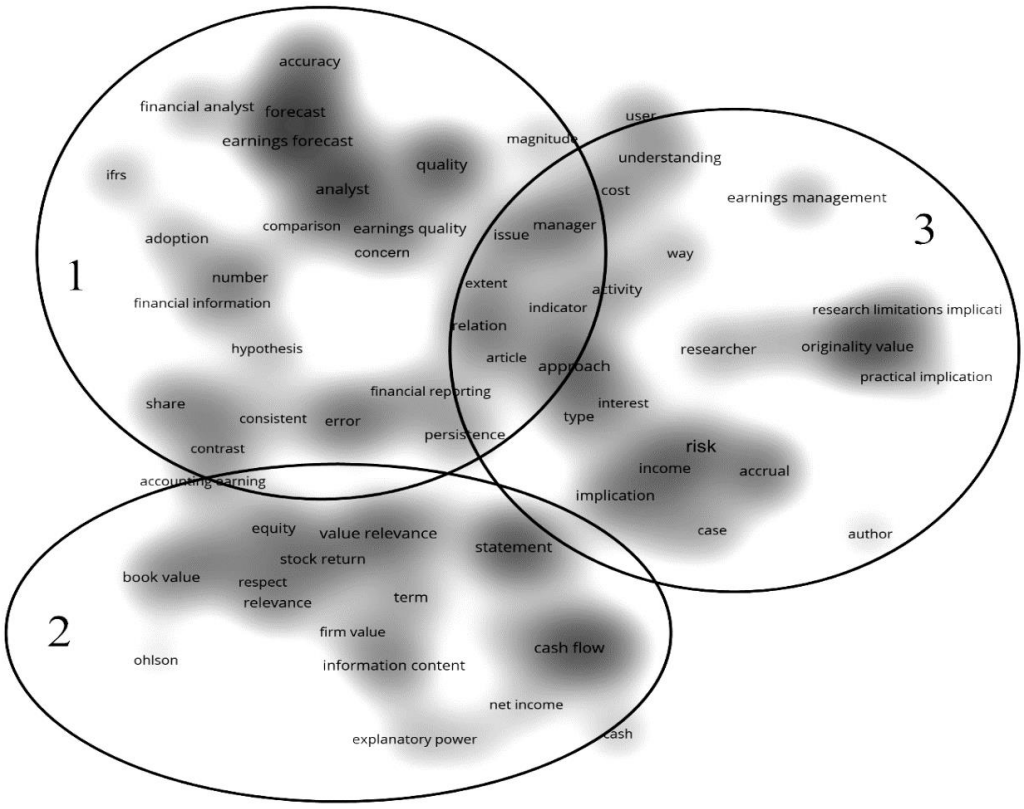


Figure 2.4 Scopus term co-occurrence map

However, upon conducting a specific analysis of the co-occurrence terms within each cluster on the map, it becomes evident that certain hotspots differ significantly. These distinct terms signify diverse research directions within the two databases. This phenomenon is that even if the research in the two databases is in the same field, the different topics that researchers are concerned with will lead to different co-occurring terms. Analyzing these different terms can contribute to find the different research directions of the two databases' documents.

This study reveals that two research directions exist simultaneously; however, there is a limited correlation among numerous terms in Scopus. Research pertaining to these topics appears more independent and does not form an interconnected knowledge network, yet it exhibits greater novelty compared to WoS. Notably, Scopus research is currently in its early stage of scientific development with a predominant focus on basic theoretical investigations occupying the mainstream. Nevertheless, such studies can provide valuable support for subsequent research endeavors, thereby highlighting Scopus' substantial potential for further advancements in this field.

C) Review of relevant literature

This first cluster focuses on the capacity of the earnings to value the stock price and also includes forecasts of future earnings and stock movements, examining the ability of accounting earnings to predict the future. Research such as Dechow et al. (1998) found that accounting earnings information can better predict future cash flows. Brown and Han (2000) used a first-order autoregressive model to show a stable relationship between the

earnings period and the quarterly report aggregate information to predict future earnings data.

Furthermore, Lev et al. (2010) focused on accrued profits and examined the usefulness of accounting estimates of accrued profits in predicting future returns. They found that increased accrual accounting estimates harm future cash flow predictions. More recently, Nallareddy et al. (2018) found that, in general, cash flow is more advantageous than earnings in predicting future cash flows. Some researchers have already developed research on future excess earnings. For example, He and Narayanamoorthy (2020) found that the quarter-over-quarter change in earnings growth has a solid ability to explain future excess returns.

The literature of cluster 2 focuses on the return performance as well as on the usefulness of earnings in companies' contracts, including research on its performance. Researchers use earnings-based financial indicators to study firm performance and ultimately apply them to contracts, such as debt and salary contracts. Research such as Sloan (1993) investigated the role of accounting earnings in executive compensation contracts. Beatty et al. (2008) studied the conservative modifications associated with debt contracts, finding that companies with more conservative financial reports would be more likely to make conservative changes. Rhodes (2016) studied the impact of implicit incentives provided by earnings-based debt contracts on CEO compensation contracts. Li (2016) pointed out that those earnings-based contract indicators are closer to EBITDA-based performance indicators, while Dyreng et al. (2017) affirmed that those performance indicators based on accounting earnings are not conservative when used in contracts. Also,

Curtis et al. (2021) studied the impact of using adjusted earnings for performance evaluation on compensation.

Cluster 3 literature focuses on research on the company risk. Some researchers are analyzing financial risk indicators based on accounting earnings information. The accounting surplus is linked to lower financial risk and accounting deficit with greater financial risk. At the same time, others focus on their risk on earnings or earnings-based variables. DeYoung and Roland (2001) found that earnings volatility contains information about the company risk. More recently, Shahchera and Noorbakhsh (2018) believed that the research on risk and earnings should also consider the company size and type. They found that the bank size is negatively related to earnings volatility. Other researchers try to explain the company risks based on many financial indicators, usually based on Beaver et al. (1970), which analyzed the capacity of financial indicators to explain the market beta to measure the market system risk. Following their idea, Agusman et al. (2008) showed that the standard deviation of the return on assets and the loan loss reserve could be essential concerning the absolute risk. Khan (2012) proved the correlation between risk indicators and accounting indicators.

It also has to be noted with cluster 1 that, although both databases focus on the earnings predictions for the future, in WoS, the report and the correlation between them have received more attention, such as Brown and Han (2000), while in Scopus, researchers like Lev et al. (2010) are more interested in the earnings quality. In cluster 2, both databases show that this research line focuses on the earnings return. However, in WoS, the pricing, estimation, and contract have also received attention, such as Beatty et al. (2008). Other studies have also focused on the book value and corresponding value, like Sloan (1993)

in Scopus. Finally, in cluster 3, both databases show research about risk. However, in WoS, some research also discusses the influencing factors and implications, such as Khan (2012), with other publications discussing this research line benefit and design methodology like Agusman et al. (2008).

Finally, in Figures 2.3 and 2.4, it can be seen that the degree of correlation between many terms is not very high, which means that the research on these topics is more independent and has not formed a knowledge network. Also, cluster 1 and cluster 3 in Figure 2.4 intersect which means that some Scopus publications discuss two research directions simultaneously, and the research has a higher degree of innovation. According to what it was mentioned before, Scopus research is in the early scientific development stage in the research on the usefulness of earnings. Theoretical basic research is now dominant. These theoretical studies provide support for follow-up research, so Scopus has more development potential in this field.

2.2.2 Aggregate earnings

The present study aims to establish the significance of "aggregate earnings" research within the academic discourse. Upon thorough examination of the existing literature, it was observed that these investigations are typically categorized under the first cluster pertaining to future earnings predictions. Kothari et al. (2006) identified variations between aggregate earnings and firm-level accounting earnings, thereby instigating a surge in research on aggregate-level accounting information. Consequently, researchers commenced deliberations on incorporating macroeconomic data into discussions surrounding aggregate earnings.

A) Yearly publication and citation frequency

The present chapter already discovered that aggregate earnings research belongs to the first research line of earnings usefulness research (see section 2.2.1). After manually eliminating irrelevant fields, it obtained 74 publications on WoS and 94 publications on Scopus. This section discusses its research status and future development trends in the two databases. First, it compared the two databases' annual publications (Figure 2.5) and annual citations (Figure 2.6) on this topic. At the same time, the quartiles were also collected from the two databases corresponding to these publications, as shown in Appendix 2.

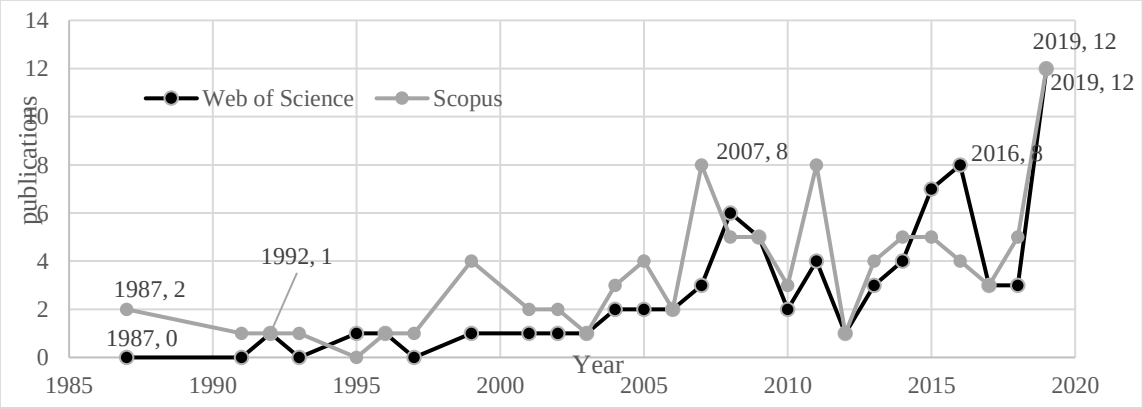


Figure 2.5 Aggregate earnings yearly number of publications in WoS and Scopus

It can be seen in Figure 2.5 that the earliest Scopus research was published in 1987. WoS results are slightly later than Scopus (1992). As the years pass, the number of publications in the two databases have remarkable similarities, as it happened with the research of earnings usefulness (see Figure 2.1).

Moreover, this lately developed topic has not been rapidly developed until recent years. According to Price's law (Price, 1986), it has just entered the exponential growth stage from the precursor stage of scientific development. Hence, this topic has now excellent development potential. Furthermore, its development curve becomes exponential, indicating that it will become a research hotspot in the following years.

According to Appendix 2, for the quartiles of these publications, it is found that in the same situation as the research on earnings usefulness, WoS included 19% publications from non-impact journals (impact factor or quartiles), which is more than Scopus 4% in the topic of aggregate earnings. In addition, in the collection of Scopus in recent years, the proportion of Q1 journals is more significant than that of WoS (54% vs 43%). Also, the high-impact Q1 and Q2 journals account for a large proportion of the two databases, which have 63% in WoS and 83% in Scopus.

In Figure 2.6, it can be seen that the behavior of the two databases is very different. In WoS, the number of citations shows a regular upward trend from the beginning, while in Scopus, this field was very active from 1997 to 2005, but the number of citations decreased steadily after 2005. There might be two reasons for this phenomenon. From a macro perspective, as shown in Figure 2.2 before, after 2005, the number of citations of Scopus research in the usefulness of earnings field has generally shown a downward trend. The research on aggregate earnings is one of the research lines on the earnings usefulness, which leads to unified results. Secondly, according to the comparative analysis of the terms in Figure 2.4, Scopus research is more independent than WoS research. The development of new areas has not received attention yet, leading to a decline in citations.

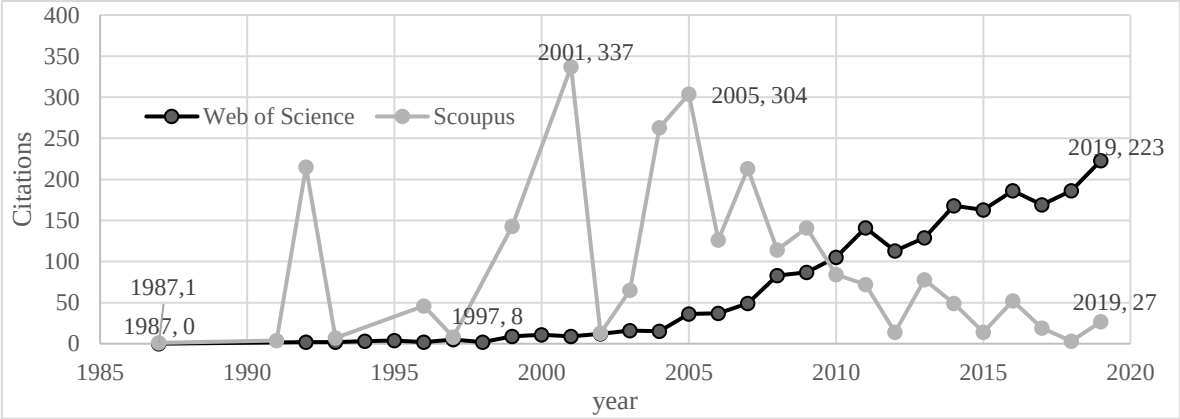


Figure 2.6 Aggregate earnings yearly number of citations in WoS and Scopus

B) Term co-occurrence maps and research lines

As with the previous analysis on the usefulness of earnings, the present subsection will analyze the research lines on aggregate earnings through the two databases' term co-occurrence map. To better study the clustering of terms, it also uses binary counts to generate maps. For the term co-occurrence threshold, called critical value, which refers to the lowest or highest value that an effect can produce, because of the limitation of the number of terms, this research modifies it to 5. In the end, it got 53 meets in WoS 1525 terms. Similarly, VOSviewer, in order to ensure the results are meaningful, only keeps the most important top 60% of terms, so it only gets 32 terms to generate the maps. This study uses the same settings for Scopus data, and in 180 terms, we get 73 meets. Finally, 44 generated terms are retained.

Figure 2.7 shows the term co-occurrence map based on WoS results, and Figure 2.8 shows the term co-occurrence map based on Scopus results. It also uses density visualization to see the clustering of terms. VOSwievier identified three clusters in the two databases' co-occurrence maps circled in both figures.

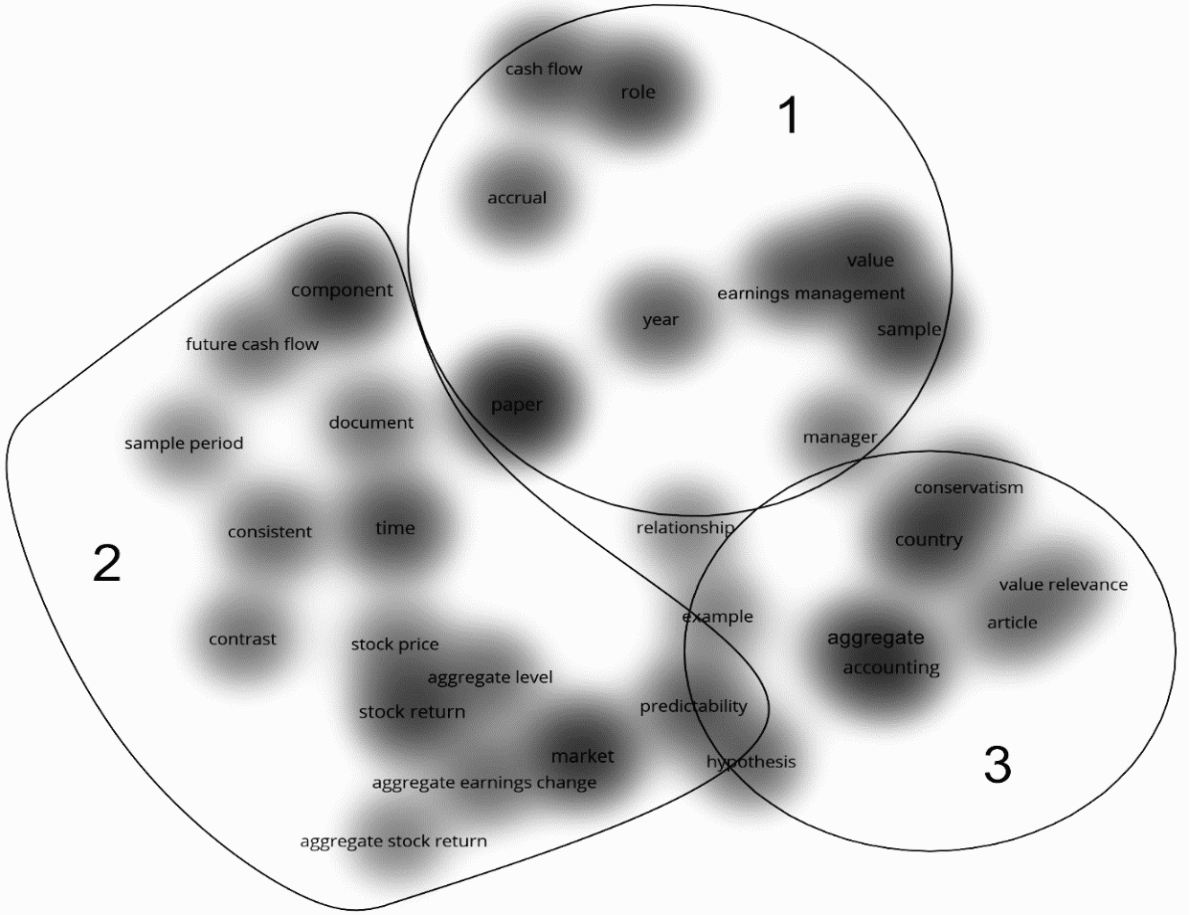


Figure 2.7 WoS term co-occurrence map

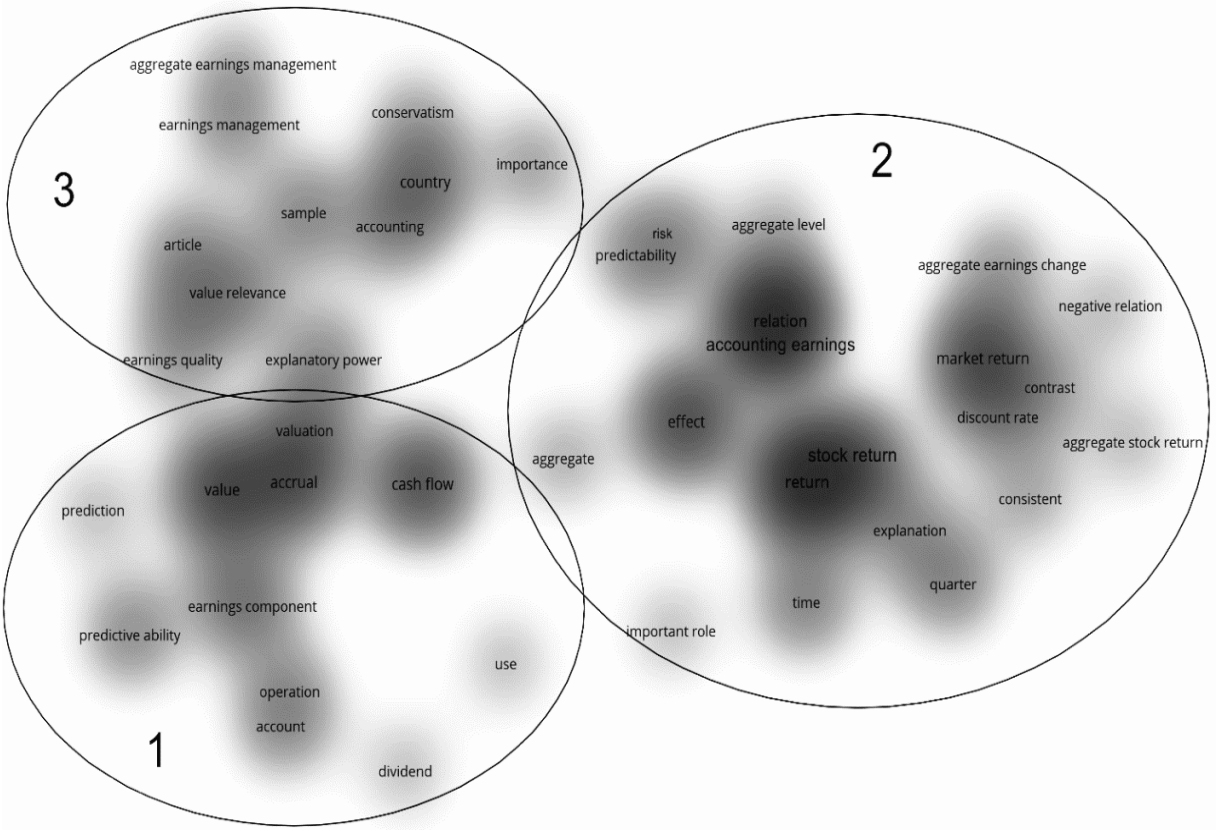


Figure 2.8 Scopus term co-occurrence map

The clusters show the different research lines. The results of both databases show that there are three research lines. We compared the co-occurrence terms of these three clusters and found that they are very similar, showing that there are three main research lines for the research of aggregate earnings. However, the results are also not identical due to the different internal links between the two databases. According to the results in the two figures, smaller research directions are different. In cluster 1, "paper", "value", "sample" and "role" are hot terms. Both databases show that this research line is related to value research and existing papers (e.g. Berkman & Yang, 2019; Gkougkousi, 2014; Kothari et al., 2006). According to these same terms, most research tends to be theoretically exploratory. However, research in WoS also pays attention to traditional earnings management research within this research line, such as Patatoukas (2014), while

Scopus results also focus on the composition and prediction of earnings, such as Berkman and Yang (2019).

For cluster 2, hotspot terms are "component", "time", "stock return" and "market". Both databases show market and stock return research (e.g. Berkman & Yang, 2019; Patatoukas, 2014). Nevertheless, WoS also focuses on time and market (e.g. Kang, 2019; Kothari et al., 2006), and Scopus focuses on effect and some financial indicators (e.g. Berkman & Yang, 2019; Cready & Gurun, 2010).

Finally, for cluster 3, terms "aggregate", "accounting", "country", and "conservatism" are of concern for researchers. Both databases' studies focus on the country, accounting, and conservatism. These terms show that this research line is about the relationship between the micro and macro levels (e.g. Konchitchki & Patatoukas, 2014; Shivakumar, 2007; Sumiyana et al., 2019). However, there are no more small research branches in WoS, and Scopus also mentions other research directions such as importance and aggregate earnings management (e.g. Ball et al., 2019; Gallo et al., 2016).

C) Review of relevant literature

Since this topic is relatively new, neither database has much research, and most is duplicated. Based on the above results, some research involves multiple research lines simultaneously making it difficult to analyze each research area as precisely as in the previous section. Therefore, based on the two databases' results, the present section analyzes and reviews those studies with high impact.

As this study found, accounting information usefulness theory is based on the usefulness of accounting information for relevant decisions. The usefulness of accounting information at the aggregate-level is primarily reflected in the predictive value of aggregate earnings (AE) due to their extensive use in forecasting market returns.

In the early stages of aggregate earnings research, the literature extensively employed it to establish a connection between a company's earnings information and macroeconomics. Pioneering this exploration, Kothari et al. (2006) extended the study of income information to the aggregate level, discovering that aggregate earnings contain information about future inflation in the United States. Subsequent studies, such as Cready and Gurun (2010); Patatoukas (2014); Shivakumar (2007); Shivakumar and Urcan (2014), affirmed the inclusion of inflation information or information related to future discount rates in aggregate earnings.

The company's earnings information represents the level of profitability of the company. Listed companies with higher earnings can often bring higher returns to the stock market, a point of view scholars have widely accepted. However, in some studies, researchers have discovered different phenomena. For example, in an analysis of the aggregate earnings from the US market data, Kothari et al. (2006) found that aggregate earnings are negatively correlated with stock market returns, while Gkougkousi (2014) reached a similar conclusion in his research based on the bond market. These results lead to believe that the aggregate-level of accounting information has unique information, generating scholars' enthusiasm for aggregate earnings, an indicator based on the company's earnings information. It is the integration of company-level accounting earnings information and can reflect the aggregate-level of accounting earnings.

Kothari et al. (2006) pointed out that the negative correlation is due to the discount rate. They believe that the increase in aggregate earnings can increase investors' expectations of interest rates. Ball et al. (2009) found that the aggregate earnings negatively correlate with the previously expected US market returns, suggesting that aggregate earnings do not reflect more new information content.

In order to verify the views of these two papers, Patatoukas (2014) decomposed the stock market returns according to Campbell (1991) method: expectations for future market interest rates during the period, expectations for future cash flows during the period, and the expectations of the market return during the previous period. He validated the view of Kothari et al. (2006) that the aggregate earnings are positively correlated with the expected interest rates and the expected future cash flows. Specifically, when aggregate earnings are negatively correlated with stock market returns, the positive correlation between aggregate earnings and expected interest rates is greater than the positive correlation between aggregate earnings and future cash flows. To facilitate the understanding of the relationship between these studies, see Figure 2.9.

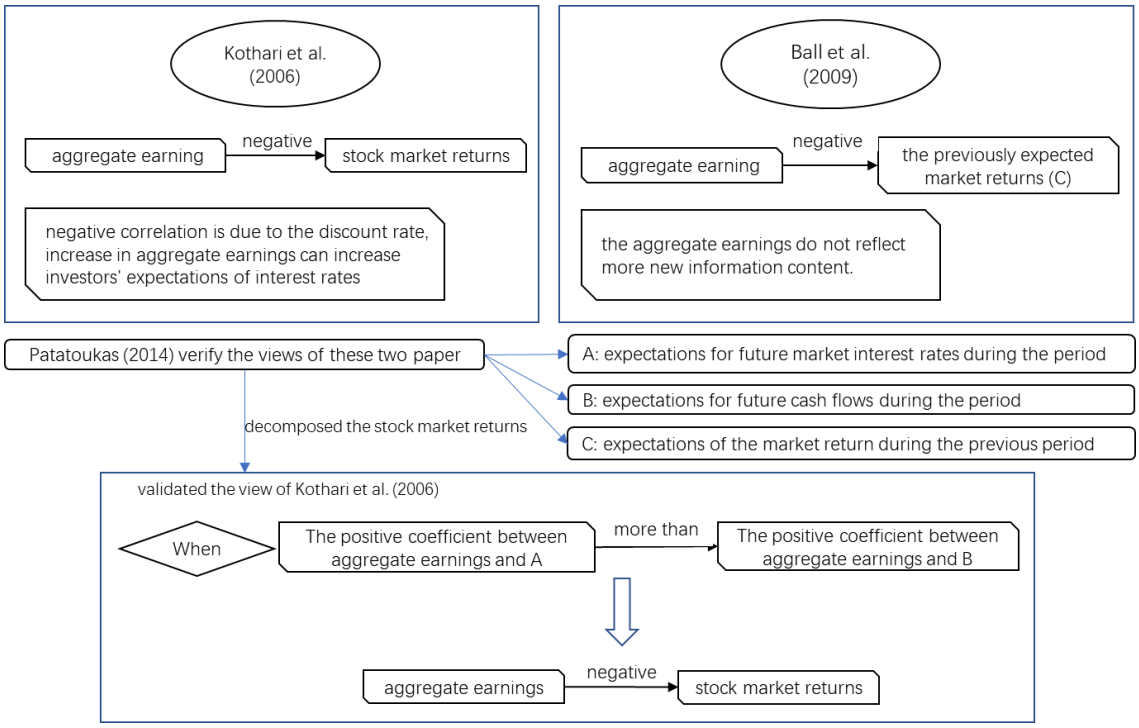


Figure 2.9 Mainstream views of aggregate earnings.

Later, Choi et al. (2016) found that the aggregate earnings relates positively to the US market returns. They also verified the result of Kothari et al. (2006), that the discount rate does cause their negative relationship. Bailey and Lai (2020) modeled the aggregate earnings time series using principal components analysis, finding that the key to the relation between the aggregate earnings and the US market returns lies primarily in the expected component.

Also, several studies have focused on the relationship between aggregate earnings and macroeconomic growth. Early Kothari et al. (2006) showed that aggregate earnings positively correlate with macroeconomic growth indicators such as industrial output, GDP, and personal consumption to better explain the relationship between enterprises and capital markets. Konchitchki and Patatoukas (2014) confirmed that aggregate earnings growth is positively correlated with the US future nominal GDP growth and can

predict future economic growth. They also found that aggregate earnings contained more quantitative forecast information than professional predictions. Cready and Gurun (2010) highlighted a negative correlation between aggregate earnings news and market returns, regardless of the announcement period, indicating that the market does not necessarily appreciate the information conveyed by aggregate earnings. In addition, Patatoukas (2014) posited that aggregate earnings are intertwined with all components of stock market returns, and his findings revealed a positive correlation between the cash flow component in aggregate earnings and the discount rate.

Several studies have delved into the correlation between aggregate earnings and inflation, seeking to establish an indirect impact on market returns. Shivakumar and Urcan (2014) corroborated the notion that the expansion of aggregate earnings is prognostic of future inflation, a relationship that can be further elucidated by examining the interconnection between aggregate earnings and market returns. Gallo et al. (2016) uncovered a positive correlation between aggregate earnings and unexpected fluctuations in the U.S. funds target rate, thereby indicating a parallelism between aggregate earnings and risk premium. Bailey and Lai (2020) employed predictive regression modeling of aggregate earnings, employing principal component analysis. Their findings revealed a negative correlation between aggregate earnings and expected market returns prior to 2000, which reversed upon an increase in volatility post-2000. Kim et al. (2020) delved into the reasons behind the variation of aggregate earnings growth with market returns, concluding that aggregate earnings exhibit a significant positive correlation with the growth of the U.S. Industrial Production Index. Moreover, they observed that the ability of aggregate earnings in the U.S. to explain market returns had improved in recent years, attributed to more accurate fair value estimates.

Previous research also examined the correlation between aggregate earnings and GDP to facilitate the forecasting of GDP. Seminal studies, such as those conducted by Konchitchki and Patatoukas (2014a, 2014b), have tested the relationship between aggregate earnings and GDP. Their findings corroborate the predictive value of aggregate earnings for future GDP and highlight the potential of these earnings to improve the accuracy of GDP forecasts. Ball et al. (2019) focused on the smoothness of company-level earnings. They investigated whether the smoothness of earnings can increase companies' information contribution to the aggregate earnings in future GDP forecasting research. Furthermore, they found that aggregate earnings are more focused on companies with smoother earnings, making these companies' financial information more informative. Sumiyana et al. (2019) tested the ability of aggregate earnings to predict GDP growth. They compared the results of multiple countries and found that aggregate earnings, operating income, operating cash flow, and accrued expenses can predict GDP growth in the following one and two years. The company earnings component is an excellent predictor of future GDP growth. Berkman and Yang (2019) defined the aggregate analyst recommendation at a country level as the value-weighted average of the stocks of companies incorporated in that country. They found that this proposal also helps predict GDP and aggregate earnings changes.

Finally, few studies have investigated the relationship between other aggregate-level accounting information and GDP. Abdalla and Carabias (2022) not only highlighted the information about future GDP embedded in aggregate earnings but also examined the GDP-related information content contained in special items at the aggregate level. Their research revealed that special items at the aggregate level could better capture changes in

GDP. Son and Jeong (2022) also validated the predictive ability of aggregate earnings on GDP through South Korea's data.

The above literature shows that the aggregate earnings indicator is a comprehensive reflection of the company's horizontal earnings and has unique information content. The aggregate earnings index reflects the profit information of the whole company and affects the stock market return and future macroeconomic activities. However, in the accounting field, the topic of aggregate earnings information has not received enough attention compared to other topics. Therefore, it is necessary to study aggregate earnings, as it has practical significance for predicting economic growth.

2.3 AGGREGATE EARNINGS RESEARCH TRENDS

2.3.1 Findings and discussion applying the terms

The development and future trends of the aggregate earnings research are compared below based on the terms of the two databases.

For WoS term development, most terms occurred in 2010-2015. Specifically, from 2005-2010 o before, only "stock returns" and "information" had attracted the attention of researchers, such as Kothari et al. (2006). While, from 2010 to 2015, more terms, such as "prices", "information-content", and "accruals", have become the focus of attention of researchers, like Cready and Gurun (2010).

From 2015 to 2020, terms such as "affect market returns", "guidance", "investment", and "announcement" first appeared in the research on aggregate earnings. Currently,

researchers are paying more attention to research on aggregate earnings and investment. After that, keywords such as "quality", "tax avoidance", and "economic growth" became hotspots, which means that in recent years, researchers have paid greater attention to the relationship between aggregate earnings and macroeconomics (e.g. Ball et al., 2019; Gallo et al., 2016; Patatoukas, 2014).

For Scopus, the term development around 2005 or before, "employment", "wage", "accrual" have attracted the attention of researchers. After 2005, research on the relationship between aggregate earnings and national economic growth began with "economic analysis", "economic growth". Lately, "gross domestic product" has become a research hotspot (e.g. Ball et al., 2019; Konchitchki & Patatoukas, 2014).

Comparing the results in WoS and Scopus, the term "accrual" occurred in WoS around 2010, five years later than Scopus, showing that Scopus research has paid more attention to accrual accounting research earlier in this field. Furthermore, related research on "earnings management" occurred in WoS before 2015 and in Scopus not until 2015-2020. The study of earnings management belongs to the traditional study of earnings usefulness. Again, this is also why the "stock return" occurred in WoS earlier than 2005 and in Scopus not co-occurred until 2015-2020. However, the Scopus research on "economic growth" has occurred around 2015, and in WoS did not occur until recent years.

2.3.2 Findings and discussion applying a network model

The present research also wants to compare the predictive ability of traditional time series modeling ARIMA (Autoregressive Integrated Moving Average) and neural network BP (Back Propagation) model and optimized PSO-LSTM (Particle Swarm Optimization-

Long Short-Term Memory) model on this topic. For the ARIMA model, the differential moving average autoregressive model is referred to as the ARIMA model for short. It is mainly used to fit time series with stationary attributes or converted into a time series with stationary attributes. Box et al. (2015) proposed the complete process of constructing an ARIMA model. The central idea is to make the unsteady original sequence stable through the difference operation method

Based on the existing PSO-LSTM model, Liang et al. (2021) proposed a prediction method for emerging research topics, predicting the future popularity score of research topics based on historical observations. Their model shows as follows:

$$AFD_i = DF_i - \alpha * ADF_{i-1}, \text{ (2-1)}$$

$$P_i = In(AFD_i + \delta) * \frac{DF_i+\delta}{DF_{i-1}+\delta}, \text{ (2-2)}$$

Formula (2-1) measure the annual frequency AFD_i of each term, based on the number of documents that contain specific terms. Where DF_i represents the document frequency of a given term at time i and α is the attenuation factor range from 0 to 1. It is set to 0.9, which is a moderate decay rate, halving the impact of the subject after 5 years. Then, the annual growth rate of the subject is calculated through $\frac{DF_i+\delta}{DF_{i-1}+\delta}$. Finally, the activity score P_i is calculated by combining the AFD_i as shown in formula (2-2). Research terms and their occurrences are defined as a time series, and the model is trained based on the historical series to make the model have predictive capabilities.

The present research will draw on the model of Liang et al. (2021) to predict the future research direction of aggregate earnings.

To better investigate the *RQ2* in this thesis, the present research considers the ability of different prediction models to predict the terms activity score P_i in formula (2-2), comparing the performance of the most common forecasting model ARIMA from financial modeling and the neural networks model. This research splits the 1525 terms from WoS and 180 terms from Scopus into series with a fixed length of 5. The value of each series is the real value at the historical term occurrence time. First, the PSO-LSTM model of this study is trained using sample data and then the predictive capabilities of financial modeling and neural network models for terms are compared. The results are shown in Table 2.1.

Table 2.1 Forecast effect comparison

	Model	Mean square error (MSE)	Root mean square error (RMSE)	Mean absolute deviation (MAE)
5-years forecast effect comparison	Neural networks	0.1787	0.4916	0.2853
	ARIMA model	0.2291	0.4885	0.3366
10-years forecast effect comparison	Neural networks	0.4790	0.7315	0.4739
	ARIMA model	0.5402	0.6979	0.4896
20-years forecast effect comparison	Neural networks	0.7440	0.7745	0.6899
	ARIMA model	0.6590	0.8308	0.7455

Through a longitudinal comparison between the ARIMA model and neural networks for forecasting, it is observed that both models exhibit similar values of MSE, RMSE, and MAE. Compared with the neural networks model, it has different degrees of reduction most of the time. Among them, the indicators of the ARIMA model for the 5-years

forecast part were reduced by 0.0504, -0.0031, and 0.0513, respectively. Indicators of the ARIMA model for the 10-years forecast part were reduced by 0.0612, -0.0336. For the 20-years forecast part, the various indicators of the PSO-LSTM model of PSO were reduced by -0.0850, 0.0563, and 0.0556.

According to the PSO algorithm, this study selects a mini-batch learning size of 128 in order to reduce the number of iterations and enhance model training efficiency. The epoch is set to 10 based on a total sample size of 1705, resulting in 134 iterations. After determining the model parameters, the training data consists of 1525 terms from WoS and 180 terms from Scopus, which are divided into fixed-length sequences of 5 with an input dimensionality of 5. Subsequently, an optimization algorithm model is constructed and trained, and the results are presented in Table 2.2.

Table 2.2 Comparison of optimized forecasting effects

	Model	Mean square error (MSE)	Root mean square error (RMSE)	Mean absolute deviation (MAE)
5-years forecast effect comparison	Neural networks	0.2158	0.4574	0.3106
	ARIMA model	0.2227	0.5475	0.2739
	Optimization algorithm model	0.2093	0.4825	0.2623
10-years forecast effect comparison	Neural networks	0.4834	0.6987	0.5419
	ARIMA model	0.5422	0.7238	0.4509
	Optimization algorithm model	0.4828	0.6913	0.4664
20-years forecast effect comparison	Neural networks	0.6610	0.8358	0.6799
	ARIMA model	0.6744	0.7970	0.6684
	Optimization algorithm model	0.6477	0.7964	0.6442

The optimized algorithm model consistently exhibits smaller values for MSE, RMSE, and MAE compared to the ARIMA model in both forecasting and longitudinal comparison. Among them, the indicators of the optimized algorithm model for the 5-years forecasting part decreased by 0.0134, 0.0650, and 0.0116. The indicators of the optimized algorithm model for the 10-years forecasting part decreased by 0.0594, 0.0325, and -0.0155. The indicators of the optimized algorithm model of the 20-years forecast part decreased by 0.0267, 0.0006, and 0.0242 in turn. It can be seen that the optimized algorithm model is indeed effective for the correction of the ARIMA model, and the hybrid model can achieve better prediction results.

Subsequently, the present study incorporated the data from both databases into models (2-1) and (2-2), specifically employing Liang et al. (2021)'s PSO-LSTM model. Based on the model's prediction results, Table 2.3 presents the ranking of each database's influence on the terms related to this particular topic.

Table 2.3 Forecast term ranking of two databases

WoS ranking	Terms	Scopus ranking	Terms
1	Returns	1	Accruals
2	Accruals	2	Economic growth
3	Earnings quality	3	Economic analysis
4	Stock market returns	4	Returns
5	Economic growth	5	United State
6	Tax avoidance	6	Earnings management
7	Information-content	7	GDP
8	Prices	8	Information
9	Earnings management	9	Wage
10	Announcement	10	Employment

Hence, this part answers the *RQ1*, as it finds that traditional research on earnings such as returns, stock market returns, and earnings quality will continue to receive attention. Some studies extend the usefulness of earnings research and have gathered attention from scholars. Although WoS has also begun to focus on economic development research in recent years, economic growth period is very small and the loss of agglomeration, enterprises, funds, talents, technology and other factors of production are absorbed by a larger center or economies, and there are not many related studies. Additionally, tax avoidance research will receive heightened attention from scholars. Furthermore, in the forthcoming era of WoS research, there will be an increased integration of macroeconomic analysis, encompassing both direct examination of macroeconomic indicators and forecasts.

Through a comparative analysis, this thesis places greater emphasis on economic development concerns and reveals that Scopus research is poised to outperform WoS research in terms of aggregate earnings due to the heightened activity of macroeconomic factors within Scopus. Consequently, Scopus's focus will no longer be confined solely to traditional topics related to earnings usefulness, but it will expand rapidly into new directions.

The research on macroeconomic development in WoS has exhibited gradual progress yet it lacks future prospects due to its limited focus on traditional aggregate earnings questions. Consequently, the exploration of new topics is impeded as most research ideas have already been exhaustively explored within WoS.

2.4 OTHER RELATED THEORETICAL FRAMEWORKS

2.4.1 Theories of National Accounts

The GDP represents the market value of all the economic society's final products using production factors in a certain period. It is an essential indicator of economic activity and reflects the total output value of a country or region. As a core indicator of national accounts, GDP is vital in reflecting economic development and macro service decision-making.

According to the website of the Statistical Commission of the United Nations Department of Economic and Social Affairs (UNDESA, 2022), the national accounts are based on the economic theory, comprehensively using statistics, accounting, mathematics, and other means to describe and measure the economic operation processes and the results of a country (or region) in a certain period. Also, according to UNDESA (1993) the economic growth rate can be measured by the GDP growth. There are three methods for calculating the GDP, namely, the production approach, the income approach, and the expenditure approach that are briefly explained below.

A) Production approach. The GDP is the total value of the final production. It calculates how much value is contributed at each stage of production. GDP is equal to the total output of each industrial sector minus the intermediate sales of various industrial sectors, that is, the value created by the production factors owned by each industrial sector, indicating the concept of an added value. The formula for calculating the GDP by the production approach is:

$$GDP = grossvalueofoutput - valueofintermediateconsumption \quad (2\text{-}1)$$

B) Income approach. Since the GDP is the added value of production factors, these added values are also equivalent to their income. Therefore, the GDP is also equal to the cost of each department's expenditure on obtaining these factors. Specifically:

$$GDP = wage + interest + profit + rent + indirecttax + enterprisetransferpayment + depreciation \quad (2\text{-}3)$$

C) Expenditure approach. It accounts for the fact that the GDP is separated from the production process, and it accounts for the GDP from another perspective. According to the final product destination, the whole society purchases its total output, i.e. the GDP. The final product's purchase in the social system is divided into four categories: consumers, enterprises, governments, and foreign units. Therefore:

$$GDP = consumption + investment + governmentspending + netexport \quad (2\text{-}4)$$

The GDP accounting theory shows that although the meanings of the production-based and income-based methods are different, the explanations are the same. Therefore, the values of the GDP production method and each country's income method are almost identical after adjustment. Earnings information at the company level is an essential component of the GDP. Moreover, as the economy company-level main body is the core of the economic system for the expenditure method. It affects the accounting of the GDP, but it also affects consumers, governments, and foreign units in the whole system. It shows the company's important position in the entire economic system. As the company's

most fundamental value indicator, accounting earnings should have a meaningful impact on the GDP calculation from a theoretical perspective. This thesis hopes to quantify this impact through an empirical perspective.

2.4.2 Development of Artificial Neural Network and BP Neural Network Model

Reflecting the growing interest in artificial intelligence (AI) methods since the turn of the century, various research fields have witnessed an increasing adoption of artificial neural network (ANN) models, multi-case reasoning systems, and support vector machines. Among these, ANN, a representative of AI approaches, has been extensively utilized across diverse research domains (Wu & Feng, 2018).

The early ANN was initially referred to as the "Perceptron", a model introduced by (Rosenblatt, 1960). Building upon this foundation, Widrow and Hoff (1962) developed the Adaptive Linear Neuron or later Adaptive Linear Element (ADALINE) network model and employed the ANN for the first time in the investigation of practical issues. Before long, the ANN model experienced significant growth, including the subsequent development of discrete neural networks (Hopfield, 1982), Multi-layer Network Learning Algorithm models, Boltzmann machine models (Ackley et al., 1985), Error Backpropagation (BP) algorithms (Rumelhart et al., 1985), and Cellular Neural Network (CNN) models (Chua & Yang, 1988).

The BP algorithm (Rumelhart et al., 1985) possesses a significantly enhanced learning capability due to its error backpropagation mechanism and has become one of the most prominent neural network models. The architecture of a typical three-layer BP neural

network is illustrated in Figure 2.10. This network model features no interconnections within the feedback layer.

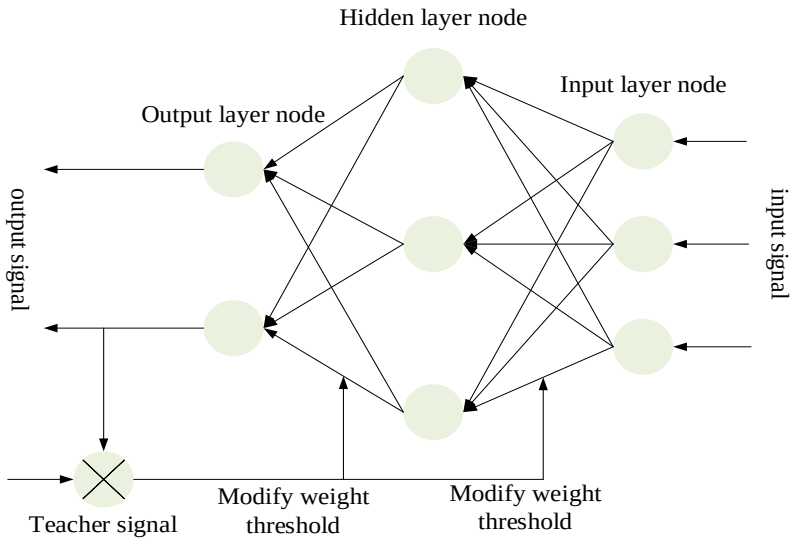


Figure 2.10 The topological structure of a three-layer BP neural network

The application of the BP neural network has been extensively explored in various research studies. For instance, in the financial sector, Mai et al. (2019) employed the BP neural network for bankruptcy prediction. Alameer et al. (2019) leveraged the BP neural network to forecast the future gold price. In the accounting domain, Geng et al. (2015) incorporated the BP neural network to predict the financial health of Chinese listed companies. In the business realm, Iftikhar and Khan (2020) employed the BP neural network to investigate social media requirements based on big data.

2.4.3 GDP Forecast and Artificial Neural Network Model

Forecasting GDP employing existing methodologies can be generally categorized into two types (Baffigi et al. 2004). The first approach involves employing a linear regression model to predict the GDP indicator. This approach benefits from extensive research and development by scholars, possessing a solid theoretical foundation. However, this method

often necessitates stringent assumptions, such as determining parameters and adjusting research models, which may impact the quality of the forecast outcomes. The second approach employs a non-linear model to estimate GDP, with the most prominent example utilizing Artificial Neural Networks (ANN). Previous research, such as Tkacz (2001), employed ANN models to enhance GDP forecasting precision and found that neural network models exhibited superior forecasting accuracy in his sample. Teräsvirta et al. (2005) employed both traditional econometric models and ANN models to compare and predict monthly macroeconomic variables in the G7 economies. Their findings indicated that ANN possessed a distinct advantage in predicting long-term sample data, but not in the short term. Furthermore, Jena et al. (2021) focused on GDP forecasting during the COVID-19 pandemic. They utilized ANN models to construct a GDP predictor, anticipating a significant decline in GDP for the sample countries from April to June 2020.

In parallel, Loermann and Maas (2019) employed an ANN model to project the quarterly GDP of the United States. Their feed-forward neural network approach exhibited forecast precision on par with that of professional forecasters. Jahn (2020) examined the predictive performance of ANN models in dealing with non-linear structured panel data, highlighting that the ANN model advantage lay in its lack of temporal trend restrictions, thereby enabling more accurate GDP predictions.

More recent studies have demonstrated the predictive power of machine learning algorithms in economic modeling. For instance, Richardson et al. (2021) utilized an ANN model to estimate New Zealand's annual GDP, highlighting the significant enhancement that these algorithms can bring to traditional econometric methods. Building upon this, Longo et al. (2022) proposed a joint machine-learning approach, which combined a

recurrent neural network model, a dynamic factor model, and a generalized autoregressive score. Their ensemble model demonstrated robust predictive capabilities, even for depressive data in the context of the COVID-19 pandemic.

Powered by their versatile applications, ANN models are extensively employed to forecast macroeconomic indicators, including exchange rates and inflation. Notably, Haider and Hanif (2009) concentrated on ANN-driven predictions of macro indicators such as inflation, GDP, and circulation. By leveraging Pakistan monthly macro data, they established that the ANN model outperforms traditional econometric models in terms of accuracy. Choudhary and Haider (2012) further examined monthly inflation indicators for 28 OECD countries. Their findings corroborated the superiority of the ANN model, which boasted a 45% accuracy rate compared to the 23% accuracy rate of traditional econometric models.

More recent studies, such as that conducted by Chuku et al. (2019), have compared the predictive capabilities of traditional econometric models and Artificial Neural Network (ANN) models for commodity prices, trade, inflation, and interest rates. Their findings corroborate the superiority of the ANN model over traditional regression models, with the latter being approximately 150 basis points more accurate.

In the 2010's, macroeconomics witnessed the emergence of new research frontiers, such as energy economics. Building upon this, Sharma et al. (2021) focused on natural gas within the realm of energy economics and employed ANN models to capture and forecast fluctuations in international natural gas prices. Their research indicates that an ANN

model integrating multiple modules demonstrates a strong predictive capacity for global natural gas prices.

2.5 CONCLUSIONS

Under the current complex and challenging economic backdrop, accounting information exerts a profound influence on economic development. While existing research primarily focuses on the usefulness of accounting information for investors, creditors, and individuals, there is a dearth of studies examining its relevance to government policies and macroeconomic conditions. Moreover, from an accounting perspective, limited research exists regarding the GDP analysis and forecast. Therefore, this chapter aimed to bridge this gap by conducting a bibliometric analysis that explored the relationship between aggregate earnings in micro-level firms' accounting information and macro-GDP at the country level.

To enhance the bibliometric analysis of aggregate earnings, this chapter initially examined the pertinent literature on the utility of earnings. In terms of comparative influence, our study reveals that Scopus research exhibits less impact compared to WoS. Furthermore, upon comparing term co-occurrence maps, it is observed that Scopus research topics demonstrate greater independence without forming a cohesive knowledge network; however, they are more innovative. The development of Scopus in this field is still at an early stage and holds significant potential for further advancement. On the other hand, WoS research distinguishes three distinct lines of inquiry with no strong correlation among them. Simultaneously, this thesis posits that advancing WoS research in this domain will encounter substantial resistance.

In the comparative analysis of co-occurrence term maps, this chapter found that there are relatively few publications in both databases due to the novelty of the topic and its multiple research directions. While WoS shows more terms due to a larger number of articles, Scopus has demonstrated better performance in developing new topics, as WoS still focuses on traditional earnings usefulness research. Regarding future aggregate earnings research, this chapter compared the predictive capabilities of traditional ARIMA and neural network models and found that the Optimization algorithm model performed best. Using it to predict future active terms in both databases, Scopus has shown greater potential for development than WoS.

Although some researchers have obtained seemingly reliable results through theoretical and empirical research, these conclusions are subject to various confounding factors, leading to a lack of consensus among researchers. After establishing the relationship between earnings and a country's economic growth, empirical research validates the appropriateness and credibility of employing aggregate earnings as a methodology. In addition, this chapter also analyzes the application of theories of national Accounts and artificial intelligence in this field. This thesis holds high expectations for exploring the predictive ability of earnings data on future economic growth.

3

THE DATABASE

This thesis aims to utilize Chinese data to examine the information on GDP changes embedded in aggregate-level accounting data, thereby exploring the linkage between microeconomic and macroeconomic levels. Consequently, it is imperative to analyze the data prior to conducting specific empirical tests. Accordingly, this chapter presents an overview of China's accounting data and the international comparability of China's GDP data. Subsequently, it outlines the sample data and provides a detailed account of how to it was pre-processed.

3.1 CHINESE ACCOUNTING STANDARDS AND THE INTERNATIONAL FINANCIAL REPORTING STANDARDS CONVERGENCE

After the transformation of the International Financial Reporting Standards Committee (IASC) into the International Financial Reporting Standards Board (IASB) in 2001, the adoption of the International Financial Reporting Standards (IFRS), developed by the IASB, emerged as a prominent subject within the global accounting profession. According to data from the IFRS report (IFRS, 2023) by September 2023, over 168 countries and regions worldwide had achieved convergence with IFRS in their accounting standards. Following China's completion of its accounting standards reform in 2007, it ultimately attained fundamental alignment with IFRS.

China's economy has experienced rapid development since the implementation of the "Reform and Opening" policy, which has also led to significant advancements in its accounting system (Zeghal & Mhedhbi, 2006). However, due to China's unique economic and political environment, the convergence of accounting systems differs from that observed in developed countries.

During the period of "Reform and Opening," China's economic environment embarked on a market-oriented development path, while the adoption of IFRS remained under strict control by the Chinese government. Prior to this economic reform in 1978, China had implemented the Unified Accounting System (UAS), which was derived from the former Soviet Union and tailored to suit the planned economic policies at that time when there was no presence of a market economy and all enterprises were state-owned (Xiao et al., 2004).

The implementation of UAS posed significant challenges in attracting foreign investment due to the absence of a project on income and profit distribution, leaving foreign investors unable to align their financial statements with UAS guidelines. Consequently, the Ministry of Finance of China (MOF) prioritized an accounting policy reform and introduced the Accounting System for Sino-Foreign Joint Ventures for Trial in 1983 (Liu, 2009). This system, officially implemented in 1985, incorporated commonly used elements such as assets, liabilities, capital, income, costs, profit and loss. Additionally, it introduced balance sheets, profit and loss statements, and cash flow statements – marking China's inaugural international accounting system.

Later, in 1992, the Ministry of Finance of China introduced a set of 13 industry-specific accounting standards and 10 general industry accounting standards, signifying the complete abandonment of the Unified Accounting System within the Chinese accounting framework and initiating a formal alignment with the International Accounting Standards (IAS) (Chen et al., 2019).

China's accession to the World Trade Organization (WTO) in 2001 further propelled the impetus for convergence of China's accounting system with International Financial Reporting Standards. Consequently, the New Chinese Accounting Standards (CAS, 2006) were introduced.

After its formal implementation in 2007, it began to be applied to listed companies, and since then Chinese Accounting Standards (CAS) have achieved a fundamental alignment with International Financial Reporting Standards (IFRS) (Ding & Su, 2008). Furthermore, CAS has also introduced the concept of fair value accounting and published the Chinese Accounting Conceptual Framework (CAS, 2006). According to CAS 2006, Chapter 4 of the General Provisions clearly stipulates the objectives of financial information in China: “It provides users with accounting information pertaining to financial statements, operating results, and cash flows of companies. This information reflects management's fiduciary responsibility performance and assists financial accounting users in making economic decisions.” This objective aligns with the usefulness objective stated by IFRS and FASB's conceptual frameworks for accounting information.

It is noteworthy that, prior to the release of the new accounting standards, a joint announcement by IFRS and the Ministry of Finance of China acknowledged the

substantial integration of CAS with IFRS, subsequently leading to successful recognition of Chinese financial standards by both the European Union and the United States (Zhang & Ye, 2020). In 2011, China formulated a "Roadmap for Continuing Convergence of Chinese Accounting Standards for Business Enterprises with International Financial Reporting Standards" (MOF, 2010), demonstrating its commitment towards achieving full convergence between CAS and IFRS. Furthermore, in 2015, a working group established by IASB, and the Ministry of Finance of China actively facilitated complete convergence between CAS and IFRS. The motivation behind this convergence lies in the reduction of financing costs within international markets through the elimination of additional financial reporting requirements (Zhang & Ye, 2020). For researchers utilizing financial data from Chinese listed companies for academic research purposes, convergence between CAS and IFRS presents an opportunity to access larger sample sizes while providing a solid theoretical foundation.

3.2 INTERNATIONAL COMPARABILITY OF CHINA'S GDP

Furthermore, ensuring the international comparability of China's GDP accounting data holds significant importance. From the early days of the founding of the People's Republic of China to the early days of China's policy "Reform and Opening", China's national accounts' core indicator was the National Income of the Material Product System (MPS) arising from the Soviet Union. After China implemented the policy "Reform and Opening" to meet macroeconomic management needs, China National Bureau of Statistics (NBS) began to study the GDP index of the System of National Accounts (SNA) formulated by the United Nations. In 1985, it carried out GDP accounting and gradually transitioned from National Income accounting to GDP accounting. In 1993, GDP completely replaced National Income as the core indicator of China's national economic

accounts. China's System of National Accounts (SNA) (NBS, 2023) adheres to the fundamental accounting principles, content, and methodologies outlined in the United Nations' 1993 SNA and UNDESA (1993). Therefore, China's GDP data can be considered internationally comparable.

In light of the implementation of China's new accounting system, the Chinese National Bureau of Statistics (NBS) has undertaken a comprehensive revision of historical quarterly GDP data to ensure its alignment with international standards and enhance international comparability. This meticulous process involves reacquisition, correction, and adjustment of data to guarantee consistency and accuracy (NBS, 2023). Furthermore, as previously mentioned, in 2007, China's accounting system underwent a significant transformation with the implementation of new accounting standards. These standards aimed to align more closely with international norms, enhancing the quality and transparency of financial reporting. The substantial differences between the old and new standards have resulted in considerable variations in accounting treatments and disclosures across different periods. Consequently, researchers conducting macroeconomic studies on China must be cognizant of potential disparities resulting from changes in accounting methods that may impact the comparability of data at an international level. When undertaking cross-national analyses, caution should be exercised when utilizing Chinese data, particularly when comparing economic indicators across different countries.

3.3 DATABASE ANALYSIS

To accomplish the objective of this dissertation, quarterly macroeconomic data released by the Chinese government, along with quarterly financial data from listed companies in

China were selected. The focus is solely on listed companies due to their unified financial reporting and comprehensive data records (Song et al., 2017). Also, obtaining financial statement data of Chinese SMEs remains challenging due to various factors such as legal policies implemented by SMEs, inward-looking corporate culture, immature accounting technology, and market competition (Li et al., 2017).

At the macro level, this dissertation utilizes China's quarterly GDP data obtained from the Chinese National Bureau of Statistics, which corresponds to company-level financial statement intervals. The cumulative absolute value of quarterly nominal GDP requires adjustment to reflect quarterly value added. It is important to note that using nominal GDP helps capture direct price changes during the period, thereby reflecting market fluctuations in enterprise micro-data. Some studies argue for the use of real GDP to mitigate inflationary effects (e.g. Lalwani & Chakraborty, 2020; Sumiyana et al., 2019). However, these studies overlook that real GDP is adjusted at constant prices and does not incorporate inflation information. In contrast, enterprise-level data contains inflation information that cannot be accounted for through constant prices adjustments. Therefore, employing real GDP fails to effectively capture the micro-information embedded within changes in GDP.

This study utilizes the quarterly reports of all A-share listed companies in China as micro-level data. An A-share listed company refers to a company that is publicly listed and traded on one of the main stock exchanges in mainland China, specifically the Shanghai Stock Exchange (SSE) or the Shenzhen Stock Exchange (SZSE).

As already mentioned, in 2007, China's accounting system underwent significant changes by adopting new accounting standards, aligning them closer to international accounting standards and enhancing the quality and transparency of financial reporting. Due to substantial differences between the old and new accounting standards, there are notable variations in the treatment and disclosure of financial statements across different periods. Consequently, data prior to 2008 cannot be compared. Hence, to ensure research accuracy and credibility, the sample period for all empirical analysis of the present dissertation commences from the first quarter of 2009.

The quarterly reports of these listed companies were obtained from the China Stock Market and Accounting Research Database (CSMAR)[2], which is widely recognized as one of the most commonly used financial and economic databases in China (Li et al., 2023). CSMAR was developed to meet the needs of academic research, drawing on the experience of internationally renowned databases such as CRSP and Compustat. It consolidates a vast amount of financial, accounting, and market data from listed companies with a high degree of integrity for Chinese data. Notably, this database stands out for its timeliness and accuracy in providing researchers with up-to-date financial and market data through its cooperative relationship with Chinese securities regulators and listed companies. Consequently, it served as the primary data source for this dissertation.

Hence, this study compiles comprehensive balance sheets, income statements, and cash flow statements of all A-share listed companies sourced from CSMAR, which are denominated in RMB on the Shanghai and Shenzhen stock exchanges. Simultaneously,

[2] CSMAR, http://us.gtadata.com/

it excludes ST-listed companies based on the definition provided by the China Securities Regulatory Commission. The ST (Special Treatment) designation indicates that these companies exhibit financial or other abnormal conditions and have received a delisting risk warning. Therefore, these entities were excluded from the analyses conducted in this dissertation.

Furthermore, the present dataset excludes subsidiary reports containing raw data from the original dataset, retaining only consolidated statements of the parent company. This approach aims to eliminate data redundancy and prevent inclusion of duplicated profits. Subsequently, it merges the balance sheet and income statement to facilitate unified access to information. Moreover, this investigation also necessitates combining the balance sheet and income statement by utilizing the VLOOKUP function to align their sequencing. It is important to note that cumulative data across all financial reports must be adjusted for current period value addition.

Finally, as this study aims to initially test and validate the existing AE-GDP (Aggregate Earnings-GDP) model in Chapter 4, it is imperative to calculate total benefits using the most commonly employed methods in previous studies. Among these methods, Konchitchki and Patatoukas (2014) approach stands out as the most prevalent, utilizing the market capitalization of companies on the date of financial report announcement as a weight. Therefore, this study collected market capitalization data for corresponding listed companies from CSMAR during the respective quarter (data published at each quarter's end). Due to some missing data, it utilized the RESSET database[3] to supplement these

[3] RESSET, http://www.resset.cn/enindex

gaps. The RESSET database is also widely recognized for its high integrity and credibility regarding Chinese financial and economic data, and encompasses various aspects such as financial reports, corporate governance information, macroeconomic indicators, market transaction data, etc. While CSMAR primarily focuses on market research related to Chinese listed companies, RESSET specializes more in financial and economic fields. However, ultimately a small number of incomplete records (less than one percent of the total sample but exceeding a thousand) had to be discarded in order to ensure reliable findings.

4

AGGREGATE-LEVEL ACCOUNTING INFORMATION CONTAINS GDP INCREMENTAL INFORMATION[4]

[4] This chapter has been sent to a high impact journal for publication.

Macroeconomics plays a crucial role in influencing businesses, investors, and governments. The prediction of national macroeconomic development has always been an area of interest for academics. However, since the onset of the global financial crisis in 2008, the world economy has experienced significant turmoil. In today's uncertain economic environment, there is a need to utilize micro-corporate accounting data to observe macroeconomic conditions at a granular level. This approach can offer fresh insights into accounting effectiveness research by leveraging potential macroeconomic GDP information within the micro-level data.

Examining the implicit incremental GDP information within accounting data is crucial for predicting future economic growth, which serves as a key driver of the economy. Several studies focus on investigating how macroeconomics influences microeconomic decision-making, highlighting the intrinsic connection between microeconomics and macroeconomics (Sun et al., 2022, 2023). Analyzing the relationship between enterprise-level accounting data and national-level economic growth aids in understanding the practicality of accounting information. However, despite this evident correlation, there remains a scarcity of relevant research. The full quantification and widespread utilization of macroeconomic insights embedded in micro-enterprise accounting data have yet to be achieved, with existing international studies often lacking theoretical support regarding the link between GDP and accounting information.

Considering the variations in accounting regulations across nations, it is imperative to engage in an independent comprehensive analysis of each nation. China, being the world's second-largest economy, is experiencing rapid economic growth. However, due to frequent updates in accounting standards, previous studies encountered challenges in obtaining accurate financial data. Consequently, conducting an extensive investigation into international comparability and adaptability of Chinese financial information holds practical significance for this research topic. According to the main objective of this thesis, the aim is to interpret the connection between microeconomics and macroeconomics through a systematic exploration of GDP growth information contained in accounting data. To achieve this goal, this section will specifically study two aspects: the effectiveness of existing research on the aggregate earnings model and its applicability to Chinese data. Henceforth, this chapter will explore the following research questions that have been introduced in the first chapter of this thesis:

RQ3: Can traditional aggregate earnings model explain China's economic growth?
RQ4: Does the aggregate-level accounting information based on the GDP income method model contain China's GDP growth information?

To attain this objective, the present chapter employs Chinese data to validate prevailing models of aggregate earnings research. Subsequently, the performance of sample data in GDP components under an income-based approach is scrutinized, culminating in interesting conclusions.

4.1 SAMPLE, VARIABLES AND METHODOLOGY

This chapter utilizes China's GDP data and quarterly financial data from A-share listed companies in China. Considering the reasons outlined in Chapter 3 of this thesis, as well as the international comparability and reliability of the Chinese sample, all 43 quarters from Q1 2009 to Q3 2019 have been selected for the analysis.

First, this research verifies the research question *RQ3* raised to confirm the reliability of previous research on aggregate earnings and GDP. It refers to Konchitchki and Patatoukas (2014) practice for measuring aggregate earnings. First, the company's net profit P for the current quarter is divided by the company's total revenue R for the current quarter to obtain the profit margin E, which is multiplied by the company's market value at the end of each quarter divided by total market value weight W:

$$AE_{i,t} = \frac{P_{i,t}}{R_{i,t}} \times W_{i,t}, \text{ (4-1)}$$

Konchitchki and Patatoukas (2014) model is shown in formula (4-2):

$$g_{q+k} = \alpha_k + \beta_k \Delta X_q + \varepsilon_{q+k}, \text{ (4-2)}$$

where g_{q+k} is the GDP growth for quarter $q + k$, forecasted by professional analysts, k= 1, 2, 3, 4, and ΔX_q is aggregate accounting earnings growth for quarter q.

It must be pointed out that this model cannot directly use data from other regions as, except for some developed countries or regions such as the United States, most countries

currently cannot obtain historical forecast data from analysts like they did. Some studies (e.g. Lalwani & Chakraborty, 2020; Sumiyana et al., 2019) have changed the definition of g_{q+k} in the model to directly use the model for testing. However, it changes the content of the original model. The g_{q+k} in their study is not the professional analysts forecast value, but the direct GDP change.

Therefore, this research tests the linear regression of aggregate earnings growth (ΔX_q) to GDP growth (ΔGDP_q) for quarter q. The model is as follows:

$$\Delta GDP_q = c + \beta_k \Delta X_q + \varepsilon_{q+k}, \text{ (4-3)}$$

Model (4-3) tests whether aggregate earnings added value will affect the GDP added value. The difference from previous studies is that those studies (e.g. Abdalla & Carabias, 2022; Lalwani & Chakraborty, 2020; Sumiyana et al., 2019) typically use quarter-to-quarter GDP growth rates, but their models do not discuss the impact of seasonal or other factors on quarter-on-quarter GDP. Therefore, for robustness, this research uses the year-on-year GDP growth rate used in most existing studies (e.g. Choi et al., 2016; Gallo et al., 2016; Son & Jeong, 2022).

For the *RQ4*, this research uses company-level data to test the reliability of China's income-based GDP method. According to the "China 2022 Statistical Yearbook" (NBS, 2022), when using the income-based method to calculate GDP, it is:

$$GDP = Compensationof Employees + Nettaxesonproduction + Depreciationof assets + Operatingsurplus, \text{ (4-4)}$$

According to the Chinese NBS definition of the income method to measure GDP, its four components can be interpreted as the four financial accounts in the financial statements. The "compensation of employees" could be approximately equal to the "employee salaries payable" account disclosed in the balance statements. "Net taxes on production" could roughly be equivalent to the "operating tax surcharge" account in the income statements. "Fixed asset depreciation" directly finds the same account in the cash flow statement, and "operating surplus" would be approximately equal to the "income from operations" account in the income statements. Because this research wants to study whether this microdata will have an impact on the country's macro-level to verify the reliability of China's income-based GDP model, it builds the following model:

$$GDP_q = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \varepsilon, \text{ (4-5)}$$

where: X_1= employee salaries payable, X_2= operating tax surcharge, X_3= fixed asset depreciation, X_4= income from operations.

Based on the above literature, this research sorts out the collected financial reports. First, it organizes the corresponding accounting accounts in the collected samples in time series. However, the sample initially includes quarterly reports from all companies. Therefore, this research needs to adjust all the variables to turn the cumulative value into a quarterly added value. This allows the data to contain more information about changes in the corresponding quarter, while the GDP data is also the adjusted quarterly added value.

According to the Chinese NBS definition of GDP calculation by the income-based method, when the value-added of any one of the four variables of an enterprise in a period is negative, it will be recorded as 0 when calculating GDP. Currently, the variable whose value is negative for this firm no longer contributes to GDP. Therefore, the present research removed all negative values in the variables and replaced them with 0.

Furthermore, the fixed asset depreciation is only disclosed three times a year according to Chinese law, namely the initial report on January 1, the semi-annual report on June 30, and the annual report on December 31. Therefore, this study uses the quarterly reports of other variables, namely, the company's semi-annual and annual reports. After adjusting the cumulative value to the added value every half year, the quarterly fixed assets are used as the weighted average to calculate fixed assets depreciation for each quarter.

Finally, this research obtains the aggregated added value of each variable for each quarter. Simultaneously, it also uses the existing research to calculate the weighting method of aggregate earnings, the company's market value for weighting, and all variables' aggregate value. This research will test the unweighted and weighted variables separately to verify whether weighting can optimize the model.

Unless otherwise indicated, all calculations were carried out using Eviews X12.

4.2 RESULTS AND DISCUSSION

4.2.1 Aggregate earnings impact test on GDP.

First, this research tests the model (4-3) formula. Since the model independent variable and dependent variable data are time series data, they need to pass the unit root test to ensure their stability. The Augmented Dickey-Fuller test (ADF) evaluates the null hypothesis that a unit root is present in a time series sample. The results are shown in Table 4.1.

Table 4.1. ΔGDP_q and aggregate earnings growth ADF test results.

Augmented Dickey-Fuller test statistic				
Variable	Abbreviation	Exogenous	t-Statistic	Prob.
GDP Growth	GDP_G	Constant	-3.135641	0.0330
Aggregate Earnings Growth	X_G	Constant	-6.968622	0.0000

The GDP growth (GDP_G) and the aggregate earnings growth (X_G) can directly pass the ADF test with intercept as both are significative (Prob < 0.05), which means both variables are stationary.

Table 4.2 shows the linear regression results using model (4-3). It can be seen that the p-value of X_G (aggregate earnings growth) is not significative (Prob > 0.05), accepting the null hypothesis, which means that growth in aggregate earnings and GDP growth are not linearly related by model (4-3). Hence, this research finds no evidence to support the inclusion of aggregate earnings growth in GDP growth information

Table 4.2. Model (4-3) results.

Dependent Variable: GDP_G.

Sample: 2009Q1 2019Q3; Included observations: 39 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.091254	0.016673	5.473287	0.0000
X_G	-0.001327	0.003948	-0.336141	0.7387
R-squared	0.003045			
Adjusted R-squared	-0.0239			

In the first test, the data did not yield results similar to some existing studies (e.g. Konchitchki & Patatoukas, 2014; Shivakumar, 2007; Sumiyana et al., 2019). In other words, for the *RQ3* proposed in this thesis, this chapter research did not find evidence to support that the traditional aggregate earnings model can explain China's economic growth. However, this research noticed that the stationarity of time series data is not considered, so it does not rule out the possibility of spurious regression existence that often produces extraordinary model-fitting results.

4.2.2 Reliability of the income-based GDP model

This part will use model (4-5) to test the weighted and unweighted four variables. All four variables have been adjusted for robustness using the EViews X12 seasonal adjustment module. Seasonal adjustment is a process of estimating and removing seasonal influence from the time series to reveal the seasonal series characteristics or fundamental trends. Also, to reduce the impact caused by data scale, the present chapter took the natural logarithm of all variables. The ADF unit root test results for all variables are shown in Table 4.3.

Table 4.3. Model (4-5) weighted variables ADF test results.

Augmented Dickey-Fuller test statistic					
Variable	Abbreviation	Operation	Exogenous	t-Statistic	Prob.
GDP	LN_GDP_SA	None	Constant, Linear Trend	-4.163829	0.0108
X1	LN_SALARIES_SA	First-order difference	None	-7.100841	0.0000
X2	LN_TAX_SA	First-order difference	None	-6.863319	0.0000
X3	LN_DEPRECIATION_SA	None	Constant	-3.802469	0.0058
X4	LN_INCOME_SA	First-order difference	None	-8.141344	0.0000

Table 4.3 shows that GDP can pass the ADF test after seasonal adjustment. Except for the X_3 variable (fixed asset depreciation), the other three variables, X_1 the employee salaries payable, X_2 the operating tax surcharge, and X_4 the income from operations can pass the ADF test only after they undergo a first-order difference (Prob < 0.05).

Figure 4.1 shows graphs of all five variables, that were analyzed using the Hodrick-Prescott filter method. Since this study uses quarterly data, the lambda value is set to 1600. On the overall trend, it can be seen that all variables have almost the same increasing trend. The depreciation and income curves are stable, the seasonally adjusted GDP shows only quarterly volatility, and the salaries show irregular fluctuations in the graph. In addition, the tax curve fluctuated wildly between 2015-2017.

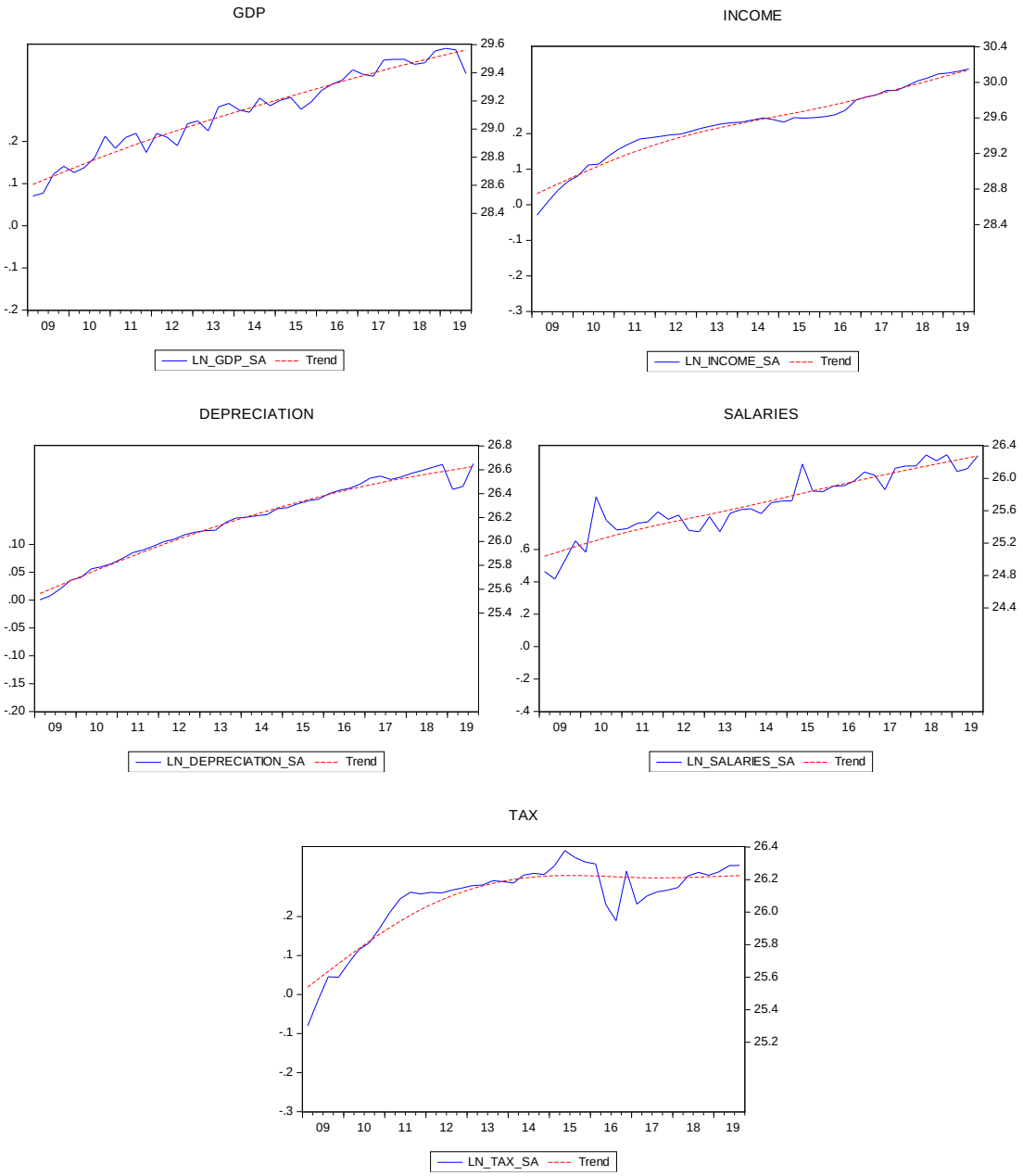


Figure 4.1. Graphs of all variables.

The linear regression results using model (4-5) with weighted variables are shown in Table 4.4. It can be seen that the p-value of all four independent variables is bigger than 0.05, accepting the null hypothesis, which means that all four independent variables in the test have no statistical effect on the dependent variable GDP. However, similar to our aggregate earnings test results, this test's R-squared is also very small, and the model does not fit well. These dependent variables, including aggregate earnings, are weighted by

market value, and this research cannot say that using market value weighting can optimize this model.

Table 4.4. Model (4-5) linear regression results using weighted variables.

Dependent Variable: GDP_ SA; Sample: 2009Q1 2019Q3; Included observations: 42 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	4.61E+12	3.39E+11	13.59691	0.0000
D_SALARIES_SA	240.5305	1496.585	0.16072	0.8732
D_TAX_SA	96.78095	497.7051	0.194454	0.8469
DEPRECIATION_SA	156.3618	515.6109	0.303255	0.7634
D_INCOME_SA	-2.468759	20.01768	-0.123329	0.9025
R-squared	0.009122			
Adjusted R-squared	-0.097999			

In the third test, this research examined unweighted data. Again, it performed the seasonal adjustment and natural log processing for time series data. The ADF test results of the four unweighted independent variables and the dependent variable GDP are presented in Table 4.5. All five variables, GDP, the employee salaries payable X_1, the operating tax surcharge X_2, the fixed asset depreciation X_3 and the income from operations X_4 can pass the ADF test after both logarithmic and seasonal adjustments.

Table 4.5. Model (4-5) unweighted variables ADF test results.

Augmented Dickey-Fuller test statistic					
Variable	Abbreviation	Operation	Exogenous	t-Statistic	Prob.
GDP	LN_GDP_SA	None	Constant, Linear Trend	-4.1638	0.0108
X1	LN_SALARIES_SA	None	Constant, Linear Trend	-4.8161	0.0019
X2	LN_TAX_SA	None	Constant	-3.7845	0.0061
X3	LN_DEPRECIATION_SA	None	Constant	-3.2898	0.0221
X4	LN_INCOME_SA	None	Constant, Linear Trend	-5.131	0.0008

Table 4.6 shows the linear regression results using unweighted variables in model (4-5). Surprisingly, the p-values of the operating tax surcharge, the fixed asset depreciation, and the income from operations are all less than 0.05, rejecting the null hypothesis within the 0.05 significance level. Hence these three variables have an impact on the dependent variable GDP. Furthermore, the adjusted R-square value is 0.95, indicating that this model has a high degree of fit. The positive coefficients of the income from operations and the fixed asset depreciation prove the importance of earnings and depreciation in GDP accounting. Unexpectedly, the operating tax surcharge's coefficient is negative, and the variable employee salaries payable has a small impact.

Table 4.6. Model (4-5) linear regression and robustness test results using unweighted variables.

Dependent Variable: LN_GDP_SA; Sample: 2009Q1 2019Q3; Included observations: 43				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	8.909038	1.190115	7.485861	0.0000
LN_SALARIES_SA	0.038603	0.06989	0.552339	0.5840
LN_TAX_SA	-0.154891	0.073546	-2.106052	0.0419
LN_DEPRECIATION_SA	0.41337	0.124606	3.317422	0.0020
LN_INCOME_SA	0.421467	0.109871	3.836024	0.0005
R-squared	0.955046			
Adjusted R-squared	0.950314			
Heteroskedasticity Test: White				
F-statistic	1.199451	Prob. F(8,34)	0.3285	
Breusch-Godfrey Serial Correlation LM Test:				
F-statistic	2.470483	Prob. F(2,36)	0.0988	

To verify the robustness of the test, this research also performed a residual autocorrelation test (Breusch-Godfrey Serial Correlation LM Test) and heteroskedasticity test (White Test) on the regression results. The results of both tests (see Table 4.6) show that the null hypothesis cannot be rejected (Prob. > 0.05), demonstrating that neither residual autocorrelation nor heteroscedasticity are present in the model (4-5), indicating that the regression results of the model in this study are reliable and meaningful.

For the third test, this research found (see Table 4.6) that the coefficient of the operating tax surcharge (LN_TAX_SA) is negative. To explore the reasons for this result, a scatterplot of the operating tax surcharge and the GDP is shown in Figure 4.2. According to Table 4.6, the operating tax surcharge has been inversely proportional to GDP in recent years. Most probable this phenomenon is due to the Chinese government's reduction of taxes in recent years. In theory, tax cuts will negatively impact GDP, but they will also positively impact GDP indirectly, such as stimulating enterprises and employees' production enthusiasm.

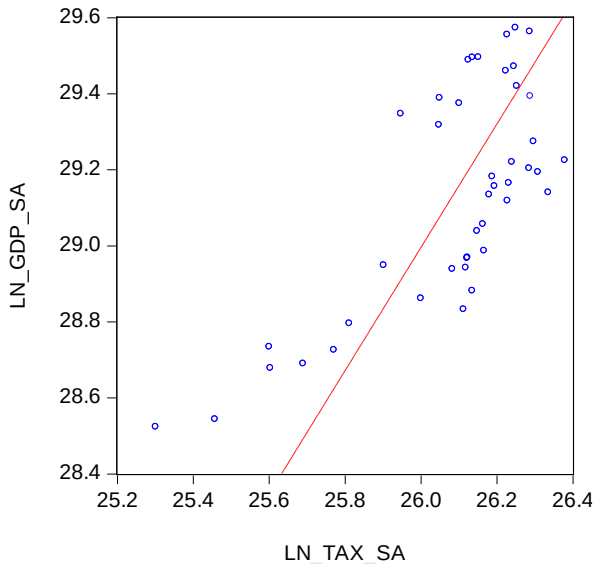


Figure 4.2. Scatter plot of operating tax surcharge and the GDP.

The absolute value of the additional coefficient of the operating tax surcharge (LN_TAX_SA) is almost one-third of income (LN_INCOME_SA) and depreciation (LN_DEPRECIATION_SA), which shows that it has little impact on its experiments, and the results have scientific significance.

One of the reasons of the variable employee salaries payable (LN_SALARIES_SA) to have no significant impact might be its complexity and rapid change. Although aggregate-level information has downplayed the impact of its micro-level changes. But this result confirms that it does not contain sufficient GDP information.

In addition, this research considered whether using market capitalization to weigh the independent variables could better the model. The advantage of market value weighting is that the impact of company size on earnings can be ignored. Nevertheless, the variables weighted by market capitalization did not show a better fit (the results are shown in Table 4.4). In addition to the "fixed asset depreciation" of the weighted variables, other variables must pass the first-order difference before passing the ADF stationarity test. The consequences of difference can make the results more challenging to interpret. Therefore, this research does not recommend weighing the variables in the study. Consequently, this section of the research provides evidence to support *RQ4* proposed in this dissertation, demonstrating that aggregate-level accounting information derived from the GDP income method model has predictive power for China's GDP.

4.3 CONCLUSIONS

The research presented in this chapter introduces a fresh perspective on the current uncertain macroeconomic predictions. This study not only establishes a theoretical foundation for the rationality of utilizing aggregate-level data in China, but it also develops a four-factor model based on the GDP income approach accounting model. By doing so, it aims to contribute to future related studies and offer additional insights for professional macro forecasters.

The empirical investigation conducted in the present chapter fails to discover any evidence supporting previous research that suggests no statistical correlation between aggregate earnings growth and GDP growth using the Chinese sample. Simultaneously, the results obtained in this chapter seem to point out that utilizing market capitalization as a weighting factor for variables in existing studies does not optimize the regression results of the model. Furthermore, the present research reveals that the most crucial factor is the influence of corporate profits on GDP. Enhancing profitability stands as the primary objective for enterprises. Undoubtedly, increased profits contribute to higher GDP figures. The advancement of GDP necessitates further development in corporate profit generation.

One of the limitations this chapter is the absence of a comprehensive cross-sectional analysis on how taxes affect GDP, which presents an intriguing avenue for future research that warrants thorough examination and quantification. Additionally, delving into the impact of taxes on GDP is a captivating subject that merits further discourse. In general, there remains incomplete exploration regarding the extent to which other accounting information encompasses macro-level data, necessitating additional advancements in this area.

Also, it should be acknowledged that variations exist in the specific methodologies employed for data collection across different countries, thereby imposing certain constraints on research pertaining to this topic. Quantifying these disparities represents another fascinating direction for future investigation.

5

THE PREDICTION OF GDP BY AGGREGATE ACCOUNTING INFORMATION. A NEURAL NETWORK MODEL[5]

[5] This chapter has been Published in November 2023:

Sun, M., del Campo, C., Chamizo-González, J., & Urquía-Grande, E. (2023). The Prediction of GDP by Aggregate Accounting Information. A Neural Network Model. International Journal on Recent and Innovation Trends in Computing and Communication, 11(9), 1426–1438. https://doi.org/10.17762/ijritcc.v11i9.9121

In recent times, there has been a growing focus on the potential of micro-level accounting information to provide insights into macroeconomic phenomena. However, conventional econometric techniques impose stringent assumptions when analyzing time series data. In cases where the data is non-stationary, adjustments are often necessary to achieve stationarity. Numerous prior studies have also demonstrated the efficacy of artificial neural network (ANN) models in forecasting macroeconomic indicators.

In this chapter, a novel GDP forecast model is constructed using the income-based GDP accounting method to address *RQ5* proposed in this thesis. Additionally, a new research concept is introduced. By leveraging existing literature on aggregate-level accounting information and GDP forecasts and considering the time series data utilized in this dissertation, it is suggested that the backpropagation (BP) neural network model be employed instead of the traditional linear regression model to assess the overall predictive capability of future GDP. Furthermore, for *RQ6* proposed in this dissertation, a comparison between the performance of the conventional econometric model and BP neural network model in predicting GDP is conducted to explore fresh insights into changes in future GDP at an aggregate level.

Henceforth, this chapter will address the following research questions:

RQ5: Can aggregate-level accounting information based on the GDP income method model predict China's GDP?

RQ6: Can the neural network model optimize the GDP forecasting model proposed in this thesis?

5.1 SAMPLES, VARIABLES AND METHODOLOGY

Similarly to previous chapters, this chapter also uses China's GDP data and quarterly financial data of China's A-share listed companies. At the same time, taking into account the international comparability and reliability of Chinese samples, the sample period for this research spans from 2009 Q1 to 2022 Q2, consisting of 54 quarters of comprehensive financial reports.

It should be clarified here that since the research of the three empirical chapters was completed at different times, it tries to expand the available samples after 2009.

Similarly to chapter 4, the present research is based on the UNDESA (1993) system of national accounts and the definition of the GDP income-based method by the "China 2019 Statistical Yearbook" (NBS, 2022). Four components make up the GDP: compensation of employees, net taxes on production, depreciation of fixed assets, and operating surplus, as shown in Model (5-1).

$$GDP = compensationofemployees + nettaxesonproduction + depreciationofassets + operatingsurplus, \quad (5\text{-}1)$$

As it has already been mentioned, these four components can be identified with the four financial accounts in the financial statements. The “compensation of employees” is approximately equal to the current added value of the “employee salaries payable” item on the balance sheet plus the current value of "cash paid to employees and for employees" in the cash flow statement. The "net taxes on production" is roughly equivalent to the "operating tax surcharge" account on the income statement. The “depreciation of fixed asset” directly finds the same account in the cash flow statement, and the "operating surplus" is approximately equal to the “income from operations” account. Hence, the baseline model of this research is shown in Model (5-2).

$$GDP_q = \alpha + \beta_1 salaries_q + \beta_2 tax_q + \beta_3 depreciation_q + \beta_4 income_q + \varepsilon, \text{(5-2)}$$

Therefore, this research uses the changed values of the four variables in the q quarter to predict the GDP growth in the $q+1$ quarter ΔGDP_{q+1}.

$$\Delta GDP_{q+1} = \alpha + \beta_1 \Delta salaries_q + \beta_2 \Delta tax_q + \beta_3 \Delta depreciation_q + \beta_4 \Delta income_q + \varepsilon_{q+k}, \text{(5-3)}$$

All variables are at the aggregate level, including accounting information in the quarterly reports of all Chinese A-share listed companies. Table 5.1 shows this research's variable definitions, interpretations, and sources.

Table 5.1. Variable definitions

Abbreviation	Variable	Definition Explanation	Source
gdp	Nominal GDP	China's quarterly nominal GDP, unit: yuan	NBS China
ln_gdp_sa	GDP seasonally adjusted	Eviews X-12 seasonally adjusted original GDP and take its natural logarithm	Calculated in this thesis
ln_gdp_sa_c	GDP growth	ln_gdp_sa changes between the current quarter and the previous quarter	Calculated in this thesis
salaries	Compensation of employees	The present value of the item "employee compensation payable" plus the present value of the cash flow statement "cash paid to and for employees" from the quarterly financial reports of Chinese A-share companies. unit: yuan	CSMAR
ln_ salaries_sa	Compensation of employees seasonally adjusted	Eviews X-12 Seasonally adjusted original salaries values and take their natural logarithm	Calculated in this thesis
ln_ salaries_sa_c	Compensation of employees growth	ln_ salaries _sa changes between the current quarter and the previous quarter	Calculated in this thesis
tax	Net taxes on production	"Operating tax surcharge" on the income statement of Chinese A-share companies. unit: yuan	CSMAR
ln_ tax _sa	Net taxes on production seasonally adjusted	Eviews X-12 Seasonally adjusted original tax values and take their natural logarithm	Calculated in this thesis
ln_ tax _sa_c	Net taxes on production growth	ln_ tax _sa changes between the current quarter and the previous quarter	Calculated in this thesis
depreciation	Depreciation of fixed assets	"Depreciation of fixed asset" on the cash flow statement of Chinese A-share companies. unit: yuan	CSMAR
ln_ depreciation _sa	Depreciation of fixed assets seasonally adjusted	Eviews X-12 Seasonally adjusted original depreciation values and take their natural logarithm	Calculated in this thesis
ln_ depreciation _sa_c	Depreciation of fixed assets growth	ln_ depreciation _sa changes between the current quarter and the previous quarter	Calculated in this thesis
income	Operating surplus	"Income from operations" on the income statement of Chinese A-share companies. unit: yuan	CSMAR
ln_ income_sa	Operating surplus seasonally adjusted	Eviews X-12 Seasonally adjusted original income values and take their natural logarithm	Calculated in this thesis
ln_ income_sa_c	Operating surplus growth	ln_ income _sa changes between the current quarter and the previous quarter	Calculated in this thesis

In addition, for the method of processing aggregated accounting information, the general calculation method, such as the market value weighting method (Konchitchki & Patatoukas, 2014a; Kothari et al., 2006), is based on the company's profit rate and the weight of its market value in the total market value, as shown in formula (5-4):

$$Aggregateearnings_{i,t} = \sum \frac{P_{i,t}}{R_{i,t}} \times W_{i,t}, \text{ (5-4)}$$

where P is the company's net profit, R is the total revenue, E is the profit margin, and W is the market value weight. However, this research found in previous tests that weighting the four aggregate accounting information variables with market value as the weight does not increase the model's explanatory performance for GDP. Therefore, it uses direct arithmetic aggregate values of the original data.

It must be pointed out that, according to the explanation of "China Accounting Standards for Business Enterprises No. 4: Fixed Assets" (MOF China, 2006), the depreciation of fixed assets is only disclosed twice a year, namely semi-annual report, and annual report. The present research adjusts them to four quarters by weighting the corresponding quarterly fixed assets.

In addition, the present chapter also tests whether the accuracy of GDP forecasts could be optimized using the BP neural network model. It considers pre-training methods to provide objective and accurate initial parameters for subsequent model training. The BP neural network model established in this chapter corresponds to the traditional linear regression model expressed in (5-3). The input layer has four neurons corresponding to

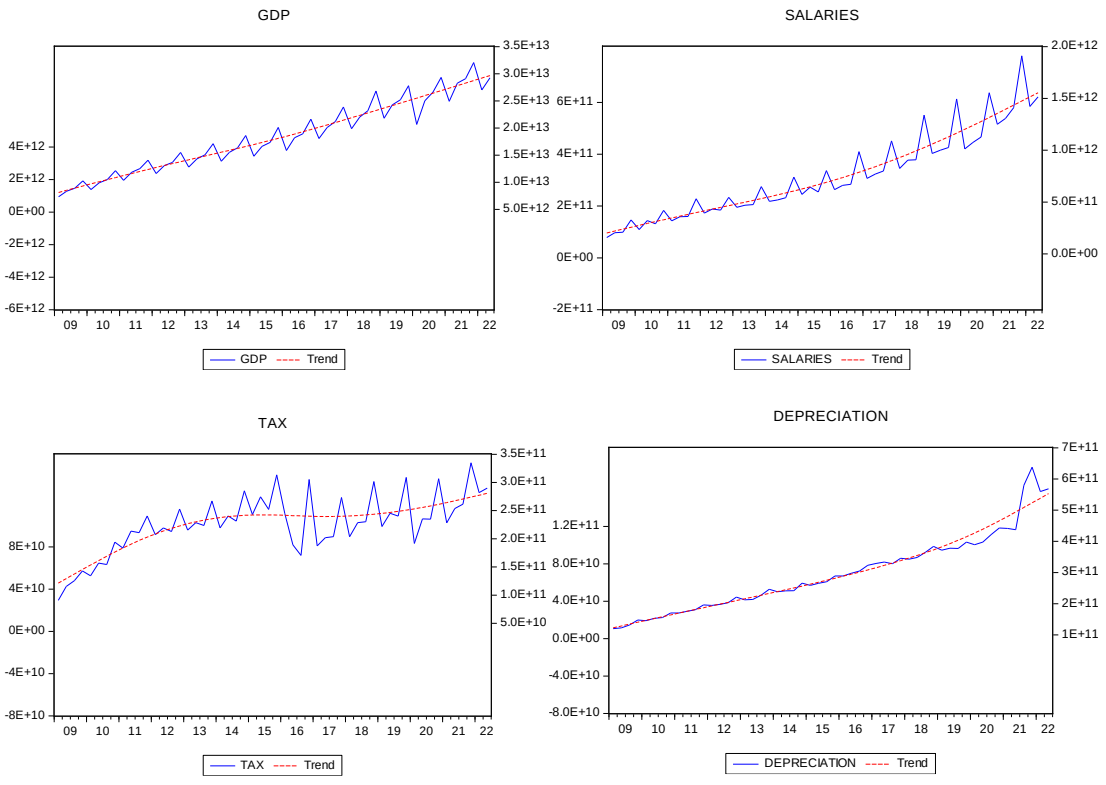
the four independent variables, one hidden layer, and one neuron in the output layer corresponding to the dependent variable ΔGDP_{q+1}.

The linear time series regression of this chapter was carried out in Eviews10, and the BP neural network was implemented in MATLAB (version R2021a).

5.2 RESULTS AND DISCUSSION

5.2.1 Linear Regression Analysis

First, this research used the Hodrick-Prescott filter method to analyze trends in the raw data. Setting the value of Lambda to the default 1600 yields the results shown in Figure 5.1.



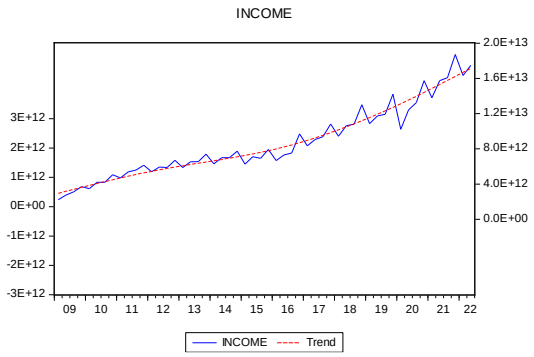


Figure 5.1. Variables Trend

As illustrated in Figure 5.1, it can be observed that, in general, all variables exhibit a consistent upward trend, with notable seasonal fluctuations. Both GDP and salaries demonstrate a similar steady escalation in volatility. The tax curve, however, displays relatively significant seasonal fluctuations from 2015 to 2022, with the upward trend of the curve decelerating. This outcome is attributed to the tax reduction policy implemented by the Chinese government in 2015 (Chinadaily, 2015). The most consistent performance is demonstrated by the depreciation of fixed assets. Excluding the abrupt short-term fluctuations in 2021-2022, the other periods are comparatively stable. It should be noted that, following the outbreak of the COVID-19 pandemic in 2020, the global economy was severely affected, resulting in a corresponding downward trend in China's real economy and fixed asset depreciation curve. However, China's epidemic control measures in early 2021 enabled the nation's economy to recover rapidly (World Bank, 2021). Consequently, from 2021 to 2022, the quantity of fixed assets held by Chinese enterprises escalated rapidly, leading to a corresponding rapid increase in depreciation expenses. The income curve, generally, exhibits a continuous upward trend, with the negative impact of the COVID-19 pandemic in 2020 being evident.

For time series regression models, it is crucial to ensure the stationarity of all variables included in the analysis. Consequently, based on the findings presented in Figure 5.1, all independent and dependent variables series exhibit intercepts and trends and need adjustments for stationarity. Therefore, EViews X12 seasonal adjustment module was employed to smooth these variables. Additionally, to mitigate the impact of data scale, we applied natural logarithm processing to all seasonally adjusted data. The results of the ADF unit root test for the time series variables across all models are presented in Table 5.2.

Table 5.2. Augmented Dickey-Fuller test statistic

Variable	Exogenous	t-Statistic	Prob.
LN_GDP_SA	Constant, Linear Trend	-2.821715	0.0068
LN_GDP_SA_C	Constant, Linear Trend	-9.250467	0.0000
LN_SALARIES_SA	Constant, Linear Trend	-5.62684	0.0001
LN_SALARIES_SA_C	Constant, Linear Trend	-9.404729	0.0000
LN_TAX_SA	Constant, Linear Trend	-3.709841	0.0302
LN_SALARIES_SA_C	Constant, Linear Trend	-9.404729	0.0000
LN_DEPRECIATION_SA	Constant, Linear Trend	-2.874467	0.0059
LN_DEPRECIATION_SA_C	Constant, Linear Trend	-7.253022	0.0000
LN_INCOME_SA	Constant, Linear Trend	-4.433257	0.0044
LN_INCOME_SA_C	Constant, Linear Trend	-6.54086	0.0000

The null hypothesis is rejected for all sequences (all p-values are smaller than 0.05), suggesting that the sequence variables can pass the ADF test after seasonal adjustment and natural logarithm processing, indicating their stability. Model (5-2) was employed via linear regression analysis. The outcomes of the three tests are included in Table 5.3. These tests investigate the impacts of the four independent variables on GDP for the current, subsequent, future second and quarter after that, respectively. To consider the robustness of the test, a residual autocorrelation testing (Breusch-Godfrey Serial

Correlation LM Test) and heteroskedasticity testing (White Test) were conducted on the three regression test results.

Table 5.3. Model (5-2) linear regression test results

Variable	Test 1 Dependent Variable: LN_GDP_SA Sample: 2009Q1 2022Q2	Test 2 Dependent Variable: LN_GDP_SA(1) Sample (adjusted): 2009Q1 2022Q1	Test 3 Dependent Variable: LN_GDP_SA(2) Sample (adjusted): 2009Q1 2021Q4
C	12.77534**	12.85886**	13.84662**
LN_SALARIES_SA	0.597649**	0.532601**	0.544352**
LN_DEPRECIATION_SA	0.090722	0.186811**	0.172795**
LN_TAX_SA	0.021501	0.041759	0.076936**
LN_INCOME_SA	0.012937	0.022684	0.02251*
R-squared	0.903255	0.902443	0.912965
Adjusted R-squared	0.902704	0.901813	0.912366
Heteroskedasticity Test: White	Prob. F(7,46): 0.0130	Prob. F(7,46): 0.0751	Prob. F(7,46): 0.1038
Breusch-Godfrey Serial Correlation LM Test:	Prob. F(2,47): 0.0113	Prob. F(2,47): 0.1275	Prob. F(2,47): 0.1417

**: Prob. <0.05, *: Prob. <0.1

Overall, the adjusted R-squared values for the three tests are all above 0.9, with the third test demonstrating the highest degree of fit, reaching an adjusted R-squared of 0.9123 (see Table 5.3). These results indicate that the time series model regression fit is rather satisfactory. For Test 1, only salaries with a p-value less than 0.05 reject the null hypothesis that it can significantly positively affect the current GDP. These robustness results of Test 1 reject the null hypothesis, indicating residual autocorrelation and heteroscedasticity in the regression.

The results of Test 2 demonstrate that both salaries and depreciation can have a significant positive effect on GDP in the subsequent quarter, with all its robustness tests accepting the null hypothesis, suggesting no residual autocorrelation and heteroscedasticity in the model.

The findings of Test 3 reveal that all four independent variables, except for income, can have a significant positive impact on the future second-quarter GDP. However, the p-value of income only exhibits a positive impact on the subsequent second-quarter GDP within the confidence interval of 0.1. All robustness results of Test 3 accept the null hypothesis, indicating the absence of residual autocorrelation and heteroscedasticity in the model.

In summary, considering the results of the three tests, Test 3 contains more statistically significant variables, making it more suitable for Model (5-2) proposed in this research. This demonstrates that accounting data at the aggregate level possesses an excellent ability to explain the GDP of the subsequent second quarter.

Now the results of the linear regression analysis based on model (5-3) are presented. Analogously to the findings in Table 5.2, Table 5.4 also comprises the results of the three tests. As per model (5-3), these tests scrutinize the impact of the change values of the four independent variables on the GDP change in the present quarter (Test 1), the subsequent (Test 2) quarter, and the second quarter thereafter (Test 3).

Table 5.4. Model (5-3) linear regression test results

	Test 1	Test 2	Test 3
Variable	Dependent Variable : LN_GDP_SA_C Sample: 2009Q1 2022Q2	Dependent Variable : LN_GDP_SA_C(1) Sample (adjusted): 2009Q1 2022Q1	Dependent Variable : LN_GDP_SA_C(2) Sample (adjusted): 2009Q1 2021Q4
C	0.07630	0.01328	-0.01893
LN_SALARIES_SA_C	0.161217	0.071872	0.129020*
LN_DEPRECIATION_SA_C	0.203101*	0.120911	0.593401**
LN_TAX_SA_C	0.976223**	0.190110	0.264475**
LN_INCOME_SA_C	0.058301**	0.247478	0.433401**
R-squared	0.054457	0.096674	0.156670
Adjusted R-squared	0.049271	0.075182	0.083367
Heteroskedasticity Test: White	Prob. F(7,46): 0.0000	Prob. F(7,46): 0.9617	Prob. F(7,46): 0.3232
Breusch-Godfrey Serial Correlation LM Test:	Prob. F(2,47): 0.0000	Prob. F(2,47): 0.1575	Prob. F(2,47): 0.2432

**: Prob. <0.05, *: Prob. <0.1

In Table 5.4, overall, the adjusted R-squared value for the change in the four independent variables' effect on the GDP change in the second quarter next year is the highest (0.08), followed by 0.075 for the subsequent quarter and 0.049 for the current quarter although all three are quite small. Only Tax and Income demonstrate a significant positive correlation in the test of current GDP changes, whereas no independent variable exhibits statistical significance in the test of future GDP changes. In the examination of GDP changes in the subsequent second quarter, all four independent variables, excluding Salaries, have a significant and considerable positive influence on the dependent variable, and the p-value of Salaries can also positively impact the dependent variable within the confidence interval of 0.1. Thus, model (5-3) exhibits greater sensitivity to changes in

GDP in the subsequent second quarter, and its explanatory power for GDP changes is deemed acceptable.

Moreover, to assess the robustness of the analysis, this study additionally conducted the LM Test and the Heteroskedasticity Test on the three regression outcomes. The second and third tests passed these robustness checks, indicating that the model exhibits no residual autocorrelation or heteroscedasticity.

Overall, the findings from models (5-2) and (5-3) corroborate the *RQ5* of this research, namely, the accounting information derived from the four components of the income-based GDP method, contains predictive information about future GDP. Specifically, both research models demonstrate a positive impact of the four types of accounting information on GDP responsiveness in the subsequent quarter. The four accounting variables exhibit strong predictive power for forecasting future GDP values, as the changes in these accounting variables also possess explanatory power for future GDP growth fluctuations.

5.2.2 BP neural network regression analysis

In this subsection, a BP neural network model for the GDP growth part of the subsequent second quarter in the model (5-3) is constructed, aiming to investigate the *RQ6* proposed in this research. The model is shown in Equation (5-5).

$$\Delta GDP_{q+2} = \alpha + \beta_1 \Delta salaries_q + \beta_2 \Delta tax_q + \beta_3 \Delta depreciation_q + \beta_4 \Delta income_q + \varepsilon_{q+2}, \quad (5\text{-}5)$$

According to Equation (5-5), the input layer of the BP neural network consists of four independent variable neurons, with a single dependent variable neuron in the output layer. In this research model, a preliminary set of 3, 6, 8, and 11 hidden layer nodes was established for testing purposes. Subsequently, these nodes with superior fitting performance were selected based on error analysis in various scenarios. The number of network training iterations and training result errors of different hidden layer nodes in MATLAB are presented in Table 5.5.

Table 5.5. Comparison of nodes in different hidden layers

Number of hidden layer nodes	Number of iterations	Mean square error (10^{-4})
3	5000	52.81
6	815	36.14
8	820	12.08
11	2281	22.19

The optimal number of hidden layer nodes is determined to be eight, as it yields the smallest mean squared error (see Table 5.5). Concurrently, the activation function for the hidden layer is selected as the hyperbolic tangent function, while the activation function for the output layer is the identity function. In order to abbreviate the learning time and preclude the established backpropagation (BP) neural network from converging to an optimal local solution, this study employs three enhanced functions from the MATLAB toolbox, namely *trainlm* (Levenberg-Marquardt algorithm), *trainrp* (Resilient backpropagation algorithm), and *trainbfg* (BFGS quasi-Newton backpropagation algorithm) for comparative analysis. *Trainlm* generally performs well on moderately sized neural networks, with fast convergence, but may become slower for large networks. *Trainrp* is generally able to converge faster and is particularly suitable for training deep

neural networks because it can overcome the vanishing and exploding gradient problems. *Trainbfg* generally performs well on small to medium sized neural networks. The functional properties, performance, and characteristics of these three functions are specified in Table 5.6.

Table 5.6. Comparison of three training functions

ID	Function	Fit the Problem	Performance	Training Times (sec)	Mean Square Error
1	*trainlm*	Function fitting	Fast convergence and small error	1410	0.0136
2	*trainrp*	Simulation classification	Fastest	1726	0.0208
3	*trainbfg*	Function fitting	Fast convergence	2103	0.0171

According to the training results of the network training function, it can be found that compared with other training functions, the training speed of the *trainlm* function is the fastest, and the mean square error is smaller than 0.0136 (see Table 5.6). Therefore, this research finally chooses *trainlm* as the training function of the model (5-3).

Furthermore, according to the results in Table 5.7, it can be seen that the independent variable importance results in the BP neural network model are similar to the linear regression results. Among them, both Depreciation and Income importance are higher than 0.4, the importance of Tax is 0.1970, and the importance of Salaries is the lowest 0.0716. These results show that in the test of GDP growth in the subsequent second quarter, the growth of the Depreciation and the Income have the highest positive impact, Tax has a moderately positive impact, and Salaries has the smallest positive impact.

Table 5.7. Importance of features

Feature	Importance
LN_SALARIES_SA_C	0.0716
LN_DEPRECIATION_SA_C	0.4310
LN_TAX_SA_C	0.1970
LN_INCOME_SA_C	0.4502

In order to verify the *RQ6* and test whether the BP neural network can optimize the prediction ability of the traditional linear regression model for GDP growth, the present research compares the regression residuals of the BP neural network model and the traditional linear model for the subsequent second-period GDP forecast.

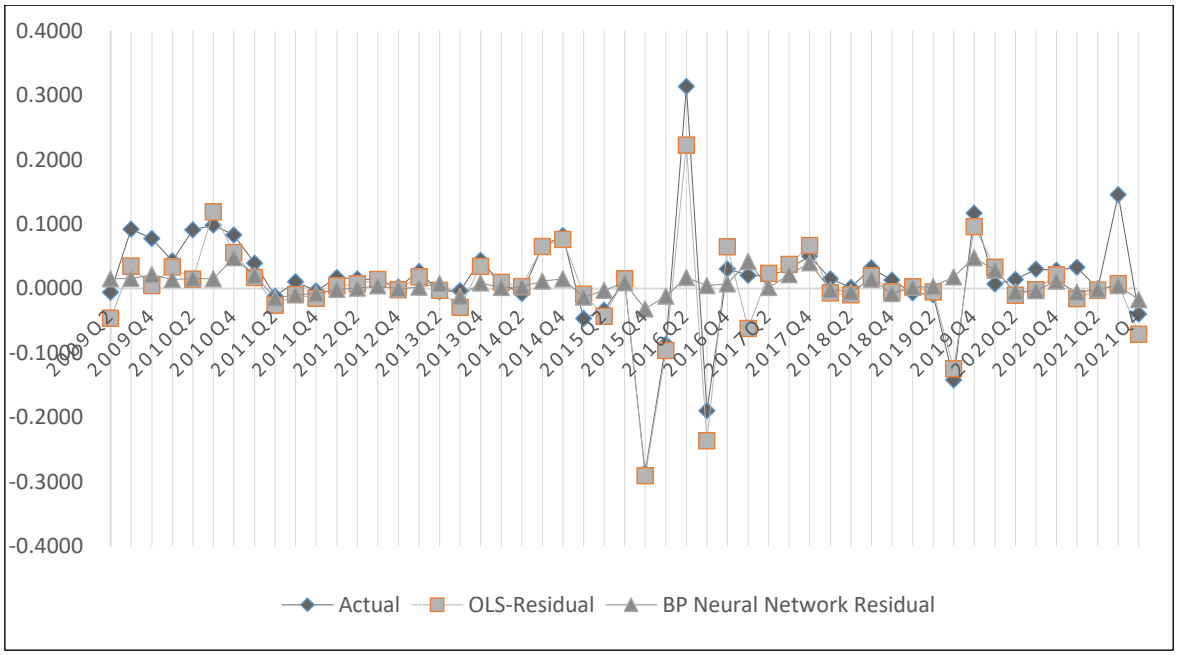


Figure 5.2. Comparison of forecast results

Figure 5.2 shows a graph of the residuals and actual values of the two models, showing the predictive effect of the two models. The closer the residual is to the horizontal axis, the better the fitting effect. It can be seen that the residual performance of the BP neural network model has remained stable near the horizontal axis throughout the whole study

period, while the residual of the traditional linear regression has a significant fluctuation between 2015Q4-2016Q3. Although the considerable fluctuation of the actual GDP growth value in the 2015Q4-2016Q3 interval is the reason for the significant prediction error of the linear regression, the non-linear regression fitting results of the BP neural network remain stable. Hence, the BP neural network is better than the traditional linear regression model.

5.3 CONCLUSIONS

Considering the established findings from current research that validate how aggregate earnings offer additional insights into GDP, exploring the utility of accounting information across different levels of aggregation presents an innovative standpoint on this matter. Furthermore, incorporating artificial neural networks into diverse domains in recent times has introduced fresh ideas and improved previous studies.

The primary focus of this chapter's research was on addressing the research questions *RQ5* and *RQ6* presented in this thesis. The test results of the aggregate level accounting information model, which is based on the four components of China's GDP income approach, highlight fixed asset depreciation and income as crucial factors influencing China's income-based GDP. Furthermore, when comparing the predictive performance of the BP neural network model with that of the traditional linear model for forecasting future second-quarter GDP growth, it becomes evident that the BP neural network exhibits superior fitting capabilities compared to its linear regression counterpart. Additionally, this section of research also confirms that COVID-19 has caused abnormal fluctuations in variables, thereby increasing challenges associated with macroeconomic forecasts.

For future attributes and advancements, it is recommended that future investigations make efforts to examine additional comprehensive-level accounting data in order to uncover incremental GDP information. Additionally, this study solely relies on one neural network algorithm model for analysis. It is anticipated that incorporating a wider range of interdisciplinary approaches will facilitate enhanced research outcomes in this field.

6

THE PREDICTIVE POWER OF AGGREGATE ACCRUAL ACCOUNTING INFORMATION ON FUTURE GDP[6]

[6] This chapter has been sent to an impact journal for publication.

The management of earnings is emphasized in accrual accounting standards, which highlights the significance of accrued income and expenses. Previous studies have shown that accruals provide valuable information about future accounting earnings and macroeconomic conditions (Son & Jeong, 2022). However, due to differences in accounting standards across countries leading to variations in accruals, it is necessary to comprehensively examine the additional information contained within accruals at an aggregate level. Therefore, this chapter aims to contribute to this area by integrating accrued revenues and expenses from the balance sheet into our four-factor model.

Numerous empirical studies have consistently demonstrated the benefits of incorporating neural network models into macroeconomic forecasting. As a result, this chapter adopts a hybrid approach to examine the incremental information regarding future GDP contained in aggregate-level accounting data. This examination is conducted using both linear models and neural network models, with the aim of re-evaluating *RQ6* proposed in this thesis.

Henceforth, this chapter will address the following research questions:

RQ5: Can aggregate-level accounting information based on the GDP income method model predict China's GDP?

RQ6: Can the neural network model optimize the GDP forecasting model proposed in this thesis?

RQ7: Do aggregate-level accruals and accruals contain information about future changes in GDP?

6.1 SAMPLES, VARIABLES AND METHODOLOGY

Similarly, to previous chapters, the present one selected a specific sample time frame from the first quarter of 2009 to the second quarter of 2023, encompassing a total of 58 quarterly samples.

According "China Statistical Yearbook 2023" (NBS, 2023), the financial statements contain corresponding information for each of the four items that make up the GDP. Specifically, according to 'Accounting Standards for Enterprises No.9: Wages and Salaries of Employees' by the Ministry of Finance of China (MOF China, 2014), "employee compensation" can be approximated as the sum of the present value of "employee compensation payable" on the balance sheet and the present value of "cash paid to and for employees" on the cash flow statement. The item "net production tax" corresponds to the account "operating tax surcharge" on the income statement. The depreciation of fixed assets can be directly found as an identical account in the cash flow statement, while accounting results for "operating surplus" are essentially similar to those for "operating income" (CAS. China Accounting Standards, 2006b; Sun et al., 2023).

Thus, the fundamental model adopted in this study can be written as follows:

$$GDP_q = \alpha + \beta_1 salaries_q + \beta_2 tax_q + \beta_3 depreciation_q + \beta_4 income_q + \varepsilon, \text{(6-1)}$$

The variables in model (6-1) should be adjusted to reflect the difference between the current quarter q and the quarter $q + k$, where k=1,2,3,4. Thus, the modified model is as follows:

$$\Delta GDP_{q+k} = \alpha + \beta_1 \Delta salaries_{q+k} + \beta_2 \Delta tax_{q+k} + \beta_3 \Delta depreciation_{q+k} + \beta_4 \Delta income_{q+k} + \varepsilon_{q+k}, \text{(6-2)}$$

Model (6-2) once again verifies *RQ5* proposed in this thesis and tests whether the four components of GDP based on the income method at the aggregate level can provide predictive information for future changes in GDP.

Model (6-3) verifies *RQ7* proposed in this dissertation. The model includes accruals and revenue accruals, as well as information on future changes in GDP:

$$\Delta GDP_{q+k} = \alpha + \beta_1 \Delta salaries_{q+k} + \beta_2 \Delta tax_q + \beta_3 \Delta depreciation_{q+k} + \beta_4 \Delta income_{q+k} + \beta_5 accrued\ revenue_{q+k} + \beta_6 accruals_{q+k} + \varepsilon_{q+k}, \text{(6-3)}$$

Table 6.1 shows the explanation and sources of variables used in this research already mentioned in chapter 3. All variables are at arithmetic aggregate-levels, and in order to eliminate the influence of unit scale between variables, these variables are transformed by natural logarithms. Gaertner et al. (2020), Konchitchki and Patatoukas (2014a) used the current market capitalization ratio as the weight for calculation in general aggregation methods. However, the present research found that using market capitalization ratios as calculation weights did not produce a better performance.

Table 6.1. Variable description. Unit: yuan

Abbreviation	Variable	Definition Explanation	Source
GDP	Nominal GDP	China's quarterly nominal GDP.	NBS China
salaries	Compensation of employees	It refers to the total wages paid by an employer to employees during an accounting period.	CSMAR and authors' calculations
tax	Net taxes on production	It refers to the difference between product taxes minus product subsidies.	CSMAR
depreciation	Depreciation of fixed assets	It refers to describing the loss in value of a fixed asset during its useful life.	CSMAR and authors' calculations
income	Operating surplus	It measures the surplus or deficit generated by production.	CSMAR
Ad_revenue	Accrued revenues	Revenue that a business has earned but has not yet received payment for.	CSMAR and authors' calculations
accruals	Accrued expenses	Expenses that a business has incurred but has not yet been billed.	CSMAR and authors' calculations

Moreover, as quarterly adjustments are necessary for time series data to eliminate the impact of the quarter level, this study employs the Eviews X-12 seasonal adjustment module to perform seasonal adjustments on all variables. Following logarithmic transformation to eliminate unit scale effects and seasonal adjustment, the variable is denoted as 'ln_variable_sa', while the quarterly change value is represented by 'lnvariablesac'. Furthermore, China's financial standards require fixed assets to be disclosed only in the cash flow statement in the second and fourth quarters of each year (MOF China, 2006). Consequently, this study utilizes fixed assets from sample enterprises across all four quarters as weights to derive corresponding depreciation values for fixed assets.

Finally, to answer *RQ6*, this study first trained the model through pre-training, aiming to provide objective and accurate initial parameters for subsequent model training. The constructed BP neural network model corresponds to the models (6-2) and (6-3) defined in this study, aiming to evaluate whether the models proposed in this thesis can be further optimized.

There are four independent variables and one dependent variable in model (6-2). Therefore, the input layer of this BP neural network consists of four neurons, the output layer is only one neuron, and the hidden layer is set to one layer. Since model (6-3) has six independent variables, the input layer of the BP neural network has six corresponding neurons. At the same time, similarly, the output layer is only one neuron, and the hidden layer is set to one layer. Linear regression analysis in this study was performed using Eviews10. The implementation of the neural network model was carried out in MATLAB (R2023a).

6.2 RESULTS AND DISCUSSION

6.2.1 Time series linear model

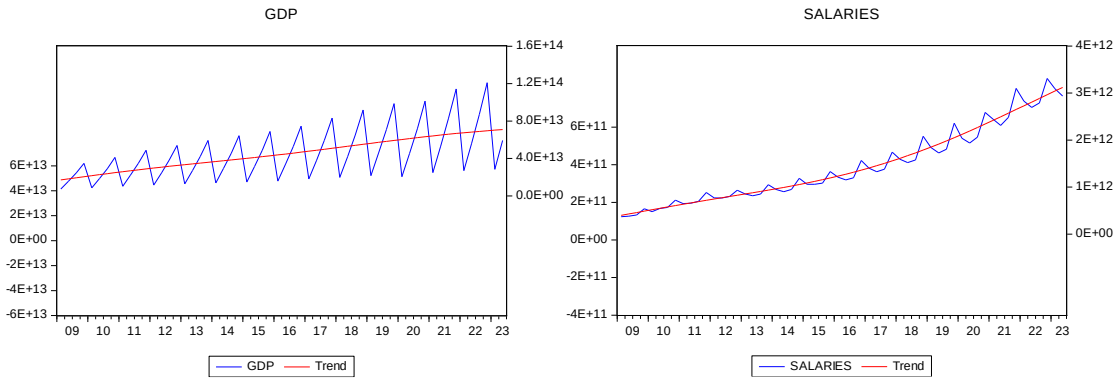
In order to better verify the research questions raised in this chapter, some preparatory work was first carried out. The descriptive statistical analysis of all variables is presented in Table 6.2.

Table 6.2. Variables descriptives

	GDP	ACCRUALS	AD_REVENUE	INCOME	TAX	SALARIES	DEPRECIATION
Mean	4.50E+13	2.13E+13	1.10E+13	9.30E+12	2.30E+11	1.46E+12	3.21E+11
Median	3.98E+13	1.86E+13	1.12E+13	7.62E+12	2.30E+11	1.21E+12	2.95E+11
Maximum	1.21E+14	4.82E+13	2.00E+13	1.90E+13	3.34E+11	3.31E+12	6.40E+11
Minimum	7.33E+12	3.52E+12	3.49E+12	2.23E+12	9.07E+10	3.72E+11	1.21E+11
Std. Dev.	2.80E+13	1.40E+13	4.82E+12	4.58E+12	5.33E+10	8.06E+11	1.45E+11
Observations	58	58	58	58	58	58	58

It is obvious that the change in GDP has the largest difference, with the difference between the maximum value and the minimum value being close to 16 times. Most of the other variables have a difference close to 10 times between their maximum and minimum values, while the depreciation shows the smallest change of less than 6 times. The median accruals represent about half of the median GDP, while the median accrued revenues represent only a quarter of the GDP. In addition, the highest value of accruals is 2.5 times the highest value of income, indicating that the debt ratio of Chinese listed companies has been relatively high in recent years.

To observe the trend fluctuations of the original data, we conducted a Hodrick-Prescott (HP) filter analysis on all variables' original data. The smoothing parameter Lambda was set to the default value of 1600. Figure 6.1 displays the results.



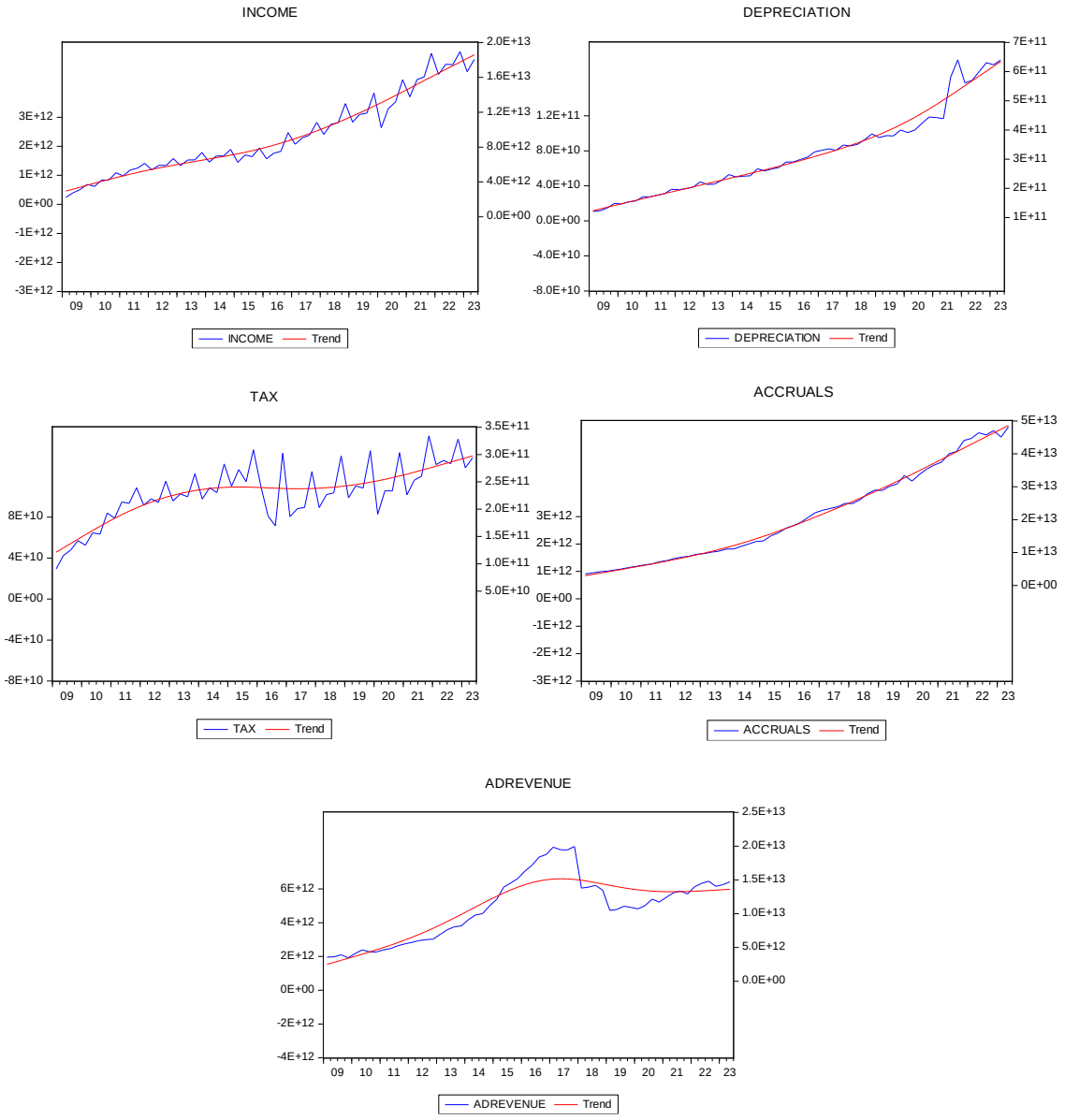


Figure 6.1. Hodrick-Prescott filter analysis results

The HP analysis results for all original variables (Figure 6.1) show a consistent upward trend in all variables except accruals, reflecting the rapid growth of China's economy in recent years. Notably, accrued revenue and tax exhibit significant fluctuations between 2015 and 2020, attributed to China's implementation of the business tax to value-added tax policy in August 2015 (China Briefing, 2016). This policy has had a profound impact on China's tax structure. Furthermore, influenced by the business tax to VAT reform and a series of tax and fee reduction policies, China's macro tax burden started to decline after

reaching its peak in 2015 (Shen, 2022). During this period, accruals also experienced substantial growth, aligning with the positive effects of tax cuts. Apart from accruals, other variables displayed quarterly fluctuations that corresponded well with the characteristics inherent to quarterly data.

The ADF (Augmented Dickey-Fuller) test results for all variables are presented in Table 6.3. As it has been already mentioned, the ADF test is a statistical method employed to examine the presence of a unit root in time series data. In order to establish reliable regression models for time series data, it is essential that the mean and variance of the data remain stable over time. Analysis of the results reveals that both the natural logarithm-processed and seasonally adjusted variables lead to rejection of the null hypothesis (all p-values < 0.05), hence the time series are stationary showing that the stability of the variables used in this research is acceptable.

Table 6.3. ADF test results

Variable	Exogenous	t-Statistic	Prob.
LNGDPSA	Constant	-2.736375	0.0042
LNGDPSAC	Constant	-7.693738	0.0000
LNACCRUALSSA	Constant	-5.213231	0.0001
LNACCRUALSSAC	Constant	-7.787653	0.0000
LNADREVENUESA	Constant	-2.097205	0.0246
LNADREVENUESAC	Constant	-3.850921	0.0000
LNDEPRECIATIONSA	Constant, Linear Trend	-2.752828	0.0220
LNDEPRECIATIONSAC	Constant, Linear Trend	-3.354154	0.0170
LNINCOMESA	Constant, Linear Trend	-4.490558	0.0036
LNINCOMESAC	Constant, Linear Trend	-6.966010	0.0000
LNSALARIESSA	Constant, Linear Trend	-3.877512	0.0194
LNSALARIESSAC	Constant, Linear Trend	-8.496914	0.0000
LNTAXSA	Constant	-3.730189	0.0061
LNTAXSAC	Constant	-8.666944	0.0000

This part of the test also verified *RQ5* proposed in this thesis. Model (6-2) is employed to conduct a linear regression analysis, examining the predictive power of the four GDP components based on the income method at an aggregate-level for future GDP changes. The outcomes are presented in Table 6.4 that shows the extent to which the independent variables in the test model explain the current quarter q and GDP fluctuations in the next four quarters $q + k$ (k=1, 2, 3, 4).

Table 6.4. Results using model (6-2) (k=1,2,3,4)

Column	1	2	3 (HAC)	4(HAC)	5(HAC)
Dependent Variable:	LNGDPSAC	LNGDPSAC (k=1)	LNGDPSAC (k=2)	LNGDPSAC (k=3)	LNGDPSAC (k=4)
Sample: 2009 Q2 to	2023Q2	2023Q1	2022Q4	2022Q3	2022Q2
C	-0.08579	0.22681**	0.14396**	0.19838**	0.23581**
LNSALARIESSAC	-0.09028	-0.06717	0.08667	0.13842*	0.15419
LNTAXSAC	-0.06597**	0.03470	-0.01732	-0.05483**	-0.00226
LNDEPRECIATIONSAC	0.02872	-0.05988*	-0.03753*	-0.05437**	-0.06462**
LNINCOMESAC	0.49911**	0.03184	0.09775**	0.11970**	-0.01647
R-squared	0.61775	0.07648	0.08337	0.14222	0.09237
Adjusted R-squared	0.58835	0.00404	0.01004	0.07220	0.01674
Heteroskedasticity Test: White	Prob.Chi-Square (14)	Prob.Chi-Square (14)	Prob.Chi-Square (14)	Prob.Chi-Square (14)	Prob.Chi-Square (14)
	0.0000	0.0000	0.1430	0.0902	0.7896
Breusch-Godfrey Serial Correlation LM Test:	Prob.Chi-Square (2,50): 0.4862	Prob.Chi-Square (2,50): 0.3254	Prob.Chi-Square (2,50): 0.2464	Prob.Chi-Square (2,50): 0.1741	Prob.Chi-Square (2,50): 0.3668

**: Prob. <0.05, *: Prob. <0.1

Overall, among the five test results, changes in the four independent variables have the highest explanatory power for current GDP changes, with an adjusted R-squared value of

0.588. However, in terms of performance over the next 1-4 quarters, GDP fluctuations in the next third quarter are the best explained, but the adjusted R-squared is only 0.072.

At the same time, in order to verify the validity of the results, this study conducted residual autocorrelation tests (LM) and heteroskedasticity tests (White) on all the results. As all p-value of the LM test are bigger than 0.05, the null hypothesis that there is no heteroskedasticity cannot be rejected for all regression analysis (see the last row in Table 6.4). As for the heteroscedasticity test (columns 3, 4, and 5 in Table 6.4) the null hypothesis is rejected, hence, there is residual autocorrelation. Therefore, we used standard HAC regression for subsequent quarter 2, 3 and 4 (columns 3, 4 and 5).

Examining the current period's GDP change (column 1 in Table 6.4), tax variations exhibit a significant negative impact on GDP fluctuations, while income changes demonstrate a substantial positive influence on GDP alterations. Similarly, investigating future third-quarter GDP changes (column 4 in Table 6.4), both tax adjustments and income modifications yield analogous outcomes as observed for current quarter. Furthermore, salary at the aggregate level have a significative favorable impact on GDP changes in the upcoming third period (P.<0.1). Conversely, aggregate-level depreciation alterations are found to have an adverse significative impact on third-quarter GDP fluctuations. This study reveals that these four variables at the aggregate level account for approximately 58.88% of the observed variations in current-period GDP changes. Additionally, it confirms the *RQ5* that all four variables encompass valuable information regarding future GDP dynamics with sensitivity towards third-quarter fluctuations.

RQ7 proposed in this dissertation examines whether aggregated accrued revenues and expenses contain information about future GDP change. Model (6-3) is employed for this analysis, and the findings are presented in Table 6.5.

Table 6.5. Model (6-3) linear regression results

Column	1	2	3	4(HAC)	5
Dependent Variable :	LNGDPSAC	LNGDPSAC (k=1)	LNGDPSAC (k=2)	LNGDPSAC (k=3)	LNGDPSAC (k=4)
Sample: 2009 Q1 to	2023Q2	2023Q1	2022Q4	2022Q3	2022Q2
C	-0.13783*	0.27076**	0.09592	0.22538**	0.18085**
LNSALARIESSAC	-0.10226	-0.05960	0.07785	0.14717*	0.10793
LNTAXSAC	-0.06383**	0.03247	-0.01559	-0.05482**	-0.00658
LNDEPRECIATIONSAC	0.04242*	-0.07135*	-0.02518	-0.06153**	-0.04888**
LNINCOMESAC	0.45442**	0.07419	0.04628	0.13725**	0.00046
LNACCRUALSSAC	0.16642*	-0.15338	0.18502	-0.07371*	0.00409
LNADREVENUESAC	0.00577	0.00277	-0.00926	-0.01127	0.10752
R-squared	0.64329	0.09559	0.105919	0.14921	0.21654
Adjusted R-squared	0.60048	-0.01514	-0.005841	0.08060	0.11436
Heteroskedasticity Test: White	Prob.Chi-Square (27)	Prob.Chi-Square (27)	Prob.Chi-Square (27)	Prob.Chi-Square (27)	Prob.Chi-Square (27)
	0.0000	0.0000	0.0041	0.9999	0.0248
Breusch-Godfrey Serial Correlation LM Test:	Prob.Chi-Square (2,50): 0.9204	Prob.Chi-Square (2,50): 0.4224	Prob.Chi-Square (2,50): 0.2869	Prob.Chi-Square (2,50): 0.2448	Prob.Chi-Square (2,50): 0.7103

**: Prob. <0.05, *: Prob. <0.1

Similarly, this study also uses five tests to analyze the impact of GDP changes in variable q in the next four quarters $q + k$ (k=1, 2, 3, 4). In comparison with the findings presented in Table 6.4, in column 1, the adjusted R-squared slightly increases to 0.600. The adjusted R-squared also slightly increased to only 0.080 in column 4. Conversely, other tests yield similarly unsatisfactory outcomes.

In the LM residual autocorrelation tests, the null hypothesis cannot be rejected (all p-values > 0.05), indicating no presence of autocorrelation. Regarding the heteroskedasticity test, only subsequent second quarter (column 3) rejects the null hypothesis; therefore, this study employs standard HAC for regression analysis for k=2.

This section primarily focuses on examining whether aggregate-level accruals contain information about future GDP changes and specifically analyzes the impact of accrued income and expenses on model outcomes. Results for current quarter and for subsequent second quarter demonstrate that aggregate-level accrued expenses significantly influence GDP changes within a confidence interval of 0.1. Notably, the coefficient suggests a positive effect of aggregate accrued expenses on the current period but a negative effect on future third-quarter GDP.

Regarding this aspect of the findings, firstly, it was observed that incorporating accrued expenses and accrued revenues enhances the explanatory power of the model for changes in GDP. Additionally, *RQ7* of this study was verified, indicating that aggregate-level accruals contain information about future GDP changes, albeit with insignificant impact. Interestingly, alterations in aggregate-level accruals positively influence current-period GDP changes but negatively affect GDP changes in the subsequent quarter. This confirms the lagged effect of comprehensive liability accounting. If accrued expenses increase during a period, it may stimulate economic activity associated with those expenses; for instance, higher wage expenditures can encourage employees to spend more and thereby boost current-period GDP. Similarly, increased supplier payments can spur economic activity throughout the supply chain. However, when these modifications are converted

into liabilities in the future period(s), their negative impact on GDP becomes evident. It also reaffirms *RQ7* that total accruals contain information about future changes in GDP. At the same time, it should be noted that compared to the findings of existing studies, such as Gaertner et al. (2020), which primarily examined the amount of GDP information embedded in negative accrual accounting items at the aggregate-level, the current research disaggregates accrual accounting into accrued revenues and expenses. Its objective is to provide a more detailed analysis of the future GDP change information encompassed within accrual accounting at the aggregate-level.

6.2.2 BP neural network

This section is mainly dedicated to examining whether the neural network performs better than the conventional linear models (6-2) and (6-3). For model (6-2), which corresponds to four variables, a BP neural network model with 4 independent variable neurons, a hidden layer, and 1 dependent variable neuron was carried out using MATLAB. Similarly, for model (6-3), which corresponds to six variables, a BP neural network model with 6 independent variable neurons, a hidden layer, and one dependent variable neuron was developed. To prevent overfitting, this study considered hidden layer nodes 3, 4, 6, 8 and 10 while employing early stopping to halt training that no longer improves error rates. Finally, the optimal node is selected based on iteration errors. The training results of both models are presented in Table 6.6.

Table 6.6. Comparative analysis by number of hidden layer nodes

	Model (6-2)		Model (6-3)	
Hidden layer nodes	Iterations	MSE (10^{-4})	Iterations	MSE (10^{-4})
3	1850	56.42	1942	61.03
4	1560	49.30	1720	52.36
6	840	17.17	1678	39.81
8	1120	28.92	1197	20.40
10	1281	35.44	1311	37.74

According to the findings presented in Table 6.6, the model demonstrates optimal fit when the Mean Square Error (MSE) is minimized. Consequently, for model (6-2), the number of hidden layer nodes is set to 6, while for model (6-3), it is set to 8. Typically, an identity activation function is employed in the input layer. In this study, the activation function of the hidden layer is the hyperbolic tangent function, and the activation function of the output layer is the identity function to directly produce the actual value.

At the same time, in order to find the most suitable training algorithm for the two models, this study compares three training algorithms built into MATLAB: Levenberg-Marquardt algorithm (*trainlm*), elastic backpropagation algorithm (*trainrp*) and BFGS quasi-Newton backpropagation algorithm (*trainbfg*). The performance results are presented in Table 6.7. Based on the MSE results, *trainlm* demonstrates superior performance in both models. Consequently, *trainlm* is selected as the designated training function for both models.

Table 6.7. Comparative analysis of training functions

		Model (6-2)		Model (6-3)	
ID	Function	Training Times (sec)	Mean Square Error	Training Times (sec)	Mean Square Error
1	*trainlm*	2010	0.0016	2218	0.0019
2	*trainrp*	3026	0.0028	3751	0.0032
3	*trainbfg*	2813	0.0059	3160	0.0064

Based on the results presented in Table 6.8, the variable importance of the BP neural network aligns closely with the coefficient outcomes obtained from linear regression analysis (shown in Table 6.5). In Model (6-2), tax exhibits the lowest importance, while income demonstrates the highest significance. In Model (6-3), accrued revenues display relatively lower impact importance compared to other variables, approximately one-tenth of their significance, whereas income remains highly influential.

Table 6.8. Importance of variables

	Model (6-2)		Model (6-3)	
Importance	LNGDPSAC	LNGDPSAC (3)	LNGDPSAC	LNGDPSAC (3)
LNSALARIESSAC	-0.1720	0.1806	-0.1636	0.24577
LNTAXSAC	-0.0121	-0.0326	-0.0989	-0.0871
LNDEPRECIATIONSAC	0.0455	-0.0847	0.0708	-0.1039
LNINCOMESAC	0.5204	0.2814	0.5453	0.2360
LNACCRUALSSAC			0.2712	-0.1326
LNADREVENUESAC			0.0095	-0.0176

A comparative analysis of regression residuals is conducted to assess and compare the predictive performances between model (6-2) and model (6-3). Consequently, this section focuses solely on analyzing the explanatory power of these models for GDP changes in both the current period and third period, without considering any potential influence from variations in independent variables. The outcomes are illustrated in Figure 6.2.

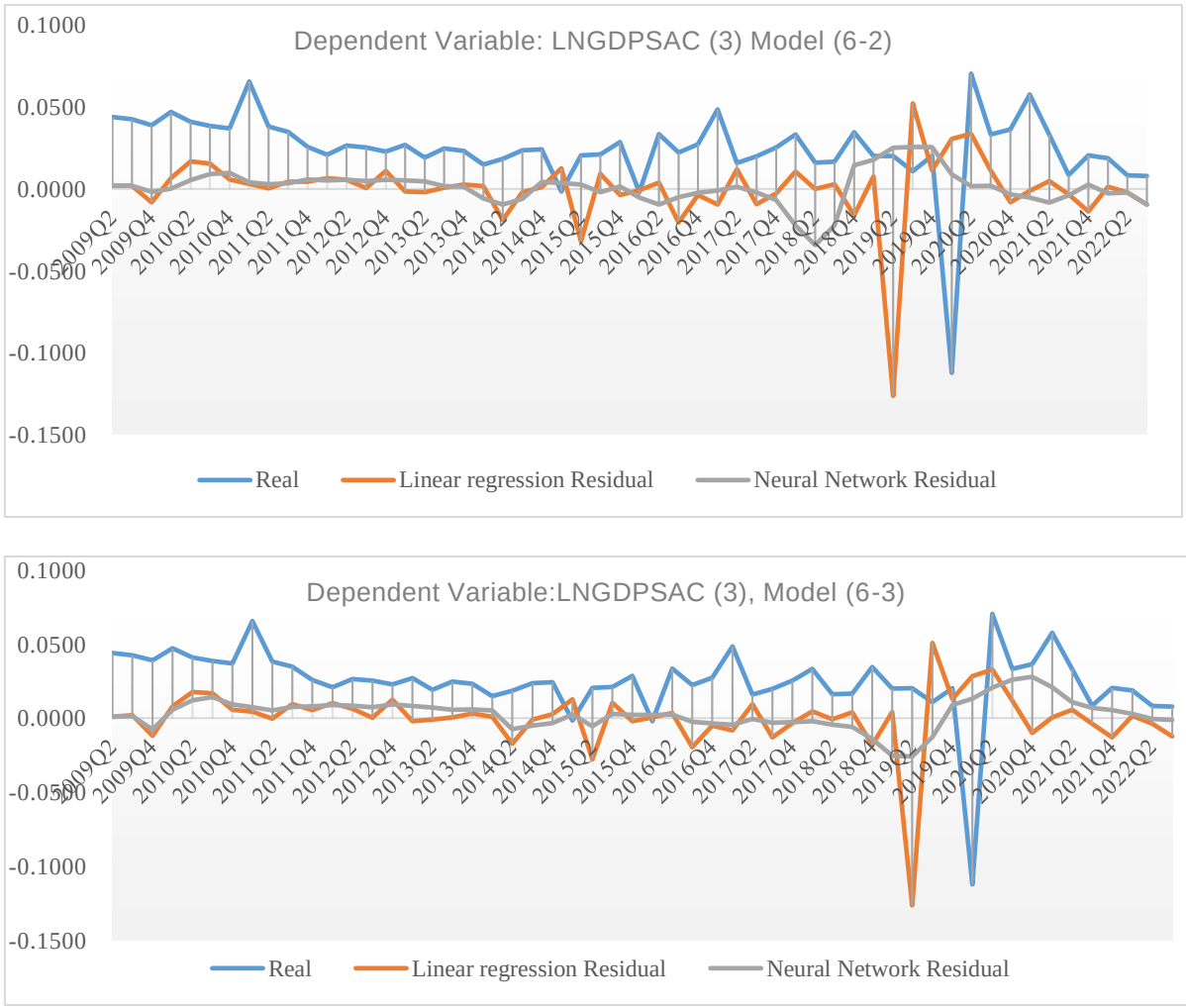


Figure 6.2. Fitting performance comparison results

As a smaller residual implies a closer approximation to the actual value, indicating a superior fitting effect, it is evident that in both models' results, the residuals of the BP neural network model (gray line in Figure 6.2) exhibit a relatively stable distribution near the horizontal axis. Conversely, for the traditional linear regression model (orange line in Figure 6.2), there were significant fluctuations in residuals between 2019Q2 and 2020Q1.

China's economy was impacted by the pandemic in 2020, both models (6-2) and model (6-3) experienced a decrease in forecast accuracy around 2020. However, the BP neural network demonstrate consistent stability. Consequently, it can be inferred that the neural

network model performed better than the linear regression model in predicting analysis for both model (6-2) and model (6-3). This verified *RQ6* of this thesis, which suggests that the neural network algorithm model can enhance the conventional prediction model utilized in this research.

A summary of the hypothesis is presented in Table 6.9.

Table 6.9. Summary of results

Hypothesis	Explanation	Result
RQ5	The four components of GDP based on the income method at the aggregate-level contain information about future changes in GDP.	Confirmed
RQ6	The BP neural network algorithm model has better prediction performance than the traditional linear model.	Confirmed
RQ7	Aggregate-level accrued revenues and accrued expenses contain information about future GDP fluctuations.	Confirmed

6.3 CONCLUSIONS

This chapter further extends the GDP income approach forecast model, aiming to predict future changes in GDP by exploring alternative forms of aggregate-level accounting information. The findings demonstrate that aggregate-level taxes and income possess significant explanatory power for current period GDP fluctuations. Furthermore, insights into future third-quarter GDP variations can be derived from aggregate-level taxes, depreciation, and income. This study also incorporates information on subsequent changes in GDP into cumulative accruals by integrating accruals and related variables into the baseline model. The results reveal that only accruals contain valuable information

regarding both current period and future third-quarter GDP changes. Additionally, this chapter demonstrates that the BP neural network model exhibits superior fitting capabilities compared to traditional linear regression models when dealing with nonlinear data.

However, it is important to note that the current study has certain limitations. Firstly, there is a need for further exploration into the intrinsic mechanism through which accounting information incorporates GDP change information. A more comprehensive analysis of its operational pathway can enhance our understanding of how changes in GDP can be explained using accounting information models. Secondly, due to constraints imposed by China's accounting standards reform, there are also limitations on the time series length used in this study. Expanding the data series could potentially improve the accuracy of the model. Lastly, it is worth mentioning that this study did not consider broader-level accounting information. The significance of accounting information for macroeconomists and policymakers worldwide cannot be overstated. In line with decision usefulness theory, there is an urgent requirement to enhance the utility of accounting information even further.

7

GENERAL CONCLUSIONS

Current research on the relationship between microeconomics and macroeconomics is rapidly developing. Under the current complex and challenging economic background, due to the overall slowdown in global economic growth since the COVID-19 pandemic, accounting information is having greater impact on economic development. Most research on the usefulness of accounting information is directed at investors, creditors, and individuals while there is scarce research related to government and country macroeconomic policies. For the analysis and forecasting of GDP, there is a lack of research from an accounting perspective. Therefore, the present thesis contributes to narrow this gap and provides a new way of thinking about the current uncertain macroeconomic forecast.

Firstly, this dissertation discloses the existing correlation between microeconomic-level accounting information and national macroeconomic-level GDP through a bibliometric analysis of aggregate earnings research. To enhance the bibliometric analysis of aggregate earnings, chapter 2 initially examines the relevant literature on the utility of earnings. In terms of comparative influence analysis, it is observed that Scopus research has less impact compared to WoS. Furthermore, upon comparing term co-occurrence maps, Scopus research topics exhibit greater independence without forming a knowledge network but are more innovative. The development of Scopus in this field is still in its early stages and holds significant potential for further advancement. On the other hand,

WoS research clearly distinguishes three distinct lines of inquiry with no strong correlation among them. Simultaneously, this thesis posits that future WoS research in this field will lack potential.

In the comparative analysis of the co-occurrence terms map, the present dissertation found that in the development of new topics, Scopus performance is better than WoS, whose research in this field is still focused on the topic of traditional earnings usefulness research. In the forecast of future research of aggregate earnings topic, this thesis first compared the predictive capabilities of the traditional ARIMA model and neural network model and found that the Optimization algorithm model performed best. Overall, Scopus developed better than WoS in aggregate earnings research. Furthermore, in future development, Scopus will have more potential, while WoS research in this field will gradually lose attention.

A review of the existing literature found that research on the relationship between microeconomics and macroeconomics is mainly based on examining the relationship between aggregate earnings and economic development indicators such as GDP. Given that scholars have corroborated that aggregate earnings encompass incremental information regarding GDP, research on the aggregate-level usefulness of accounting information offers a novel perspective on the topic. This thesis tries to fill in the gap in accounting information usefulness theory in the current research context. In recent years, the integration of artificial neural networks in various fields has also yielded novel concepts and enhancements to existing research. This dissertation also examined the development of a neural network model and its research involving GDP, concluding that,

overall, the neural network model demonstrated superior performance compared to the traditional linear autocorrelation model in the direct prediction of GDP.

Although some researchers have obtained seemingly reliable results through theoretical and empirical studies, there are numerous confounding factors that influence these conclusions. Several studies have neglected to address the international comparability of accounting standards in target economies, leading to inconsistent findings. After establishing the relationship between income and national economic growth, empirical studies have demonstrated the correctness and credibility of using total income as an approach. This thesis recommends that micro-accounting information should refer to local accounting standards, which will help the international comparability of research in this field.

In the empirical section of this dissertation, the corresponding research questions raised in this study are validated through an empirical analysis conducted in chapters 4, 5, and 6. In Chapter 4, it has been verified the practicality of the existing aggregate earnings-GDP model in the Chinese sample. The results did not find any evidence to support existing research, that is, no evidence was found to contain information about GDP growth in China's Aggregate earnings. It also establishes a four-factor test model based on the income method GDP accounting model founded on the theoretical basis proposed in this thesis. It will not only benefit future related research, but it will also provide more information for professional macro forecasters. In addition, it will as well provide theoretical and empirical support for the usefulness theory of accounting information. Furthermore, chapter 4 confirmed that using market capitalization to weight variables concerning existing research did not optimize the regression results of the model. Also,

the present research found that the most critical variable is the impact of companies' earnings on GDP. Earning is the core goal of an enterprise, and there is no doubt that more earnings will bring more GDP. The development of GDP needs the support of the development of more companies' earnings.

In Chapter 5, a GDP influencing factor model, incorporating accounting information at four aggregate levels as independent variables, was developed based on the four components of the GDP income-based method. Results revealed that both the current value of the variable (Model 2) and the added value of the variable (Model 3) contained in the four types of accounting information based on the income-based GDP method's components provide information about future GDP. The model demonstrated greater sensitivity to the performance of GDP in the subsequent second quarter. Among the four aggregate-level variables, Depreciation and Income had the most significant impact, followed by Tax and Salaries. The findings indicate that the Depreciation of fixed assets and Income are the most critical components in China's income-based GDP composition. Additionally, by comparing the performance of the BP (backpropagation) neural network model and the traditional linear model in forecasting the future second quarter GDP growth, this study found that the fitting effect of the BP neural network was superior to that of the traditional linear regression model. In addition, this study also confirmed that COVID-19 caused variables to fluctuate abnormally, which increases the difficulty of macroeconomic forecasts.

In Chapter 6, this thesis is based on the four-factor model of the GDP revenue method proposed in Chapter 4 and Chapter 5. It considered the inclusion of future GDP change information within aggregated accruals by incorporating accrued revenue and accrued

expense variables into the baseline model. Furthermore, a BP neural network model was constructed to compare its performance with that of traditional linear models in predicting future GDP. The findings indicate that in the proposed four-factor model (Employee salaries payable, Operating tax surcharge, Fixed asset depreciation and Income), Aggregate-level taxes and Income exhibit a robust explanatory power for changes in GDP during the current period. Moreover, Aggregate-level taxes, Depreciation, and Income provide insights into GDP changes in the future third quarter. Among accrued revenues and accrued expenses at the aggregate-level, only accrued expenses contain information about GDP changes both in the current period and in the future third quarter. However, there is no empirical evidence to support including GDP change information within accrued revenues at the aggregate level for either the current or future periods. Additionally, this study demonstrated that BP neural network models outperform traditional linear regression models in terms of their fitting effectiveness when dealing with nonlinear data.

One of the limitations of this dissertation is the lack of in-depth horizontal research on the impact of taxation on GDP. This can become an exciting research direction to be explored and quantified in the future. Additionally, the overall research on the amount of macro information contained in other accounting information is incomplete and requires further development. The significance of accounting information for macroeconomists and policymakers cannot be overstated, and there is a pressing need to further enhance the utility of accounting information in line with the theory of decision-making usefulness.

Another limitation is that the sample is limited to Chinese listed companies. Unlisted companies also significantly contribute to a country's GDP and incorporating them into

the research sample could further investigate the relationship between aggregate-level accounting information and economic development. However, the specific implementation methods for data collection differ by country, presenting limitations to the research on this topic. Quantifying these differences also represents an interesting future research line.

Moreover, this thesis could not conduct an in-depth discussion of the intrinsic mechanism by which accounting information contains GDP change information. A more detailed analysis of its action path could enhance the ability to explain GDP changes based on accounting information models. The study is also limited by the sample size, as it includes only 58 quarters of time series data due to accounting standards reforms constraints. Increasing the sample size might improve the model's accuracy.

Future research could explore the impact of taxation on GDP in greater depth, providing a quantified analysis of this relationship. Additionally, expanding the research to include unlisted companies could offer a more comprehensive understanding of the connection between accounting information and economic development. Investigating the specific data collection methods of different countries and quantifying these differences could further enhance the robustness of the findings.

Finally, further studies could also delve into the intrinsic mechanisms by which accounting information reflects GDP changes, offering a more detailed analysis of these pathways. Increasing the sample size and duration of the time series data could improve the accuracy of the models used. Also, incorporating more interdisciplinary methods,

beyond hybrid models of neural networks, could provide innovative approaches to studying this topic, offering new insights and enhancing the overall research framework.

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APPENDIX A

Table A1. The usefulness of earnings publications quartiles in WoS and Scopus

	WoS						Scopus					
	Q1	Q2	Q3	Q4	Other	Total	Q1	Q2	Q3	Q4	Other	Total
1968	3					3						0
1976						0	1					1
1984						0	1					1
1985						0	1		1			2
1986						0	1					1
1987						0	2					2
1988			1			1		1	1			2
1989	2					2	1					1
1990						0		1				1
1992	3		1			4	1	2				3
1993	5	1				6	2	1				3
1994	1	2	1			4	2	2	2			6
1995	1					1	3	2				5
1996	2					2	4	1				5
1997		1				1	4	2				6
1998	1		1			2	5	2	1		1	9
1999				1		1	7	3	1			11
2000	2					2	2	2				4
2001	3	3				6	5	3		1	2	11
2002	6		1			7	4	4				8
2003	6					6	5	1			2	8
2004	4				3	7	4	2			1	7
2005	2					2	2	5				7
2006	3	1	1		2	7	8			2		10
2007	2	1	1		2	6	5	1	4	1	1	12
2008	2	1	1	1		5	5	4		1	1	11
2009	1	4	1		1	7	5	3	2			10
2010	6	1	4	1	1	13	8	4	1	1		14
2011	5	2	2	1	2	12	8	3	1			12
2012	5	3		1	3	12	7	9	2	1	2	21
2013	2	2	2	1	3	10	4	1	1			6
2014	4	5	1	2	1	13	6	2	1	2	1	12
2015	4	4	3		7	18	6	1	1	1		9
2016	6	6	4	1	8	25	11	6	1	4		22
2017	5	2	4	1	13	25	2	6	2	1		11
2018	4	3	1		6	14	8	4	3			15
2019	5	5	5	3	9	27	6	3	2	1		12
Percentage	0.38	0.19	0.14	0.05	0.24	251	0.52	0.29	0.10	0.06	0.04	282

Table A2. Aggregate earnings publications quartiles in WoS and Scopus

	WoS						Scopus					
	Q1	Q2	Q3	Q4	Other	Total	Q1	Q2	Q3	Q4	Other	Total
1987						0		2				2
1991						0		1				1
1992	1					1	1					1
1993						0	1					1
1995	1					1						0
1996	1					1	1					1
1997						0	1					1
1999		1				1	2	2				4
2001	1					1	1		1			2
2002	1					1	1	1				2
2003		1				1	1					1
2004	2					2	2		1			3
2005	2					2	2	2				4
2006	1	1				2	1	1				2
2007	2			1		3	3	2	1	1	1	8
2008	1	1	2	1	1	6	3	1	1		1	5
2009	2	1	1	1		5	4		1			5
2010	1	1				2	2	1				3
2011	1	2	1			4	4	1	1	1	1	8
2012		1				1	1					1
2013	1	1	1			3	2	1	1			4
2014	3	1				4	3	1	1		1	5
2015	2	2			3	7	2	2	1			5
2016	3	1	2		2	8	2	2				4
2017	2				1	3	2	1				3
2018		1	1		1	3	2	2	1			5
2019	4		2		6	12	6	4	2			12
Percentage	0.43	0.20	0.14	0.04	0.19	74	0.54	0.29	0.13	0.02	0.04	93