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Construction of Performance Excellence Scorecard and Its Application in Advanced Manufacturing Industry in the Guangdong-Hong Kong-Macau Greater Bay Area

YANG Kejun

Doctor of Management

Supervisors:
PhD Nelson José dos Santos António, Professor Emeritus,
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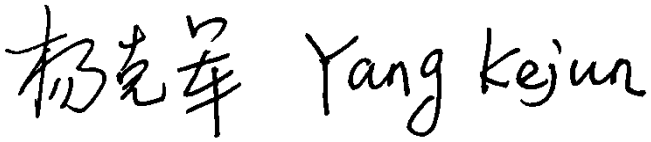

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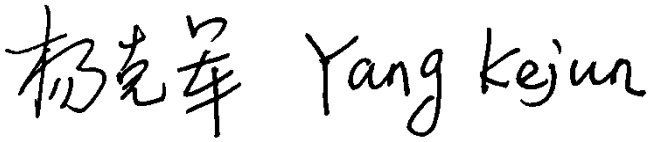

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Abstract

This thesis uses the Balanced Scorecard (BSC) as the basic framework and integrates the sustainability theory, the stakeholder theory, and the corporate innovation theory to build a new performance measurement system fully compatible with the Performance Excellence Model (PEM) – the Performance Excellence Scorecard (PESC), to overcome the shortcomings of the PEM, the BSC, and other performance management tools in building a comprehensive performance measurement system for enterprises.

Combining the Analytic Hierarchical Process (AHP) and the Entropy Method (EM), this thesis assigns weights to each indicator of the PESC, while using the Structural Equation Model (SEM) to construct and validate totally 50 categories of indicators in 12 dimensions of the PESC, exploring the interrelationships among these indicators, and providing guidelines for the top-level design and selection of corporate KPIs.

Using the PESC as the basic framework, a "PESC corporate management maturity evaluation model" is established and a maturity study conducted on advanced manufacturing enterprises in the Greater Bay Area, and through statistical analysis of 300 returned questionnaires, improvement suggestions provided for Chinese manufacturing enterprises to improve management maturity.

In addition, recommendations are made to enterprises, governments, and accreditation bodies on the application of the PESC in different fields and situations, including: replacing the BSC with a combination of the PEM and the PESC to establish a performance measurement system; using it as a dynamic and independent management method for comprehensive corporate performance improvement; and using it for modeling and measuring the QMI of specific regions, industries or groups of enterprises.

Keywords: Performance Excellence Model (PEM), the Performance Excellence Scorecard (PESC), Analytic Hierarchical Process (AHP)- Entropy Method (EM), Structural Equation Model (SEM), PESC corporate management maturity, PESC application

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Resumo

Tendo como base o Balanced Scorecard (BSC), esta tese integra a teoria da sustentabilidade, a teoria dos stakeholders e a teoria da inovação empresarial e constrói um novo sistema de medida do desempenho totalmente compatível com o Performance Excellence Model (PEM) – o Performance Excellence Scorecard (PESC). Com o PESC pretendemos colmatar as deficiências do PEM, do BSC e de outros instrumentos de gestão de desempenho, na construção de um sistema compreensivo de medida de desempenho.

Combinando o Processo de Hierarquia Analítica e o Método da Entropia, esta tese atribui pesos a cada indicador do PESC, e utiliza o Modelo de Equações Estruturais para construir e validar 50 categorias de indicadores nas 12 dimensões do PESC, explorando as interrelações entre estes indicadores e fornecendo diretrizes para a concepção e seleção dos KPIs.

Utilizando o PESC como a estrutura base, construímos "um modelo PESC de avaliação da gestão da maturidade" e realizamos um estudo sobre a gestão da maturidade nas empresas de manufatura que operam na Área da Grande Baía. Através da análise estatística dos 300 questionários recolhidos recolhemos sugestões para a melhoria da gestão da maturidade.

Esta tese faz também recomendações a empresas, governos, e organismos de acreditação para a aplicação do PESC em diferentes áreas e situações, incluindo: substituição do BSC por uma combinação do PEM e do PESC para estabelecer um sistema de medida do desempenho; utilização do novo sistema como um método de gestão dinâmico e independente para uma melhoria do desempenho das empresas; e utilizar este novo sistema para modelar e medir o QMI(Quality, Management; Improvement) de certas regiões, indústrias ou grupos de empresas.

Palavras-chave: Performance Excellence Model (PEM); Performance Excellence Scorecard (PESC); Processo de Hierarquia Analitica; Método de Entropia; Aplicação do PESC
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摘要

为克服“卓越绩效模式”（PEM）、平衡计分卡（BSC）以及其他绩效管理工具在构建企业综合的绩效测量系统方面的不足，本文以 BSC 为基本框架，融入可持续发展理论、利益相关者理论以及企业创新理论，构建了一个全新的、充分契合卓越绩效模式的绩效测量系统——卓越绩效计分卡（PESC）。

结合层次分析法（AHP）-熵值法的综合赋权法，本文对 PESC 的各指标进行了赋权，同时利用结构方程模型（SEC）对 PESC 的 12 维度共 50 类指标进行了模型构建和验证，探索了 12 个维度指标之间的相互关系，为企业关键绩效指标的顶层设计和遴选提供指南。

以 PESC 为基本框架，本文建立了一个“PESC 企业经营管理成熟度评价模型”，对粤港澳大湾区先进制造业企业开展成熟度调研，通过对 300 份回收问卷的统计分析，为我国制造业企业提升经营管理成熟度提供改进建议。

此外，本研究还就 PESC 在不同领域和场合的应用，向企业、政府以及评审机构提出建议，包括：代替 BSC，用“PEM + PESC”组合来建立企业的绩效测量系统；作为一个动态的、独立的管理方法，用于企业综合绩效改进；用于特定地区、行业或企业群体质量经营指数的建模和测评等。

关键词：卓越绩效模式（PEM）；卓越绩效计分卡（PESC）；AHP-熵值法综合赋权法；结构方程模型；PESC 企业经营管理成熟度；PESC 应用

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Contents

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List of Tables

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List of Figures

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List of Acronym

AHP	Analytic Hierarchical Process
BSC	Balanced Scorecard
CEO	Performance Excellence Model
CQA	China Quality Association
EIS	European Innovation Scoreboard
ESG	Environmental, Social and Governance
GCR	Global Competitiveness Report
GII	Global Innovation Index
KPI	Key Performance Indicators
PEM	Performance Excellence Model
PESC	Performance Excellence Scorecard
PP	Performance Prism

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Chapter 1: Introduction

1.1 Research background and significance

1.1.1 Research background

1.1.1.1 High-quality development of China’s manufacturing industry enhanced by Made in China 2025

Since China launched the reform and opening-up at the end of the 1970s, with the competitive advantages of a large labor force and relatively low labor costs, the manufacturing industry developed rapidly over the past 50 years, and has established the most complete industrial system with the most complete supply chain, and has become the world's number one "manufacturing country". However, compared with Europe, the United States and Japan and other traditional manufacturing powers, China's manufacturing industry is generally "big but not strong", and lagged far behind in the efficiency of resource utilization, business efficiency, brand competitiveness, management maturity and other aspects, with international competitiveness of leading enterprises relatively weak. Therefore, how to quickly transform and upgrade to achieve high-quality development is a major issue that China's manufacturing industry needs to resolve.

In order to realize the transformation from a "big manufacturing country" to a "manufacturing power", China has formulated a "three-step" strategy for three decades. According to the plan, China plans to be among the "manufacturing powers" by 2025; by 2035, enter the world's "manufacturing power" camp at the middle level; and by 2049, become the world's "manufacturing power" with overall strength. On May 19, 2015, with "Made in China 2025" officially issued by the State Council, China comprehensively started from "Made in China" to " Created in China ", from "China's speed" to "China's quality", from "China's products" to "China's Brands".

1.1.1.2 Guangdong province developing advanced manufacturing industry

Since the reform and opening-up, Guangdong Province has been a major economic province in China by virtue of its high-speed development and excellent performance in the manufacturing industry. However, the traditional economic development model of high energy consumption,

high pollution, low land rent, low wages, and low taxes became increasingly difficult to continue. On February 16, 2017, based on documents including "Made in China 2025", the Guangdong Provincial Government issued the "13th Five-Year Plan for Advanced Manufacturing Industry Development in Guangdong", which put forward the strategic task of focusing on the development of advanced manufacturing industry, realizing the structural adjustment, transformation and upgrading of the province's manufacturing industry, and completing the transformation of the province from a large manufacturing province to a strong manufacturing one.

The "advanced manufacturing industry" refers to the general term for the manufacturing industry that constantly absorbs the high-tech achievements of electronic information, machinery, materials and modern management technology, and applies them to the whole process of manufacturing products, thus achieving good economic, social and market benefits. In comparison to the traditional manufacturing industry, advanced manufacturing industry is advanced in industry, technology, and management: 1) the wide application of advanced manufacturing technology, such as all kinds of communication information technology; 2) the use of advanced manufacturing mode, such as digital design, automation manufacturing, information management and network management; and 3) the introduction of advanced management to achieve high-quality operation, such as lean production, Six Sigma management, and the PEM.

1.1.1.3 PEM driven by Government Quality Awards applied in advanced manufacturing industry in the Greater Bay Area

After World War II, Japan took the lead in establishing the Deming Application Prize, Japan's national quality award, in 1951 to encourage industries to adopt advanced quality management methods to improve product quality and enhance industrial competitiveness, which turned out to be a great success in the ensuing three decades. To cope with the competition from Japan, the U.S. established the Baldridge National Quality Award (BNQA) in 1987, encouraging enterprises to adopt the Performance Excellence Management Model - a more advanced management approach to improve business performance and the overall competitiveness of U.S. enterprises.

In 2004, the China Quality Association (CQA) developed and released the Chinese national standard the Evaluation Criteria for Performance Excellence (CQA, 2004), using the “Criteria for Performance Excellence” (the evaluation standard for the U.S. National Quality Award) as a reference model, and initiated the evaluation of the National Quality Award in the same year,

to guide enterprises in pursuing high-quality operation.

At present, in addition to the National Quality Award, there are a large number of provincial government quality awards and mayor's quality awards in China that adopt the Evaluation Criteria for Performance Excellence (CQA, 2004) as evaluation guidelines. In 2008, the Guangdong Provincial Government set up the Provincial Government Quality Award, and under its drive, cities and districts in Guangdong Province have set up various government quality awards, and by 2022, hundreds of manufacturing enterprises have won various awards (such as first/second/third prizes, grand prize/nomination/encouragement awards, gold/silver/bronze awards.), among which the manufacturing industry in the Greater Bay Area of Guangdong Province has the most outstanding results.

The Guangdong-Hong Kong-Macau Greater Bay Area, together with San Francisco Bay, New York Bay, and Tokyo Bay, are known as the world's four major Bay Areas. It is located in South China, and consists of 11 cities, including Hong Kong, Macau, and nine other cities in Guangdong Province (e.g., Shenzhen, Guangzhou, Dongguan, and Foshan). In 2022, the Guangdong-Hong Kong-Macau Greater Bay Area's GDP exceeded 1.9 trillion U.S. dollars and ranked at the top of the four major Bay Areas. Yet the gap among GDP per capita was huge, with per capita GDP in New York Bay Area and San Francisco Bay Area close to 100,000 U.S. dollars, while the Guangdong-Hong Kong-Macau Greater Bay Area just over 20,000 U.S. dollars, with a very large room for improvement.

1.1.1.4 Assessors' lack of evaluation standards leading to uneven evaluation results

According to the results of a survey of enterprises with tax revenues of over $100 million across the U.S., 79% of the 2,500 sampled enterprises believed that the U.S. National Quality Award had greatly improved the quality of their business operations, and 67% believed that it effectively promoted the competitiveness of their enterprises (D. F. Zhang & Du, 2004).

Since 2012, governments at all levels in China have initiated many quality award evaluations, but their credibility and influence have not been widely recognized. X. J. Hu (2018) did a questionnaire survey on the credibility of government quality awards and found that 70% of the respondents had never heard of government quality awards or paid attention to the relevant award-winning enterprises.

J. Cao (2020) points out that there are many reasons for the low credibility and influence of the quality awards through the investigation, statistics and analysis of the establishment and assessment of provincial government quality awards in China, for example, the motivation for enterprises to participate in the award is "emphasizing on honor and neglecting performance";

the "best practice sharing" activities of the award-winning enterprises are not fully carried out; and the insufficient capacity of Quality Award assessors.

W. Q. Lin (2015), in summarizing the evaluation experience of the Fujian Provincial Government Quality Award, point out that the lack of competence of many assessors has led to unsatisfactory evaluation results. For example: the Evaluation Criteria for Performance Excellence (CQA, 2004) promotes the use of methods, and enterprises use many methods in the management process, but some assessors are unfamiliar with the methods; the assessors ask questions without hierarchy, unable to raise deep or high-level questions. The assessors are accustomed to drawing conclusions from their own level of knowledge rather than based on objective facts.

1.1.1.5 Diverse organizations' (especially manufacturing enterprises') lack of efficient methodological guidance leading to different outcomes

The "Evaluation Criteria for Performance Excellence" (CQA, 2004) is not a "conformity" evaluation standard, but a "maturity" evaluation model. The evaluation of the Quality Award adopts the "maturity evaluation" method, and the evaluation of "process" and "result" involves all aspects of corporate management. For quality award declaration, there are clear procedures and guidelines, however, there is a lack of effective methodological guidance on how to practice the Performance Excellence Model (PEM).

Through an empirical study of 424 government quality award-winning enterprises in Zhejiang Province, Xiong and Wang (2013) found that there are large differences in the effectiveness of the implementation of quality awards in various regions, the quality of quality awards reviews is uneven, and many SMEs have more doubts about how to systematically utilize the relevant management tools (or methods) to improve their overall performance in the process of implementing the government quality awards.

Studying the gains and losses of corporate strategic management, it can be found that many enterprises do have strategies, and there might be no problems with their strategic decision-making, but their implementation of strategy was improper. In other words, between "strategy formulation" and "strategy implementation", there is a problem with "strategy deployment". Therefore, for companies aiming to establish a PEM system, it is particularly important to select one or more "strategy deployment" tools.

However, in terms of theoretical research and management practice, there is still a lack of effective management tools that can fully match the core values and demands of the PEM, and even the more popular performance management tools such as Key Performance Indicators

(KPI), Balanced Scorecard (BSC), and the Performance Prism (PP) have their own shortcomings. Therefore, even if enterprises have mastered these tools, they cannot fully meet the requirements of the "Evaluation Criteria for Performance Excellence", not to mention that a large number of enterprises have not even mastered these basic management tools.

To sum up, in the context of China's governments at all levels vigorously promoting the application of the Performance Excellence Model and government quality awards, the lack of effective methodological guidance has led to varied quality of evaluation when the assessors carry out the evaluation of quality awards, and the implementation effects vary when the enterprises establish the PEM. Therefore, it is necessary to study the key factors (or key indicators) affecting the maturity of corporate management, and to construct a performance measurement system that meets the actual management needs of enterprises and fits the requirements of Evaluation Performance Criteria for Excellence Evaluation, to help all kinds of organizations (especially the manufacturing industry) to achieve high-quality development.

This thesis uses the Balanced Scorecard (BSC) as the basic framework, and, based on the existing four dimensions of "Finance", "Customer", "Internal Process" and "Learning and Growth", finds new dimensions, improves the existing ones, and integrates the most advanced management concepts and methods in the 2020s, to build a new performance evaluation system on the theoretical and empirical basis.

1.1.2 Research significance

1.1.2.1 Theoretical significance

Based on the latest corporate management theories in the 2020s, this thesis constructs a new performance measurement system, the Performance Excellence Scorecard (PESC), through theoretical and empirical studies with the BSC as the basic framework. The theoretical implications of this scorecard are as follows.

1) It deeply integrates the BSC with the sustainable development theory, the stakeholder theory, the corporate innovation theory and relevant corporate performance management tools, which not only covers all indicators in the nine dimensions on four levels, i.e., Finance, Customer, Internal Process, and Learning and Growth, but also adds new indicator dimensions and types to form a new performance measurement system, surpassing the BSC. This system can be combined with the PEM and work independently as well.

2) The new performance measurement system is fully aligned with the PEM, with the relevant indicators not only covering all indicators in multiple sub-categories of seven

categories of the PEM, but also, on the basis of the latter, enhancing some of the indicators, including Environmental, Social and Governance (ESG) indicators, stakeholder indicators, and corporate innovation indicators, which can be directly combined with the PEM for the formulation and development of strategic objectives.

3) The new performance measurement system is not a simple variation of the BSC or a random mixture of indicators, but is based on today's most advanced management concepts. For example, the new system replaces the "financial" perspective of the BSC with an "enterprise value" perspective, which includes both "financial" and "sustainable development" dimensions, and is in line with the ongoing financial reporting reform of the International Financial Reporting Standards Foundation (IFRS Foundation). Furthermore, the "customer" perspective is replaced by the "stakeholder" perspective, representing a shift from the "shareholder first" theory to the "stakeholder theory". In addition, "ESG" replaces "regulatory and social processes" and "corporate innovation" replaces "innovation., reflecting the solid theoretical foundation and its alignment with the latest development trends of the new system.

1.1.2.2 Practical significance

The emergence of the Performance Excellent Scorecard (PESC) has positive and far-reaching influence on the wide application of the Performance Excellence Model (PEM) on Chinese enterprises (especially in the manufacturing industry), which has an extended application scenario in management practices, including (but not limited to) the following aspects:

1) It offers methodological guidance for enterprises to implement the PEM. When constructing the PEM, Chinese enterprises commonly use the BSC to set up and break down the performance indicators, while the Guidelines for the Evaluation Criteria of Performance Excellence (CQA, 2004) also recommends the BSC for strategic deployment. However, due to the lack of sustainable development theory, stakeholder theory, and corporate innovation theory, as well as evaluation dimensions, the BSC can hardly meet the demands of the PEM in the core values or the principles, while the PESC exactly compensates for the shortage of the BSC and can replace it in offering the PEM users top-level design on KPI.

2) It can be used by enterprises in strategy deployment and performance management, as an independent performance management tool. Similar to the BSC, the PESC is a "Translating strategy into action" management tool. Different from the PEM, whose standard texts (such as the Evaluation Criteria of Performance Excellence) are complex and obscure, not conducive to popularization, the PESC is simpler and easier to understand, and it can be used regardless of whether or not the enterprise understands and implements the PEM. The BSC has a wide user

and application base, and the PESC explains the updated concepts and performance evaluation points in the form of a scorecard, which can quickly gain the understanding and recognition of the BSC users and facilitate its popularization.

3) It is used as an independent maturity evaluation model for enterprises and accreditation institutions when conducting maturity evaluations. By using the “PESC Management Maturity Evaluation Model”, enterprises or evaluation institutions can develop maturity evaluation programs to evaluate the setting, performance, and trends of each level, each dimension and each type of KPI of the PESC, as well as the design, development and calibration of the corresponding methods, so as to obtain the maturity level of the enterprise, discover the strengths and weaknesses, and continuously improve operation maturity and management performance.

1.2 Research content

1.2.1 Definition of research problems

In China, the evaluation of quality awards using American and Chinese standards has been going on for nearly 20 years, and such awards have undoubtedly played a significant role in promoting the competitiveness and sustainable development of Chinese enterprises. However, the following problems exist in the actual process of standards implementation and award evaluation:

Various Performance Excllence Models (or standards of quality awards) provide the indicator systems to evaluate the corporate management maturity from different dimensions, but what are the key indicators for dozens or even hundreds of indicators? How much does each category of indicators contribute to the result? What are the interrelationships between the various categories of indicators (e.g., what are the driving indicators and what are the result-oriented ones)? The standards do not provide specific answers.

The problems above lead to the following consequences:

1) When establishing the performance indicator system, the enterprise highly relies on the experience and knowledge of the management team to select the performance indicators. Once omitting or selecting the wrong ones that have an important impact on the maturity improvement of the corporate management, it is very likely that the performance improvement will not be significant, and may even bring negative impacts;

2) Various quality awards have failed to give full play to the function of " improving

performance through evaluation " – helping participating enterprises identify the most valuable opportunities for improvement, and enhancing the corporate management maturity by improving the processes and results involving the KPIs.

Therefore, it is necessary to carry out research on key factors (or KPIs) affcting corporate management maturity: selecting enterprises in a specific region and industry, conducting research based on theoretical analysis, so as to construct a performance evaluation system that meets both the requirements of the PEM (or diverse quality awards) and the operational needs of such enterprises.

1.2.1 Research questions

Aiming at the problems in the actual process of standards implementation and award evaluation of various Performance Excellence Models (or quality award standards), this thesis takes the advanced manufacturing enterprises in the Greater Bay Area as the research object and carries out theoretical and empirical research, aiming at solving the following two questions, so as to improve the effect of the application of the PEM in enterprises:

RQ1: What are the factors (or KPIs) that impact the corporate management maturity of advanced manufacturing enterprises in the Greater Bay Area? What is their contribution?

Finding out these key factors (or key indicators) and their contribution can, on the one hand, helps assessors get the focus of the assessment and identify and point out important improvement opportunities for the enterprise when assessing the quality awards; and on the other hand, help the enterprises select those indicators that are the most valuable for improving the corporate management maturity when setting up the performance measurement system.

This thesis makes comparative study on different performance evaluation systems (e.g., the PEM, the BSC, the PP, Sustainability Performance Evaluation, and Corporate Innovation Performance Evaluation), explores key factors affecting corporate management maturity, and constructs a new performance evaluation system - the Performance Excellence Scorecard (PESC), and weighs the PESC indicator system with the AHP-EM to determine the contribution of each performance indicator to the management maturity.

RQ2: What is the correlation between the factors (or KPIs) affecting the corporate management maturity of advanced manufacturing enterprises in the Greater Bay Area? How do they interact with each other?

Based on the research of the contribution (or weight) of key factors (or KPIs), this thesis aims to investigate the correlation between the indicators of each dimension of the new

performance evaluation system, the PESC, by means of the Structural Equation Model (SEM)and to find out the causal relationships and priorities among them, so as to formulate corresponding short-, medium-, and long-term action plans for enterprises, and to carry out "precise" and "efficient" performance improvement.

1.3 Research methods

1.3.1 Research plan

In this thesis, the theoretical research and empirical analysis are conducted along the line of "problem explanation → problem analysis → problem solving". The steps are as follows:

First, "literature review". At that stage, the advantages and disadvantages of various performance management models as well as the similarities and differences in the setting of performance indicators are compared, the key factors affecting the management maturity of advanced manufacturing enterprises in the Greater Bay Area are explored, and a set of evaluation system for comprehensively evaluating the corporate management maturity – the Performance Excellence Scorecard (PESC) is refined.

Second, the first round of questionnaires is designed, and expert opinion surveys are carried out using the Likert Five-point Scale to evaluate the importance of the indicators in the PESC, and then the indicators are deleted or added according to the experts' opinions, and the experts' opinions are solicited again.

Thirdly, a second round of questionnaires is designed and a survey of experts' opinions is conducted using the Analytical Hierarchy Process (AHP) to determine the weights of the indicators by means of "two-by-two comparisons" between the indicators.

Step four, the questionnaire of "Evaluation of Corporate Management Maturity" is designed based on the PESC, and distributed to advanced manufacturing enterprises in the Greater Bay Area and then collected.

Step five, the Entropy Method is used to analyze the recovered questionnaires and determine the weights of each indicator, and then combined with the AHP weights formed in the third step, and the AHP-EM weights of the PESC are comprehensively derived.

Step six, to construct the Structural Equation Model (SEM) of the PESC, put forward the hypotheses, and utilize the results of the survey on "Evaluation of Corporate Management Maturity" to carry out the correlation study on the indicators of the dimensions of the PESC, and verify the hypotheses.

Step seven, to utilize the results of the Corporate Management Maturity Evaluation to conduct the evaluation and analysis of corporate management maturity of the PESC in the advanced manufacturing industry in the Greater Bay Area, and to provide suggestions for the application of the PESC to enterprises.

Finally, the research of this thesis is summarized and prospected. The chapters are organized as follows:

Chapter One：Introduction. This chapter mainly elaborates the research background and significance, research contents, research methods and major innovation. The section of "research contents" focuses on two core parts, i.e., "definition of research problems" and "research questions".

Chapter Two: Literature Review. Focusing on the research questions raised in the first chapter, this chapter combs and reviews the relevant theories and literatures of enterprise performance management, aiming at forming a new performance evaluation system. Firstly, it introduces the BSC and points out the limitations of the BSC in terms of the "sustainability", the "stakeholder" and the "corporate innovation". Second, it introduces the PEM and points out the shortcomings of the PEM itself and its combination with other management tools in the construction of the performance measurement system. Then, the theories including "sustainability", "stakeholder" and "corporate innovation" are introduced respectively, together with various corporate performance evaluation tools that accompany these theories. Finally, the performance indicators involved in various performance evaluation tools are compared, analyzed and refined, to provide a direction for the construction of a fresh scorecard model.

Chapter Three: Construction of PESC Model. The thesis adopts the Delphi Method to construct the model, with steps as follows: 1) The BSC is used as the basic framework based on the literature research in Chapter Two to conduct addition, deletion, and adjustment on relevant levels; 2) the Likert scale is used to design a questionnaire, conducting a survey with 20 experts in the research and application of the PEM, and forming the final PESC indicator system after appropriate adjustments.

Chapter Four: Study on the combined weighting of PESC based on AHP-EM. First, a brief overview of the weighting principles and procedures of various types of subjective and objective weighting methods and the combination of AHP-EM is presented; second, how to construct a hierarchical model and questionnaire design based on the AHP method is explained; then, the AHP-EM based PESC combined weighting process and its results are described in detail; and finally, the PESC Weighting Outcome are analyzed.

Chapter Five: Correlation study of PESC indicators based on the SEM. The SEM is used to validate the PESC model and to analyze the correlation of 12 dimensions of indicators. The specific steps are as follows: 1) model setting, proposing various relationship hypotheses among latent variables, and between latent variables and measured variables; 2) questionnaire design, survey, recovery and data preparation; 3) model fitting, validation and modification; and 4) interpreting the model and determining the indicator weights.

Chapter Six: Evaluation and analysis of corporation management maturity of PESC in the advanced manufacturing industry in the Greater Bay Area. First, the overall maturity of the sample enterprises and the individual maturity of some indicators are calculated based on the combined weighting results obtained by the AHP-EM; then, the influencing factors affecting the maturity of corporate management are analyzed from the dimensions of corporate operation history, scale, nature, listed or not, and with or without the government quality award; finally, based on the analysis conclusions, suggestions are made to improve the PESC maturity of corporate management.

Chapter Seven: Conclusions and expectations. The thesis summarizes major conclusions and practical value based on the research process and results, and points out shortcomings of the thesis for further studies.

1.3.2 Research tools

This thesis does an in-depth study on the construction and application of the PESC model. The main research tools include qualitative and quantitative methods, such as literature research, Delphi Method, AHP-EM method, questionnaire survey and SEM.

1) Literature Research. The literature review is an important basis for research. This thesis conducts a literature search through Google scholar, Web of Science, Scopus, Baidu Academic, China Knowledge Network and other databases, systematically combs through the theories and methods of the Balance Scorecard (BSC), the Performance Prism (PP), the Performance Excellence Model (PEM), the sustainable development, stakeholders, corporate innovation and ESG (Environment, Social Responsibility and Corporate governance), and analyzes the feasibility of integrating these theories and tools, to provide theoretical support for the construction of the PESC model.

2) Delphi Method (or Survey on Experts). Based on the construction of the PESC model, This thesis conducts a survey among 20 experts in the PEM about what levels should be included in the scorecard, what dimensions (criterion layer) should be included on each level

(target layer), and what indicators (indicator layer) should be used to measure each dimension. After 2 rounds of communication, a consensus is formed on the initial framework of PESC indicator system.

3) Analytic Hierarchy Process (AHP) -Entropy Method (EM)

In this study, the hierarchical structure model of PESC is constructed using the AHP method, and questionnaires are distributed to the same group of 20 experts, and pair comparisons are made and values are assigned to the objective layer/criterion layer/indicator layer, so as to form the subjective weights of each indicator. Meanwhile, this study uses the EM to statistically analyze the 300 recovered enterprise questionnaires, so as to form the objective weights of each indicator and assign the combined subjective and objective weights on this basis.

4) Questionnaire Survey. The questionnaire is designed based on the target, criterion and indicator layers of the PESC model, and a questionnaire survey (targeting more than 300 valid questionnaires) commissioned a consultancy is launched to key positions in advanced manufacturing enterprises in the Guangdong-HongKong-Macau Greater Bay Area (excluding Hong Kong and Macau), to gain a comprehensive understanding of their management maturity levels and to provide suggestions and guidelines for enterprises to improve their maturity.

5) Structural Equation Modeling (SEM). The process of SEM analysis is commonly divided into four steps: model construction, model operation, model modification, and model interpretation. This study constructs and validates the PESC corporate management maturity evaluation system model through the steps of theoretical construction, model setting, model identification, data collection, data preparation, model fitting, model validation, model modification, and model interpretation.

1.3.3 Technical roadmap

This thesis refers to and integrates theories and methods of the BSC, the PP, the PEM (Performance Excellence Model), the sustainable development, stakeholders, ESG, and corporate innovation, comprehensively adopts methods including literature research, Delphi Method, AHP-EM, questionnaire survey, and SEM, follows the lead of "raising questions → literature research → model construction → empirical analysis → application suggestion", and explores the construction of the PESC model as well as its application in advanced manufacturing enterprises in the Guangdong-HongKong-Macau Greater Bay Area. The detailed analysis is designed as in Figure 1.1.

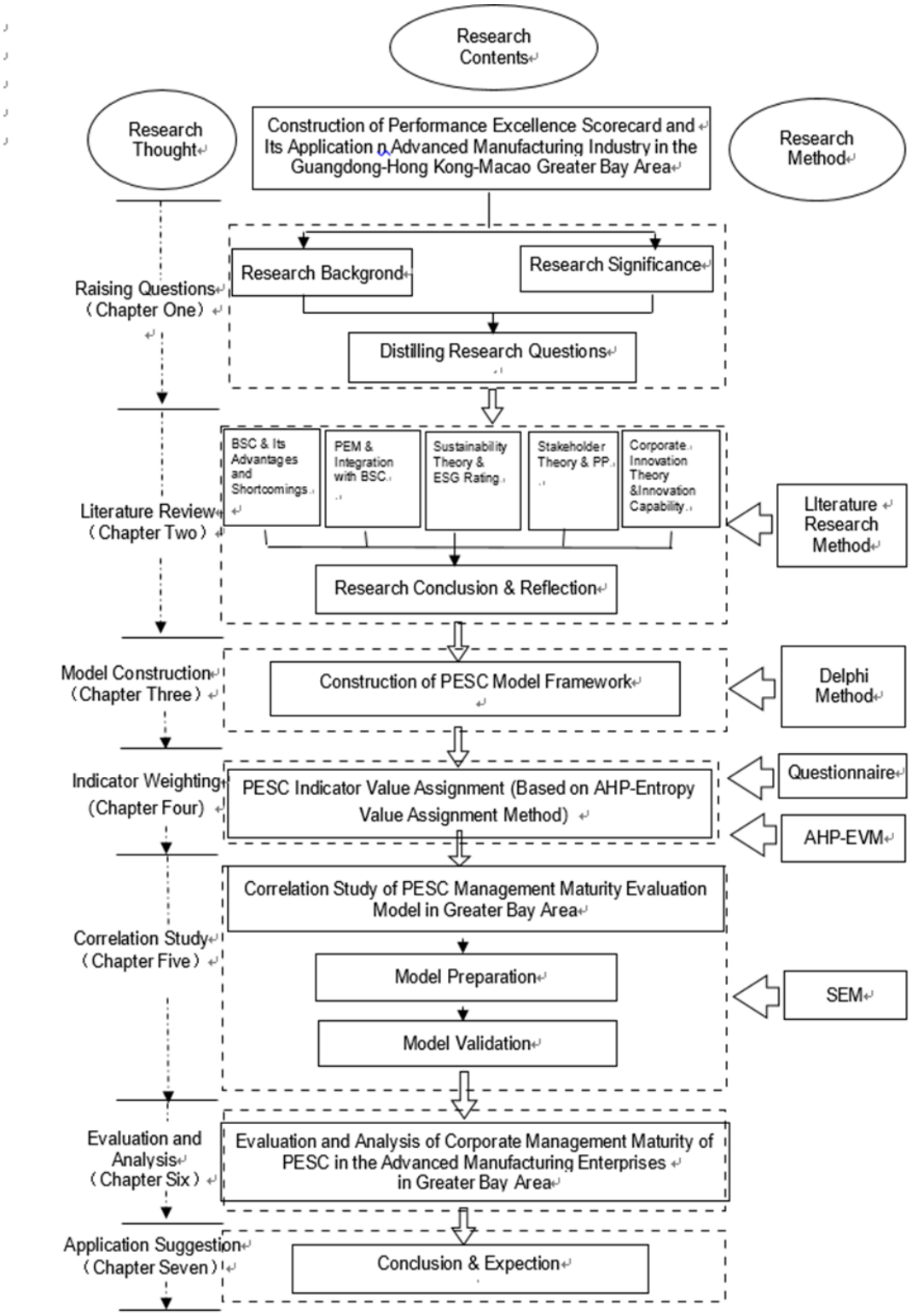

Figure 1.1 Technical roadmap

1.4 Major innovation

Through literature research, this thesis makes a theoretical elaboration and comparative analysis on the advantages and disadvantages of various performance management tools and their

integrated applications, presents a new performance management tool, the PESC, and makes an empirical study on it. There are three main innovations in this thesis.

1) A new performance measurement system is constructed which fully matches the PEM. The traditional BSC is no longer compatible with the PEM in the current context due to the lack of sustainability theory, stakeholder theory and corporate innovation theory; the PP focuses on stakeholders, but is insufficient in sustainability theory and basically does not reflect corporate innovation theory, which is not compatible with the PEM; other performance evaluation systems are limited to single perspectives and are even less well matched. The PESC proposed in this thesis draws on the basic framework of the BSC and integrates the latest corporate management of the 21st century, fully aligned and fit with the PEM.

2) The influencing factors of the corporate management maturity of advanced manufacturing enterprises in the Greater Bay Area and the correlation between the factors are studied. Based on expert opinion surveys as well as questionnaire surveys among enterprise, this study utilizes the AHP-EM to determine the key factors (or KPIs) and their weights that affect the corporate management maturity. In addition, this study utilizes SEM to investigate the correlation of these key indicators, so as to provide suggestions for enterprises to establish performance measurement systems.

3) Based on the PESC, an evaluation model of “corporation management maturity of PESC in the advanced manufacturing industry is developed and used to survey advanced manufacturing enterprises in the Greater Bay Area. In this study, the questionnaires of 300 representative advanced manufacturing enterprises are selected for statistical analysis and evaluation, and questions of "corporate operation history", "scale", "nature", "listed or not" and “with or without the government quality award” are selected to assess the overall maturity of different types of enterprises and the maturity of some key performance indicators, so as to provide suggestions and guidelines for enterprises to apply PESC.

Chapter 2: Literature Review

This chapter focuses on the research questions raised in Chapter One as well as the construction of the PESC, and reviews the relevant theories and literature. Firstly, it introduces the BSC and points out its limitations in terms of "sustainability concept", "stakeholder concept" and "corporate innovation concept" (2.1). Second, the PEM (Performance Excellence Model) is introduced, and the shortcomings of the PEM itself and of its combination with other management concepts/tools in the construction of the performance measurement system are pointed out (2.2). Then, the "sustainability theory", the "stakeholder theory" and "corporate innovation theory" and various corporate performance evaluation mechanisms that accompany these theories are all presented (2.3). Next, the performance indicators involved in the various performance evaluation concepts /tools mentioned above are compared, analyzed, and refined to provide directions for the construction of a new performance measurement system (2.4), and finally, the literature review in this chapter is reviewed and summarized (2.5).

2.1 BSC-based corporate performance evaluation

2.1.1 Emergence and development of BSC

The Balanced Scorecard (BSC) was proposed by R. Kaplan and D. Norton, initially applied to performance evaluation in human resources, and gradually evolved into a strategic deployment tool.

The evolution of the BSC can be divided into three stages: 1) evaluation indicator system (Kaplan & Norton, 1992); 2) management system (Kaplan & Norton, 1996); and 3) strategic management system (Kaplan & Norton, 2004). Kaplan and Norton published three researches consecutively in 1992, 1993, and 2007, followed by three books in 1996, 2001, and 2003, which provided a comprehensive and systematic description of the functions and applications of the BSC at different times, and summarized a new equation for its strategy execution: breakthrough results = strategy map + BSC + strategy-centered organization (H. Y. Song & Shen, 2015).

At the strategic planning stage, the BSC can be used to develop and roll out strategic objectives and to construct a performance measurement system for the enterprise in four dimensions, i.e., financial, customer, internal process, and learning and growth, which form the

framework of the BSC:

1) The financial dimension: a strategic balance of opposing forces in the short and long run. The BSC is based on the principle of "shareholders first", and its ultimate goal of the company is to maximize profits. The company's financial performance is achieved through two strategies: a revenue growth strategy, which is realized through "increasing revenue opportunities" and "enhancing customer value"; and a productivity strategy, which is realized through "improving asset utilization" and "enhancing customer value". The BSC holds that all activities of the organization should serve the financial objectives (increase in sales and decrease in expenses).

2) The customer dimension: Strategy is based on a differentiated value proposition. The BSC proposes a logical relationship among indicators such as "Customer Satisfaction Rate → Customer Retention Rate → Customer Acquisition Rate → Customer Share", and the management of customer and financial indicators, such as "Customer Acquisition Rate → Revenue Increase Opportunities", "Customer retention rate → customer value increase". The BSC also holds the customer value proposition as defining the company's strategy, and proposes four typical value propositions: lowest total cost, leading products, total solution, and system lock-in.

3) The internal dimension: Value is created through internal processes. The BSC holds that internal processes enable two key elements of corporate strategy: first, producing and delivering value propositions to customers; and second, improving processes and reducing costs, thereby bettering the productivity elements at the financial dimension. Internal processes are categorized into four types: operations management - producing and delivering products and services; customer management - enhancing customer value; innovation - innovating new products and services; and regulatory and social processes - improving communities and the environment. Each type of process is divided into multiple sub-processes.

4) The learning and growth dimension: the strategic alignment of intangible assets. The quality and efficiency of internal process operations depend on organizational learning and growth at the lowest level. The BSC classifies learning and growth into three types: human capital, information capital, and organizational capital. Despite all organizations trying to develop their labor, technology, and culture, many are unable to focus these intangible assets on strategy, operations, or alignment. The BSC is dedicated to transforming these intangible assets into tangible ones.

Since its introduction, the BSC framework has been rapidly put into practice in the United States and other Western countries. A study by the American Institute of Management

Accountants (IMA) found that more than 40% of companies were using the BSC (Frigo & Krumwiede, 2000). According to the Gartner Group, approximately 50% of Fortune 1,000 North American companies and 45% of European companies were using the BSC in 1999. The essence of the BSC is the idea of "balance" when compared to traditional financial measurement models (Z. B. Li, 2006):

1) Balance between financial and non-financial indicators. Traditional performance measurement systems focus only on financial indicators and ignore other non-financial ones (e.g., customer, operations, human capital, information capital and organizational capital). In the actual operation and management activities of an enterprise, non-financial indicators have a direct or indirect impact on the achievement of financial indicators, and they can fully measure the enterprise's operation performance and sustainable development capability (e.g., customer satisfaction, operation efficiency, innovation capability and compliance performance), so as to realize balanced and coordinated development of the enterprise.

2) Balance between process and outcome indicators. Traditional performance measurement systems pay more attention to outcome indicators (especially financial indicators), but less attention to process indicators (e.g., operations, customers, regulations and society), and financial indicators are lagging indicators, which cannot provide timely feedback or guidance on the enterprise's operation management activities. The BSC adds process indicators (or driving indicators) and establishes a causal logical relationship between process indicators and outcome indicators. Meanwhile, the improvement of process indicators can effectively drive the financial results to reach the expected goals, thus realizing the balance between process indicators and outcome indicators.

3) Balance between performance measurement and strategy deployment. The BSC is not only a performance measurement system, more importantly, it is also a strategic deployment tool. In the strategy development stage of the enterprise, around the strategic objectives, the management can decompose the business objectives and action plans from the top to the bottom, following the four levels of "Finance → Customer → Operations → Learning and Growth". The main reason why the BSC is widely sought after by Fortune 500 companies is that it can be used for both performance measurement and strategy deployment.

2.1.2 Limitation of BSC

The BSC is not only a strategy deployment tool but also a performance management tool. Although it is used globally, any performance measurement system is sub-optimal, and the BSC

is no exception (Meyer, 2003). For example, in terms of the design of the BSC framework, the causal chain of "Learning and Growth → Internal Processes → Customers → Finance" is debatable (Malmi, 2001), while L. K. Wei (2005) argues that it should be a cyclic closed loop and Norreklit (2000) sees it as a two-way, complex relationship. Furthermore, the perspective of stakeholders is not broad enough. Neely et al. (2002) argue that the BSC focuses on shareholders, customers and employees, instead of other key stakeholders such as end-users, suppliers, rule makers, pressure groups, and the community.

Business management concepts are changing day by day and business management tasks keep emerging. It has been 30 years since the birth of the BSC. In order to solve various problems arising from the application of the BSC, variations of it have been produced in academia and industry. For example, the BSC is combined with KPIs, the BSC is combined with the PEM (Performance Excellence Model), and the number of BSC dimensions grows, for example, environmental, social responsibility, corporate governance, and innovation dimensions are added (Z. H. Wang, 2009). At the same time, some performance management concepts and tools beyond the BSC have emerged, such as the Performance Prism which expands the scope of stakeholders, and the sustainable BSC which embodies the concept of sustainable development.

Based on the summary of the limitations of the BSC, the application of variations of the BSC, and the development and application of new performance management concepts/tools, The author argue that the BSC has three shortcomings in meeting the performance management needs of various types of enterprises (especially manufacturing ones) in the 2020s: first, it does not reflect the business concept of sustainable development; second, the stakeholder perspective is not broad enough; and third, the attention to innovation is insufficient.

2.1.2.1 Not reflecting sustainability principle

According to a report issued by the World Commission on Environment and Development (WCED), sustainable development is defined as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (WCED, 1987), and consists of the three pillars of economic sustainability, environmental sustainability, and social sustainability.

With the awareness of sustainable development, more and more investors are incorporating non-financial indicators into their investment decisions and demanding that companies take on social responsibility in an attempt to internalize the “externalities” caused by the pursuit of profit maximization in order to address increasingly serious social and environmental issues.

In terms of corporate social responsibility, Carroll (1991), the founder of the "corporate social responsibility pyramid" theory, points out that the CSR refers to the social expectation in a certain period of time on economy, law, ethics, and corporate discretion (philanthropy) for enterprises, which includes four levels upward, like a pyramid: economic responsibility, legal responsibility, ethical responsibility and philanthropic responsibility. Elkington (1998), the founder of the "Triple Bottomline Theory" (TBL) of corporate social responsibility, points out that enterprises must fulfill their economic responsibility, environmental responsibility and social responsibility at the same time when carrying out economic activities. Economic responsibility is the traditional corporate responsibility, environmental responsibility is the environmental protection; and social responsibility is the responsibility to other stakeholders in society. In current society, more and more enterprises gradually agree with the concept of sustainable development, focusing on environmental protection and social responsibility, rather than simply pursuing corporate profits.

Since Norsk Hydro in Norway published the world's first corporate environmental report in 1989, more and more organizations have been releasing non-financial reports such as environmental reports, CSR reports and sustainability reports independently of financial reports, on a regular basis. The current representative sustainability (ESG) reporting frameworks include GRI Four-module Guideline System, SASB Five-dimension Reporting Framework, EF Four-pillar Reporting Framework, TCFD Four-pillar Climate-related Disclosure Framework and CDSB Framework for Reporting Environmental and Social Information. These reporting frameworks cover a wide range of economic, environmental, social and governance issues.

The IFRS Foundation is currently working to develop a comprehensive set of high-quality global sustainability baseline - the IFRS Sustainability Disclosure Standards (ISDS) that will require profit organizations to disclose sustainability related financial information as an integral part of their financial reporting.

As the basic unit of human economic activities, enterprises are an indispensable and important driver of sustainable development. ESG is a projection of the sustainable development concept in industry, and is an evaluation standard and investment concept that focuses on corporate performance in the three dimensions of environment, society, and governance. The core idea is that business management and financial investment should not only consider economic and financial indicators, but also assess the impact of business activities and investment behavior on environment, society, and a broader range of stakeholders, thereby contributing to the sustainable development of human society.

In 2006, the United Nations Principles for Responsible Investment (UN PRI) was

established to advocate and promote investors to take ESG factors as part of their investment decisions. To uniformly measure the ESG level of listed companies, the capital market has developed many ESG evaluation systems, and companies with good ESG performance gain more investment opportunities and capital. The ESG rating is a rating method that takes the three aspects of the environment, society, and corporate governance as the main considerations for investment assessment. The more well-known ESG rating criteria include MSCI ESG Evaluation System, Sustainalytics ESG Evaluation System, Thomson Reuters ESG Evaluation System, TSE Russell ESG Evaluation System, Vigeo Eiris ESG Evaluation System and others.

Since entering the 21st century, the concept and practice of sustainable development have been rapidly developed, resulting in many new sustainable development performance evaluation systems, and at the same time putting forward some new performance evaluation requirements for enterprises. Although the BSC has been continuously adjusted and optimized to follow the progress of society, and many variant applications have been generated, due to the lack of guidance from the concept of sustainable development, there are major limitations in the design of the framework system as well as the setting of specific indicators. We choose the MSCI ESG rating system as a representative to compare and analyze with the BSC in terms of indicator setting.

The MSCI (Morgan Stanley Capital International) ESG Rating is a typical sustainability-based rating system that focuses on 37 KPI performance of each company across 10 ESG themes. The BSC only includes four tertiary indicators, i.e., “Environment”, “Safety and Health”, “Employment”, and “Community Investment”, under the secondary level of indicators, “Regulatory and Social Processes”, of the first level of indicators, “Internal process”. These indicators focus on “compliance” and there is a serious lack of performance indicators related to the concept of "sustainable development". See Annex I “Comparison of ESG Dimension Performance indicators” for indicator design of the MSCI ESG Rating and the BSC for sustainable development (ESG).

2.1.2.2 Not reflecting concept of stakeholders

In 1986, Freeman first invoked the "stakeholder theory", which introduced a new concept of corporate responsibility that is quite different from the traditional "shareholder primacy" theory. According to Freeman (2010), stakeholders are " any group or individual who can affect or be influenced by the achievement of the organization’s objectives ", and by introducing their interests and expectations into corporate decisions, the relationship between management and stakeholders will have an intangible impact, which will increase the corporate performance,

contribute to the corporate benefits, and constitute a value shared by all stakeholders.

The traditional “shareholder first” theory emphasizes the maximization of short-term benefits and even tolerates a certain degree of stakeholder exploitation, whereas the “stakeholder theory” argues that companies should aim to maximize long-term benefits and always benefit all stakeholders. The theory does not deny that the search for economic profitability is a legitimate goal of the company, but it is not the ultimate goal. Enterprises must create value for all stakeholders.

Only by classifying stakeholders scientifically can the scientific management of different categories of stakeholders be carried out. From three different perspectives: ownership, economic dependence, and social interest, Freeman and Medoff (1984) divides corporate stakeholders into stock holders, managers, creditors, employees, consumers, suppliers, competitors, communities, government officials and media. Frederick et al. (1992) classifies stakeholders into direct and indirect stakeholders, including shareholders, employees, creditors, suppliers, central government, local government, social activist groups, media, and the general public. Charkham (1992) classifies stakeholders into contractual stakeholders and public stakeholders according to whether there is a transactional contractual relationship between the stakeholder group and the enterprise. Mitchell et al. (1997) classifies stakeholders into three categories based on legitimacy, power and urgency: latent stakeholders, expectant stakeholders and definitive stakeholders. The performance evaluation system based on the “stakeholder theory”, the “performance prism”, divides stakeholders into investors (or shareholders), customers, employees, suppliers, partners, rule-makers and communities.

Compared with the BSC, the PP has three major breakthroughs. Firstly, the stakeholder coverage of the PP is wider, expanding from the BSC to other key stakeholders such as suppliers, partners, government, and community; secondly, the PP implements a two-way measurement of stakeholders, for example, the BSC assesses the contribution of the employees but ignores their satisfaction, and evaluates the satisfaction of the customers but ignores the contribution of the customers. Neely et al. (2002) believe that stakeholder satisfaction and contribution are actually the two wings of the survival and development of the enterprise, and need to be measured in both directions (Yan, 2004); finally, the PP sets more stakeholder evaluation indicators, comprehensively and systematically covering indicators including "customer", "employee", “supplier/partner”, and “rule-maker/community”. The BSC lacks the guidance of the "stakeholder" theory and has fewer and more fragmented indicators.

Based on the "Performance Prism", supplemented by three types of quality award standards in the United States, Europe and China, we conducted a comparative analysis of indicator

Settings with the BSC in four dimensions: "customer", "employee", "supplier/partner" and "rule-maker/community". The latter is obviously inadequate in the indicator setting of "stakeholder satisfaction". The comparative results see Annex D “Comparison of Customer Dimension Performance Indicators”, Annex E “Comparison of Workforce Dimension Performance Indicators”, Annex F “Comparison of Supplier/Partner Dimension Performance Indicators”, and Annex G “Comparison of Rule maker/Community Dimension Performance Indicators”.

2.1.2.3 Not showing sufficient concern of innovation

Schumpeter (1912) defines innovation as “the creation of a new production or supply function”, i.e. the “corporate innovation is the introduction into the production system of a ‘new combination’ of production factors that has never existed before”. With the introduction of Schumpeter’s “innovation theory”, two branches of Western innovation economics have gradually formed: one is the economics of technological innovation, which focuses on technological changes and diffusion; the other is the economics of institutional innovation (including management innovation), which focuses on institutional change and institutional formation. For decades, technological innovation dominated the whole innovation research field until the 1980s when Stata (1989), an American scholar, explicitly raised the issue of management innovation and pointed out that the real bottleneck of corporate development was management innovation rather than technological innovation in the traditional sense, thus pioneering the research on management innovation.

Peter Drucker introduced the concept of “innovation” into the field of management and further developed the theory of innovation. According to Drucker (1999), there are two types of innovation: technological innovation, which finds a new application for a natural object in nature and gives it a new economic value; and social innovation, which creates a new management institution, management style or management tool in the economy and society, thus achieving greater economic and social value in the improvement of resource allocation.

Innovation measurement has been an important area of innovation research. The tools of innovation measurement include Frascati Manual, Oslo Manual and Canberra Manual, among which Oslo Manual is the most comprehensive and influential. The Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data, the OECD’s foundational document for guiding innovation statistics, was first launched in 1992. The purpose of the Manual was to define technological innovation (product and process innovation) from a statistical perspective and to provide a clear technical specification of technological innovation statistics for the

manufacturing sector. The third edition of the Manual divides innovation into four types: product innovation, process innovation, marketing innovation and organizational innovation (OECD, 2005), and the fourth edition simplifies it into two types: product innovation and business process innovation (OECD, 2018).

As the international competitive environment becomes increasingly complex, technological innovation has become a key factor in enhancing productivity and strengthening national competitiveness, and has spawned a series of national/regional innovation indices for the evaluation of national innovation levels and competitiveness. Some of the more influential ones include the European Innovation Scoreboard (EIS), the Global Innovation Index, the Global Competitiveness Index, the U.S. Science and Engineering Indicators, and the World Competitiveness Yearbook (Ding et al., 2022). Although these innovation indexes are mainly used to evaluate the innovation performance of a certain country or region, many indicators have guiding significance for enterprise innovation.

For example, human resources, research systems, business investment, intellectual property, and sales impact in the EIS; for another example, input indicators such as institutions, human capital and research, infrastructure, and output indicators such as knowledge and technology output, creative output and other parameters in the Global Innovation Index. Another example is the human capital dimension indicators such as health and skills, and the innovation ecosystem dimension indicators such as business vitality and innovation ability in the Global Competitiveness report.

According to the theory of innovation, enterprise innovation includes technology innovation, management innovation and institutional innovation, therefore, when evaluation indices are being set, no matter the main line of setting is by input and output, or business operation, or corporate resource elements, all of them should include indices related to technology, management, and system, none of which is dispensable. The corporate innovation theory provides a theoretical basis for the selection of evaluation indicators, the setting of evaluation indicator weights, and the classification of indicators (Lin & Peng, 2009).

Through the comparative analysis of innovation evaluation systems such as the Oslo Manual (4th edition), the European Innovation Scoreboard 2018 (EIS2018) and China Enterprise Innovation Capacity Evaluation Report: 2016 of the Chinese Ministry of Science and Technology, the author conclude that the mainstream innovation evaluation systems at home and abroad mainly consist of five dimensions: “innovation input”, “innovation capability”, “collaborative innovation”, “innovation activity” and “innovation output”, involving nearly 40 innovation indicators. In comparison to the BSC, although it has set up a

secondary indicator of "innovation process" under the first level of "internal level", there exist two shortcomings: first, the four sub-processes under the innovation process are all of the "product innovation" type, which do not cover business innovation (including process innovation, marketing innovation and organizational innovation); secondly, from the perspective of value chain, the indicators are mainly set around "innovation activities" and a small number about "collaborative innovation", without covering three types of indicators: "innovation input", "innovation capability" and "innovation output". See Annex I "Comparison of Innovation Dimension Performance Indicators" for the indicators of corporate innovation performance evaluation.

2.1.3 Improvement and transcendence of BSC

In summary, due to the limitations of the times, the BSC, as an important strategic deployment tool for "translating strategy into action", can no longer meet the needs of overall corporate performance management in the 2020s, and should be changed and innovated. Currently, improvements and innovations in the BSC are taking two directions:

1) The BSC is combined with other management concepts and tools to form a new performance evaluation system. For example, the "Sustainable BSC" is formed by combining the BSC with the concept of sustainable development, and the PESC is formed by combining the BSC with the PEM.

2) Improvement beyond the BSC. For example, the PP overcomes the shortcomings of the BSC which is "not broad in its stakeholder coverage" and "does not stand up to the scrutiny of the four dimensions of causality", and redesigns a new performance evaluation system from scratch.

The next section conducts the literature research on the performance management system combining the BSC and the PEM, and discusses its advantages as well as disadvantages.

2.2 PEM-based corporate performance evaluation

2.2.1 Overview of PEM

The Performance Excellence Model (PEM) is a general term for a class of business management models represented by the "Criteria for Performance Excellence" (Criteria for the Malcolm Baldridge National Quality Award in the U.S.), which is neither a single performance evaluation system, nor an evaluation system only for quality management, but an integrated and

comprehensive management system aiming at improving the quality of corporate operation and maturity of corporate management.

The world's most representative quality award evaluation model – the Deming Application Award in Japan, the U.S. National Quality Award, and the European Quality Award were established in 1951, 1987 and 1992 respectively. So far, more than 80 countries and regions have set up national quality awards, each with different evaluation criteria, and most of them refer to the standards of the U.S. Quality Award ("Criteria for Performance Excellence").

1) Deming Prize

The Deming Prize was established in 1951 by the Japanese Union of Scientists and Engineers (JUSE), named after the American quality management expert Edwards Deming, and belongs to the national Quality Award of Japan. The Deming Prize consists of the "Deming Award" (including individuals and organizations), the "Deming Application Award" and "Deming Control Award". The Deming Award (organization category) are based on three primary, five secondary and seven tertiary indicators, which assess the organization's capabilities in the areas of "Establishment of organizational goals and strategies and top management leadership (100 points)", "Effective implementation of TQM (100 points)" and "TQM effectiveness (100 points)"

2) Malcolm Baldrige National Quality Award (MBNQA)

The United States passed the Malcolm Baldrige National Quality Improvement Act (also known as the Public Law 100-107) in 1987 to annually select the Malcolm Baldrige National Quality Award (MBNQA). The MBNQA standard "Criteria for Performance Excellence" consists of three parts: 11 core values, an evaluation model and an evaluation system, and the MBNQA evaluation model is embodied in six "process" categories and one "outcome" category. The three process categories of "Leadership", "Strategy" and "Customer" form the "Leadership Triangle", while the three categories of "People", "Operations" and "Results" form the "Results Triangle", reflecting the operational logic of "Good processes produce good results" of the PEM; and "Measurement, Analysis and Knowledge Management" emphasizes "Fact-based management", which is the foundation of the overall PEM System.

The seven categories of the "Criteria for Performance Excellence" are allocated with certain scores, among which 55% were allocated to processes and 45% to outcomes. The total 1,000 points of the measurement range covers leadership (120 points), strategy (85 points), customer (85 points), measurement, analysis and improvement (90 points), staff (85 points), operation (85 points), and outcome (450 points).

The establishment of the MBNQA has contributed significantly to the post-1990s development of the United States, and its evaluation criteria are revised every two years in an attempt to reflect those advanced management practices that have proven effective and help users meet the increasingly complex challenges they face

3) European Foundation for Quality Management Excellence Award (EFQM Excellence Award)

In 1991, the European Commission (EC), the European Organization for Quality (EOQ) and the European Foundation for Quality Management (EFQM) initiated the European Foundation for Quality Management Global Award (EFQM Global Award), and the first European Quality Award was granted in 1992. In 2006, the European Quality Award was renamed EFQM Excellence Award.

The EFQM Excellence Model consists of three parts: the basic concept, the evaluation criteria, and the RADAR logic and scoring matrix. The scoring criteria for the latest EFQM model (version 2020) include seven categories, divided into three parts: direction (200 points), implementation (400 points) and results (400 points), including:

- Purpose, Vision & Strategy;
- Organizational Culture & Leadership;
- Engaging Stakeholders;
- Creating Sustainable Value;
- Driving Performance & Transformation;
- Stakeholder Perceptions;
- Strategic & Operational Performance.

RADAR is a dynamic evaluation framework and a powerful management tool that provides a structured way to examine organizational performance. RADAR consists of four elements: Results, Approaches, Deploy, Assess and Refine, which are defined as follows:

- Results: Define the RESULTS you want to achieve;
- Approaches: Plan and develop the APPROACH that will deliver the results;
- Deploy: DEPLOY the approach
- Assess and Refine: ASSESS the impact and REFINE to ensure you achieve the desired results.

4) China Quality Award

In September 2004, China's the Evaluation Criteria for Performance Excellence (CQA,

2004) was formally released and implemented in the form of "modification and adoption" of the Criteria for Performance Excellence. The Chinese standard basically adopts the core concepts of the U.S. criteria, the standard framework and scoring rules, and the differences are mainly reflected in two aspects:

1) The difference in core values. The U.S. Criteria was built on a set of interrelated core values, a total of 11, while the Chinese Criteria has 9 core values.

2) Difference between the structures of the terms and scores of the Chinese and American quality award criteria

The major differences lie, instead of in the structures or score distributions, in resources. The “resources” category in the Chinese criteria includes “human resources”, “financial resources”, “information and knowledge resources”, “technological resources”, “infrastructure” and “relationship with relative parties”, while the American criteria emphasize the “human resources” only.

2.2.2 Construction of performance measurement system based on PEM and its deficiency

2.2.2.1 Design and implementation of PEM-based strategic targets

The MBNQA “Criteria for Performance Excellence” (2021-2022), states in relation to “Strategy Formulation” (2.1) that: What are the organization’s key strategic goals and their most important related target values? Clauses related to “Strategy Deployment” (2.2) demand that: “How the organization translate strategy and strategic objectives into implementation plans is explained … and associated key evaluation items or indicators are outlined”. However, no specific answer to what tools to use for the design and implementation of strategic goals is provided.

China's Quality Awards “Evaluation Criteria for Performance Excellence” puts forward the same requirements in the items of "strategy formulation" and "strategy deployment", and in the "Guidelines for the Implementation of Evaluation Criteria of Performance Excellence" (CQA, 2004), use methods such as goal management or the BSC to decompose and refine to achieve strategic goals. However, we have pointed out the limitations of the BSC in Section 2.1.2 that it can no longer be adapted to the needs of overall performance management in today's businesses.

The European EFQM Excellence Award (EFQM,2020), while providing a “RADAR” model for evaluating organizational performance, does not tell in the first step how to

“determine the results it is aiming to achieve as part of its strategy”, or what tools are used to achieve it.

2.2.2.2 Construction of PEM-based performance measurement system

Through literature research, it is found that experts and scholars mostly use a combination of qualitative and quantitative methods when constructing performance measurement systems based on the PEM， such as expert Grading , fuzzy Integrated Evaluation, AHP and entropy Evaluation Method .Different evaluation methods vary in their principles and implementation steps, and have different characteristics. The principles and characteristics of which are briefly introduced as follows:

1) Expert Grading. This method makes decisions based on expert opinions, and obtains the importance degree (or weight) of indicators by summarizing expert opinions to form conclusions. It is characterized by strong intuitiveness and easy operation, but it has heavily dependence on experts.

2) Fuzzy Integrated Evaluation. The method uses the knowledge of fuzzy mathematics to evaluate the data. Firstly, the evaluation index and evaluation set are determined, then the fuzzy relation matrix is constructed, and finally the weight vector is determined and the result matrix is synthesized. It is characterized by strong subjectivity and heavily relies on experts.

3) Analytic Hierarchy Process (AHP). First, a hierarchical structure model is established and a decision matrix is constructed. Then, according to the set indicators, the experts compare the importance of the indicators by pairwise comparison. Finally, the weight of each indicator is calculated by quantitative processing. It is still a subjective evaluation method, which is not applicable when there are more schemes.

4) Entropy Method (EM). According to the variation degree of each index, this method uses the tool of information entropy to calculate the weight of each index, and provides the basis for the comprehensive evaluation of multiple indicators. Different from the previous three methods, this method has strong objectivity, but its application scope is limited, and it is suitable for calculating the index.

W. H. Li (2011) categorized the seven elements of the performance excellence evaluation criteria into "foundation level", "process level" and "outcome level", thus constructing a quality competitiveness hierarchical model and an evaluation index system for manufacturing enterprises, and conducted empirical research. The study shows that the performance excellence evaluation criteria can not only be used to evaluate the maturity of corporate management, but also to evaluate the quality competitiveness of different enterprises and a certain industry.

Z. B. Huang and Zhao (2011) proposed a AHP-based indicator system for evaluating the integration effect of quality management models by absorbing the respective advantages of the ISO9001 quality management system criteria and the PEM as well as analyzing and evaluating the effect of their integration through the AHP.

Y. Y. Chen (2019) proposed the ideas and principles of constructing a performance assessment indicator system for "double-qualified "teachers in higher vocational colleges based on the existing literature, the PEM, the fuzzy hierarchical analysis method and relevant documents. The objectives, contents and specific indicators of the evaluation system were constructed in three dimensions: target level, criterion level and indicator level.

Sang et. al (2021) tentatively constructed an indicator framework based on the "Criteria for Performance Excellence" and using the literature analysis as well as seminar discussion, and established the ICU nursing quality evaluation indicator system through two rounds of expert consultation.

2.2.2.3 Existing problems

Although the Evaluation Criteria for Performance Excellence (CQA, 2004) provides a framework for assessing the maturity of business management, enterprises have the following problems in applying the criteria to establishing performance measurement systems.

1) The criteria are organized around seven aspects, i.e., "Leadership," "Strategy," "Customers and Markets," "Resources," "Process Management," "Measurement, Analysis and Improvement" and "Results" to provide a large number of performance indicators, but the criteria do not give specific tools or methods for how to choose appropriate indicators and empower them effectively (see 2.2.2.1).

2) When constructing a performance excellence measurement system with comprehensive and integrated evaluation methods (e.g., AHP), there are problems such as inconsistent expert opinions, difficulty in measuring some subjective indicators, and large differences in measuring some indicators due to the inherent characteristics of the method's strong subjectivity (R. X. Xie, 2021).

3) In practice, due to the lack of top-level design and selection mechanism of KPIs, the performance measurement system constructed by many enterprises cannot fully meet the requirements of the criteria when the PEM is implemented; at the same time, the quality award assessors cannot objectively evaluate its adaptability, adequacy and effectiveness.

The theoretical and industrial circles have made extensive research and exploration on the issues mentioned above and got some fresh solutions. These solutions are mainly applied to the

combined application of the PEM and other management concepts and tools.

2.2.3 Research and practices on the combination of PEM, BSC and other management concepts/tools

2.2.3.1 Research and practices on the combination of PEM and BSC

The BSC has become a synonym of “translating strategy into action”, due to its widespread influence internationally (Kaplan & Norton, 1996). According to He (2007), the combination of the BSC and the PEM is conducive to the achievement of corporate strategic objectives by effectively linking corporate strategy and performance, as well as long-term and short-term goals. D. H. Yang et. al (2010) compare the PEM and the BSC, and find that these two are highly similar in the measurement of leadership, strategic management, process management, customer orientation, and operation outcome, thus, many new research and applications combining the BSC and the PEM emerge in terms of theoretical research and management practices.

Since 1998, Motorola has been implementing a “Performance Excellence Scorecard” (PES) across its global operations: a management model that uses a BSC to develop long-term development strategies, specifies the content of the BSC through the development of “work to be done in the year”, and finally tests results against the content of the PES (Z. H. Wang, 2009).

J. Li and Yu (2007) believe that the traditional BSC does not fully reflect concepts about corporate governance or social responsibility in the PEM, thus, the dimension of “organizational governance and social responsibility” is added to the existing four dimensions (finance, customer, internal processes, and learning and growth) of the BSC, and is put on the same level as the dimension of “finance”.

According to Gong (2008), Motorola's practice illustrates the feasibility of the PESC, but its research Method is not yet refined enough, which has not yet systematically borrowed the performance dimensions or strategy maps of the BSC, and has not embodied the "Stakeholder Theory", and has thus constructed a new "PESC”. The scorecard takes the five types of outcome indicators in the Evaluation Criteria for Performance Excellence (CQA, 2004) as dimensions, and reconstructs a variant of the BSC.

C. C. Yang (2009) proposes an integrated model of strategic planning, the BSC, and the Hoshin management, based on diverse performance management models including the MBNQA, the EFQM Excellence Award, the BSC, and the Hoshin Management.

Dubey (2016) developed a “six-stage” model to help organizations continuously improve

their ability to apply the PEM, with a key third step being “integration with BSC”. The thesis also mentions that a large number of PEMs are used more for evaluation purposes, and there is a lack of research needed to determine how helpful they are in guiding enterprises to improve their management performance. Therefore, it’s necessary to make adjustments to the scoring terms of the model and its weights.

2.2.3.2 Research and practices on the combination of PEM and other management concepts/tools

Teixeira and António (2008) have been studying the relationships between Quality and Strategic Management since the early 1990s. Their recent development of an integrated model, QualStrategy, was preceded by the analysis of both areas' roots, in order to accomplish a sound solution resistant to erosion agents created by the continued evolution of environmental complexity and management thought. Beyond the presentation of QualStrategy itself the authors consider useful to share the results of this preparatory analysis which puts into perspective the relationships between quality management and strategic thought, as a form to devise a theoretically sound way to build a strategic framework within quality management playing the role of a management paradigm.

With the introduction of the concept of sustainable development and the gradual establishment of the enterprise sustainability evaluation system (see section 2.3), the PEM (Performance Excellence Model) has continuously absorbed the latest theories and practices of the sustainable development concept and formed some new models and applications.

Edgeman (2013) propose the concept of a Sustainable Enterprise Excellence (SEE).The key elements of SEE are derived from various PEMs and sustainability reports, including criteria of the Global Reporting Initiative, the Ten Principles of the United Nations Global Compact, the European Quality Award, and the MBNQA. SEE distills a model and key indicators, develops a maturity scale, and proposes a simple evaluation method. The indicator system of SEE includes innovation, corporate intelligence and analysis, operations, supply chain, customers, human capital, finance, marketing, social and environmental performance. The framework system of SEE includes the E3 (ethics, efficiency and effectiveness), and the 3P (people, planet, profit), and is a relatively independent performance management model compared to the PEM.

Gupta and Vrat (2020) selected six better-known PEMs, such as MBNQA and EFQA, extracted 12 KPIs from them, and then use AHP to evaluate the weight of each indicator, resulting in a new performance evaluation system. The study also show that this evaluation

system is better than many other PEMs.

Fan and Chang (2021) combine the MBNQA criteria with the Dow Jones sustainability index to propose an indicator system for the sustainability performance excellence model, including seven dimensions with 69 indicators. The framework is developed in accordance with the seven categories of the "Criteria for Performance Excellence" and incorporates the economic, environmental and social dimensions of the Dow Jones Sustainability Index.

Neri et. al (2021) combine the BSC and sustainable supply chain based on the "TBL" theory to create a six-dimensional scorecard system (including finance, customer, internal processes, learning and growth, environment and social responsibility), resulting in 33 quantifiable categories of sustainable supply chain performance indicators, each further refined into quantifiable indicators.

In addition, the combination of the PEM and the corporate innovation theory (see Section 2.3) has produced some new applications in constructing the evaluation system of corporate innovation capability. Shan et al. (2009) and Shan and Li (2010) construct a model of corporate technological innovation capability and a framework model of corporate continuous innovation mechanism through the study of corporate technological innovation capability and the PEM.

2.2.4 Problems existing after the combination of PEM and BSC

The combination of the PEM (Performance Excellence Model) with concepts/tools such as the BSC has effectively solved most of the problems in the use of single criterion, such as the lack of methods for indicator selection and assignment, and the subjective nature of comprehensive evaluation methods such as the AHP (see Section 2.2.2.3), but the following problems still exist.

1) Lack of top-level design and selection mechanism of KPI. On the one hand, although the various PEMs give clear scores (or weights) to each major category, they do not provide the way to select the KPIs or determine the weights for the sub-categories under each major category; on the other hand, according to the author's research, although the various PEMs take the most advanced management concepts as their core values, they still lack some KPIs that reflect the relevant core values in the specific standard texts (see section 2.6.1), which may lead to the omission of some key indicators in the construction of the performance indicator system. This is a shortcoming of the BSC and a deficiency of the PEM, and the problem persists even when these two are integrated.

2) Lack of an independent scorecard system that can fully match the PEM. The BSC and the PEM have been combined to form the Performance Excellence-Balanced Scorecard, the

BSC and the Sustainability Concept have been combined to form the Sustainable BSC; the PP expands the perspective of stakeholders and realizes the transcendence of the BSC, and the corporate innovation theory is combined with the PEM to form a corporate innovation capability evaluation system based on the PEM. However, there is no independent scorecard system that can simultaneously integrate the "Sustainability Concept", the "Stakeholder Theory" and the "Corporate Innovation Theory" to make up for the three shortcomings of the BSC (see Section 2.1.3), or is fully compatible with the core concepts and criteria of the PEM.

Section 2.3 of this thesis, in order to deal with issues mentioned above, respectively introduces the "Sustainability Theory", the "Stakeholder Theory", and the "Corporate Innovation Theory" as well as diverse corporate performance evaluation mechanisms emerging with these theories, so as to lay the corresponding theoretical foundation for the construction of a fresh scorecard model.

2.3 Corporate performance evaluation based on other theories

2.3.1 Corporate performance evaluation based on sustainable development

The Club of Rome, in April, 1972, finished the reported: The Limits to Growth (Meadows & Randers, 2012), which used a "Zero Growth Model" to study the five dimensions of population, agricultural production, natural resources, industrial production, and pollution, and showed that if growth continued at current levels, the planet would reach its growth limit in the next 100 years. Since then, the Club of Rome submitted 12 studies and proposing the concept of sustainable development, yet without forming an implementation plan.

In 1987, the World Commission on Environment and Development (WCED) published the report Our Common Future, defining the sustainable development as "development that meets the needs of the present generation without compromising the ability of future generations to meet their needs." This definition changes the concept of development from a one-dimensional approach, understood only as unlimited economic and material growth, to a multidimensional approach that understands that economic growth must go hand in hand with social well-being and respect for the environment. This report systematically illustrates the idea of sustainable development, and establishes three pillars of sustainable development, i.e., the sustainability of economy, environment, and society.

On 25 September 2015, the UN Sustainable Development Summit was held at its headquarters in New York. The conference adopted 17 Sustainable Development Goals (SDGs)

and shaped the 2030 Agenda for Sustainable Development. The new agenda is addressing the three dimensions of sustainable development: social, economic, and environmental, as well as important aspects related to peace, justice and efficient institutions.

How to evaluate the corporate sustainability performance? The author summarizes various studies and applications, and three models have been implemented so far: 1) a PEM based on the TBL (economy, environment, and society); 2) a BSC model incorporating the concept of sustainable development; and 3) an ESG rating based on the concept of sustainable development. In addition, there is a fourth model, the ISS Corporate Sustainability Report, which is being developed alongside IRRS financial statements and will be widely used in the future.

2.3.1.1 Performance evaluation model based on TBL

Elkington (1998) argues that in pursuing their own development, enterprises need to simultaneously meet the balanced development of economic prosperity, environmental protection, and social welfare. In other words, the purpose of an enterprise's existence cannot be limited to economic benefits, but should simultaneously consider economic, ecological, and social performance, i.e. the "triple bottom line" (TBL).

The concept of "TBL" was widely recognized by the society as soon as it was proposed. Dow Jones & Company was the first to launch the Dow Jones Sustainability Index (DJSI) in 1999, which constructed a corporate social responsibility system from three dimensions: economic, environmental, and social (Zhen & Liu, 2017). The Global Reporting Initiative (GRI) released the official Sustainability Reporting Guidelines (G1) in 2000, which has been continuously updated into G2, G3 and G4 versions. In the G3 version in 2006, the Guidelines standardized the content of social responsibility reports by dividing various types of indicators into three categories: economic, environmental and social responsibility (L. A. Xie, 2009).

Chinese scholars have constructed various types of TBL evaluation index systems in light of China's actual situation. S. B. Wen and Xue (2005) construct an evaluation system consisting of static performance evaluation, static balance evaluation, and dynamic coordination evaluation; J. Song et al. (2006) construct an index system framework for sustainable development of enterprises based on the framework of the TBL by adopting the AHP; Bai (2013) introduces the TBL theory into the evaluation system of enterprises; Y. C. Li and Cao (2013) construct a "four-in-one" social responsibility evaluation system for power supply enterprises; and Mai et al. (2012) construct a social responsibility evaluation index system based on market responsibility, social responsibility, environmental responsibility and its scientific concept of

development.

Unlike economic performance indicators, indicators for environmental protection and social responsibility are relatively difficult to quantify, and at the same time, not easy to set uniform standards, especially in different industries, regions and countries. Therefore, the TBL performance evaluation model is limited by its operability and universal applicability, which makes the promotion and application of the model at home and abroad a difficult task (Fu & Wu, 2015).

2.3.1.2 BSC model integrated in sustainable development concept

With the increasing social, economic and environmental problems and the proposition of the concept of sustainable development, the connotation of corporate performance evaluation has changed along, and the traditional BSC can no longer be adapted to the corporate performance management needs. Epstein and Wisner (2001) define environmental and social KPIs and integrate them into a BSC. Hubbard (2009) add the social and environmental dimensions to the traditional BSC. Hsu et al. (2011) improve the SBSC framework by replacing financial and customer dimensions with sustainability and stakeholder dimensions.

Since the concept and model of SBSC was proposed, diverse variations of the BSC incorporating the sustainability concept have emerged. X. Y. Wei (2012) summarizes three methods for constructing an SBSC: the additive method, the reconstructing method, and the integrating method.

1) The Additive Method

The four dimensions of the BSC are supplemented by a "sustainable development" level, which includes environmental and social dimensions as well as corresponding measurement indicators.

For example, based on the principle of SBSC, Peng and Huang (2019) establish an overall framework for sustainable performance evaluation in the new energy vehicle industry in five dimensions: financial, customer, internal operation, learning and growth, and social and environmental. Neri et al. (2021), through an extensive literature study, combine the BSC and sustainable supply chain to establish a scorecard system with six dimensions, including financial, customer, internal process, learning and growth, and environment and social responsibility, resulting in 33 categories of quantifiable performance indicators.

2) The Reconstructing Method

This method integrates the concept of sustainable development into the enterprise's mission, vision, values, and strategic objectives, and then uses the BSC to break down environmental

performance and social performance indicators at all levels, thus realizing the reconstruction of the traditional scorecard

For example, M. Yang (2015) adds an evaluation dimension of environmental performance to the BSC. The specific construction idea is as follows: first, setting the corporate environmental vision; second, incorporating the environmental vision into the corporate strategy; next, translating the corporate strategy into specific objectives, which include specific objectives in four aspects: environmental finance, stakeholders, internal processes, and learning and growth; finally, evaluating the corporate environmental performance, and feedbacking the evaluation results to the enterprise, and continuously improving the corporate environmental performance through continuous adjustment and improvement. Taking German international airports as an example, L. Chen (2016) details how to integrate environmental and social dimensions into the main corporate management system, which includes three steps: i) selection of strategic business units; ii) identification of strategically relevant environmental and social factors; and iii) determination of strategic relevance of environmental and social factors.

3) The Integration Method

This method expands the BSC's only economic performance perspective to economic, environmental and social performance perspectives, and then integrates relevant sustainability indicators into the four levels of the BSC. For example, Liang and Li (2018) integrates environmental indicators into the four levels of the BSC to design a generalized sustainable BSC indicator for enterprises; and B. J. Wang and Huang (2020) integrate environmental, social, and governance dimensions into the BSC to construct a seven-dimensional, three-tiered indicator system centered on the Sustainable Development Goals (SDGs).

2.3.1.3 ESG rating based on sustainable development concept

Along with the release of GRI's Sustainability Reporting Guidelines and other environmental, social and corporate governance (ESG) standards, more and more investors are demanding that potential investment targets (especially listed companies) publish their sustainability reports (or social responsibility reports) on a regular basis, which has given rise to a large number of ESG rating agencies. These agencies evaluate the ESG reports disclosed by companies, and investors make investment decisions based on the evaluation results to effectively control investment risks and improve long-term returns.

The ESG evaluation is also known as ESG rating or scoring. K. Wang and Zhang (2022) conduct a comparative study of the current status of ESG evaluation at home and abroad, and summarize 14 types of ESG evaluation systems, among which the following types have been

widely used at home and abroad: the MSCI ESG Evaluation System, the Sustainalytics ESG Evaluation System, the Thomson Reuters ESG Evaluation System, the FTSE Russell ESG Evaluation System, and the Vigeo Eiris ESG Evaluation System. In this thesis, MSCI ESG evaluation system and Sustainalytics ESG evaluation system are selected as ESG rating representatives for brief introduction.

1)MSCI ESG Evaluation System

Morgan Stanley Capital International (MSCI) is a New York based leading provider of key decision support tools and services in the global investment area. In May 2010, MSCI acquired Risk Metrics to establish MSCI ESG Research, and constructed its own evaluation system based on IVA model, forming the MSCI rating. In June 2018, the Chinese A shares formally introduced the MSCI emerging markets index and the MSCI global index. In March 2019, MSCI announced the increase of factors among MSCI global benchmark index in Chinese A shares, from 5% to 20% by three stages. MSCI ESG is rated for all listed companies included in the MSCI Index and as of June 2020, MSCI ESG ratings covered approximately 8,500 enterprises and over 680,000 global equity and fixed income securities worldwide.

The MSCI ESG rating system focuses on each company's performance on 37 key evaluation indicators under 10 environmental, and adopts a weighted average method, thus avoiding bias in results due to industrial differences. The final ESG rating score is not an absolute score, but rather a relative result of a corporate performance relative to its industry, and enterprises are graded from highest to lowest on a scale of AAA, AA, A, BBB, BB, B, and CCC based on their performance in their industry.

According to MSCI ratings, a "leader" (industry leading level, rated AAA or AA) indicates that a company is an industry leader in managing the most significant ESG risks and opportunities; "average" (industry average, rated A, BBB, BB) indicates that a company has a broadly consistent level of managing ESG risks and opportunities compared to its peers; and "laggard" (lagging behind industry level, B or CC) indicates that a rated company is lagging behind its industry based on its high risk exposure and failure to manage significant ESG risks.

2) Sustainalytics ESG Evaluation System

Sustainalytics is a leading independent ESG research, ratings and analytics firm owned by Morningstar Company, supporting global investors in developing and implementing responsible investment strategies, headquartered in Amsterdam. Sustainalytics provides data covering 40,000 companies globally, and ratings of 20,000 companies in 172 countries and regions. Sustainalytics' ESG research and rating system is trusted by investors around the world, and has supported many indexes and sustainable investment products, including the Star Fund

Sustainability Rating and the Star Index.

Sustainalytics' scoring index consists of three modules, namely the Corporate Management Module, the Substantive ESG Issues Module, and the Corporate Unique Issues Module. Of the three modules, the Substantive Issues Module is the core, covering a comprehensive set of indicators on three levels: environmental, social and governance, including 21 issues and 21 indicators. However, the number of key indicators and their weights vary in different industries, depending on the importance of the indicators.

Sustainalytics replaces a comprehensive ESG rating with an ESG risk rating, which measures the extent to which a corporate economic value is exposed to risks driven by ESG factors, a higher ESG risk rating represents a lower quality of financial performance (e.g., operating income or profit) presented in a company's financial statements; conversely, a higher quality. The rating system of Sustainalytics takes an ESG risk angle and assesses risks based on the corporate ESG performance. The ESG risk is categorized into five risk levels. Among them,

a) 0~9.99 is classified as "negligible risk level" (corporate value is considered to have negligible risk of significant financial impact driven by ESG factors);

b) 10~19.99 is classified as "low risk level";

c) 20~20.99 as "medium risk level" (corporate value is considered to have a moderate risk of significant financial impact driven by ESG factors);

d) 30~30.99 as "high risk level";

e) 40 points or more "severe risk level" (corporate value is considered to be at severe risk of receiving significant financial impact from ESG factors).

2.3.1.4 Corporate sustainable development reports

Since Norway's Norsk Hydro issued the world's first corporate environmental report in 1989, an increasing number of organizations have disclosed a variety of non-financial reports on the environment and social responsibility as well as the sustainable development beyond their financial statements. The information disclosed in these reports has been optimized and improved as the reporting framework requirements have evolved. After more than three decades of development, several representative ESG reporting frameworks have been formed, such as the GRI Four-module Guideline System, SASB Five-dimension Reporting Framework, the TCFD Four-pillar Climate-related Disclosure Framework, and CDSB Framework for Reporting Environmental and Social Information.

These representative frameworks have contributed to the popularization and promotion of the ESG concept and provided useful guidelines for companies to prepare ESG reports.

However, the lack of standardization has led to a lack of consistency and comparability of ESG reports disclosed based on different reporting frameworks, which on one hand increases the difficulty of selection and the cost of compliance for report preparers, and on the other hand increases the difficulty of analysis and the cost of analysis for report users (S. Z. Huang, 2021).

The International Accounting Standards Committee (IASCF), founded in London in 1973 and renamed the International Financial Reporting Standards Foundation (IFRS) in 2010, is the world's most influential financial reporting standards-setting organization, with more than 160 countries and regions adopting its accounting standards. In November 2011, the IFRS announced the establishment of the International Sustainability Standards Board (ISSB), alongside the International Accounting Standards Board (IASB), to develop the International Sustainability Disclosure Standards (ISDS) for financial reporting. On June 26, 2023, the ISSB formally issued two standards, namely, International Standard on Sustainability Disclosure for Financial Reporting (ISDS) No. 1, General Requirements for Sustainability-related Financial Disclosures, and International Financial Reporting Standards for Sustainability (ISDS) No. 2, General Requirements for Sustainability-related Financial Disclosures. These two standards come into effect on January 1, 2024, and will be followed by subsequent disclosure standards on various topics, such as water resources, biodiversity, human rights, and corporate governance.

1)ISDS Financial Reporting Orientation

Based on traditional financial statements, the IFRS hopes that by adding disclosures related to sustainability information that has an impact on financial performance (including short-, medium- and long-term ones), users of financial reports will be provided with more comprehensive information to facilitate investment decisions. With the addition of these disclosures, the new financial reporting system consists of two components:

Part A：Financial Statement. Which is designed in accordance with IFRS, and reflecting the financial position, operating results and cash flows of the enterprise;

Part B：Financial Disclosure Related to Sustainability. Which is designed in accordance with ISDS, and reflecting risks and opportunities associated with sustainable development.

2)ISDS Standard Structure System

The ISDS framework consists of three categories of guidelines and four major elements. The three categories are “General Requirements”, “General Issues” and “Sectoral Issues”. The “General Issues” are organized according to sustainable development topics (e.g. climate change, water resources and human rights), and the “Sectoral Issues” are broken down by different industries (coal mining, oil and gas). The four elements are organized from top to

bottom, namely governance → strategy → risk management → objectives and indicators, and the two guidelines (No. 1 and No. 2) that ISSB has issued follow this structure.

2.3.1.5 Influence of ESG Sustainable Development on Corporate Value

Scholars at home and abroad have conducted extensive research on the impact of environment (E), social responsibility (S), and corporate governance (G) on corporate value. In terms of environmental performance, the current major viewpoints believe that environmental performance positively affects corporate value. Q. Y. Hu (2012) summarizes the relevant studies on the impact of environmental performance on economic performance in foreign countries, respectively, there are positive correlation, negative correlation and no correlation, and there is no uniform opinion in the academic community on the relationship between environmental performance and economic performance. The relevant studies in China show that environmental performance has an obviously positive effect on economic performance. In addition, the acquisition of economic performance tends to lag the generation of environmental performance. H. Song et al. (2017) find that environmental management has no significant relationship with the improvement of financial performance in the current year, while it is significantly and positively correlated with the financial value of the next year.

Lv and Jiao (2011) study the relationship between environmental disclosure, environmental performance, and financial performance of 68 A-share listed companies (48 building materials companies and 20 paper companies), which shows that: there is a significant negative correlation between environmental disclosure and environmental performance; there is a significant positive correlation between environmental performance and financial performance; and there is a non-significant correlation between environmental disclosure and financial performance.

M. Y. Wu and Zhang (2018) conduct a study on the relationship between environmental responsibility and corporate value of 109 small and medium-sized companies listed on the Shenzhen Stock Exchange, and the study proves that there is a positive correlation between corporate environmental responsibility and corporate value, in which the environmental responsibility includes corporate environmental protection concepts, policies and guidelines, environmental protection investment, environmental protection facilities operation and maintenance, three-waste treatment, and the construction of environmental management system.

L. P. Wang et al. (2021) investigate the correlation of environmental strategy on environmental performance and economic performance of 110 medium-sized and heavy-polluting enterprises listed on the Shenzhen and Shanghai Stock Exchanges, and also examine

two mediating variables, namely corporate growth and market competitiveness, which shows that the environmental strategy of high-growth enterprises has a significant positive impact on environmental performance but does not bring about significant economic performance, while the opposite is true for low-growth enterprises. In a competitive market environment, environmental strategy is significantly and positively correlated with both environmental performance and economic performance.

With regard to social responsibility, the main current view is that CSR performance positively affects corporate value. According to Margolis and Walsh (2001), out of 80 articles of empirical studies on the relationship between social responsibility and corporate value, 50% believe that there is a positive correlation, 25% believe that there is no correlation, 5% there is a negative correlation, and the other 20% do not have a clear conclusion. Similar to the environmental performance, there is a time lag in the impact of CSR performance on corporate value. Domestic scholars S. B. Wen and Fang (2008) find that the impact of CSR on current financial value is negative, and the long-term impact is positive; Yu and Wu (2014) find that the fulfillment of social responsibility has a significant negative impact on current corporate value, but shows a significant positive correlation with subsequent corporate value.

W. Liu and Cheng (2019) select 71 listed companies in Shenzhen and Shanghai as the sample of listed companies in the food and beverage manufacturing industry from 2013-2017 to study the relationship between social responsibility and the companies' financial performance, and the study shows that there is a significant positive correlation between social responsibility and financial performance.

Z. B. Li et al. (2020) use the data of listed companies in Shanghai and Shenzhen from 2009-2016 to study the relationship between CSR and firm value, and the study found that: the fulfillment of social responsibility has a significant negative impact on the current corporate value, but with the passage of time, social responsibility eventually has a positive effect on the corporate value, that is, the positive effect of social responsibility on the corporate value has a hysteresis effect.

Q. Wang and Li (2015) conduct an empirical study on the value creation mechanism of CSR from the perspective of supply chain, which shows that the fulfillment of CSR to suppliers, shareholders, government, and customers is significantly and positively related to corporate value.

In terms of corporate governance, X. Chen and Ma (2015) find that the level of corporate governance has a positive effect on corporate value and corporate growth. Metrick et al. (2003) find that enterprises with stronger shareholders' rights have higher Tobin's Q. Ye et al. (2016)

find that, regardless of whether they are state-owned or private enterprises, the structure of corporate governance has a significant positive correlation with corporate value.

S. S. Yang (2020) studies the impact of CSR on financial performance from the perspective of corporate governance by utilizing the data of Chinese A-share listed companies, and the study shows that CSR can improve the financial performance of the company, and that corporate governance can significantly affect the relationship between CSR and the financial performance of the company.

Ma and Li (2019) studies the role of internal corporate governance structure on corporate value through a total of 5,917 data in three years in Shanghai and Shenzhen A-share Stock Exchanges. The study finds that, in the internal governance structure, the board size, board shareholding ratio, and supervisory board shareholding ratio are significantly positively correlated with corporate value; the size of independent directors is significantly negatively correlated with corporate value; and the proportion of executives' shareholding, the size of executives, and the combination of two positions of the chairman and the general manager are all not correlated with corporate value.

The three categories of elements, namely environment, social responsibility, and corporate governance, have different ways, means and degrees of impact on corporate financial performance and corporate value, sometimes canceling each other out and sometimes superimposing each other. With the emergence of ESG concepts and various types of ESG rating tools, it is necessary to examine the impact of corporate EGS performance on corporate value as a whole.

L. Zhang and Zhao (2019) studies the impact of corporate ESG performance on corporate value with a research sample of 417 listed companies in China's A-share Stock Exchanges from 2015 to 2017, and the study shows that ESG performance is positively correlated with corporate value. Based on further segmentation of the sample companies, it is found that the positive impact of ESG performance on three types of companies (private and foreign-funded companies, small and medium-sized ones, and non-focused polluting ones) is more significant.

Tian (2023) selects 4,770 listed enterprises in Shanghai and Shenzhen A-share Stock Exchanges from 2016 to 2022, categorizes the ESG rating results of the enterprises into three grades (leading, average, and lagging), and investigates the impact of the ESG performance of the enterprises on the return on stock investment, which shows that ESG performance is positively correlated with quarterly return, and that ESG performance is one of the factors affecting the return on stock, and ESG investments can earn excess profits.

A number of scholars and research institutes at home and abroad have also found that,

companies with lower ESG risk have better opportunities to deliver sustainable financial performance (Matten & Crane, 2005); good ESG management is beneficial to the long-term development of enterprises - in the same interval, the return on investment with better ESG performance is significantly higher and the yield continues to increase over a longer interval; while the investment yield of poorer ESG performance has been maintained at a lower level (Joint Research Group of STGF & Beijing Green Finance Association, 2019). In addition, according to the scoring criteria of DJSI, the top 10% and the last 10% of enterprises ranked in terms of corporate sustainability are selected and the yield is calculated separately, and it can be found that the stronger the sustainability ability, the higher its corresponding financial performance and investment value (T. F. Jiang & Li, 2010).

2.3.2 Corporate performance evaluation based on stakeholder theory

2.3.2.1 Stakeholder theory

The traditional “shareholder first” theory emphasizes the maximization of short-term benefits and even tolerates a certain degree of stakeholder exploitation, whereas the “stakeholder theory” argues that companies should aim to maximize long-term benefits in the three dimensions of sustainable development (economic sustainability, environmental sustainability and social sustainability) and always benefit all stakeholders. Freeman (2010) therefore does not deny that the search for economic profitability is a legitimate goal of the company, but it is not the ultimate goal. It must be a tool for improving the interests of stakeholders and creating shared value for all stakeholders.

Since early last century, scholars have begun to consider the purpose of the existence of enterprises, and believe that profit is not the only goal or the ultimate goal of enterprises. The enterprise can not only meet the needs of shareholders or owners, but also meet the needs of all kinds of stakeholders. It is a collection of interest subjects with their own value, and its ultimate goal should not be profit maximization but the maximization of the value of stakeholders, or the maximization of the value of the enterprise (R. M. Jiang & Jin, 2009). Since the 1960s, scholars have worked on constructing stakeholder theories, resulting in a series of theories, including the contract theory (Freeman & Evan, 1990), the principal-agent theory (Hill & Jones, 1992), the resource dependence theory (Pfeffer, 1987), the property rights theory (Donaldson & Preston, 1995), the complementary firm theory (Gorton & Schmid, 2000), and the multiple agent theory (Stiglitz, 1993).

Many different stakeholder categorizations have arisen from different stakeholder theories.

The appropriateness of a categorization is judged by its practicability – whether a company can use it to effectively manage key stakeholders and achieve sustainable operations. Since the 1990s, two categorizations have emerged: multi-cone subdivision and Mitchell scoring.

Multi-cone subdivision is a consumer behavioral research method that subdivides the market by studying consumer behavior and expectations in order to meet consumer needs. In addition, the method helps companies identify commonalities among specific consumer segments, as well as determine differences between different consumer segments. Using the multi-cone subdivision method, Freeman and Medoff (1984) categorized stakeholders from three perspectives: ownership, economic dependence, and social interest, Frederick and Evan (1990) categorized stakeholders in terms of direct and indirect influence, and Charkham (1992) categorized stakeholders according to the existence of a contractual relationship.

The Mitchell Scoring, proposed by the American scholar Mitchell et al. (1997), rates possible stakeholders in terms of three attributes, and identifies different types of stakeholders according to the level of the rating value, which are, in order of importance, deterministic, anticipatory, and potential stakeholders. The three attributes evaluated are (1) legitimacy-whether a group is endowed with legal and moral or specific claims; (2) power-whether a group possesses the status, ability, and corresponding means to influence corporate decisions; and (3) urgency: whether a group's demands can be brought to the attention of the company’s management immediately.

Unlike the multi-cone subdivision method, the Mitchell scoring does not directly inform enterprises of the types of stakeholders they need to pay attention to, but provides a scoring method for judging and defining the stakeholders of an enterprise, which is simple to learn and easy to operate, and is a major advancement in stakeholder theory. Domestic scholars have made some localized improvements to the method by combining it with the reality of Chinese enterprises, which can be used by Chinese enterprises to identify key stakeholders and implement effective management.

2.3.2.2 Overview on corporate performance evaluation based on stakeholder theory at home and abroad

In the research field of stakeholder theory, enterprise performance evaluation is the core of the whole theory. Scholars at home and abroad have proposed many performance evaluation systems based on the stakeholder theory. Bryan et al. (1982) proposes the external stakeholder evaluation model of corporate performance; Clarkson (1995) establishes the RDAP model (Antagonistic, Defensive, Adaptive and Pedictive) for evaluating corporate social performance

base on the research of Wartick and Cochran (1985) from the perspective of business, employees, shareholders, consumers, suppliers and public stakeholders; Davenport (2000) evaluates corporate performance based on Freeman and Evan's (1990) stakeholder framework, in accordance with the requirements of "corporate citizenship", from the three aspects of corporate ethical behavior, stakeholder responsibility, and environmental responsibility; Sirgy (2002) categorizes stakeholders into internal, external and end stakeholders and establishes a performance evaluation system for stakeholder relationship quality. P. L. Li (2001) studies the interest protection mechanism of different stakeholders and establishes a stakeholder model for operator performance evaluation. Y. L. Liu (2003) constructs a comprehensive performance evaluation system of natural monopoly enterprises' stakeholder orientation from five aspects: investors, fixers, government, public and consumers. In these performance evaluation systems, the Performance Prism is a typical representative. It is not only a performance management tool, but also provides the management with ideas to carry out stakeholder management.

2.3.2.3 Performance Prism (PP)

The Performance Prism (PP) is a performance evaluation model developed by Andy Neely and the Center for Business Performance at the Cranfield University. The logic of this model is that the key stakeholders of an organization include investors, customers, employees, suppliers/partners, and rule makers/communities, and in order to achieve sustainable development, an organization first needs to identify stakeholder needs and then develop a strategy accordingly; strategy execution needs to be supported by good processes; the processes need to be operated by competent people; and ultimately, the stakeholders' contributions to the organization are captured (D. Q. Deng & Wen, 2016). Stakeholder needs, strategies, processes, capabilities, and stakeholder contributions constitute the five dimensions of the PP：

1) Stakeholders’ needs. The operation of an enterprise begins with “stakeholders’ needs” and ends with “stakeholders’ satisfaction”. The PP categorizes stakeholders into five types: shareholders, customers, employees, suppliers/partners, and rule makers/community. For each type, an enterprise must first identify their key needs and expectations, and then satisfy them through strategy development, process operation, and product or service delivery. Unlike the “Shareholder First” theory, which focuses only on the needs of shareholders and customers, the PP also focuses on the needs of other stakeholders (e.g., employees, suppliers, government, and communities).

2) Strategy. Key needs of stakeholders should be used as inputs to the development of corporate strategy and as outputs to the strategic objectives; in other words, the company's

strategic objectives should include measures of the degree to which stakeholders' needs are met. These objectives balance the needs of different stakeholders, thus ensuring that the company achieves balanced growth.

3) Process. Around the strategic objectives, the company needs to plan the corresponding processes (or action plans) and implement them. When a company adjusts its business philosophy from "shareholders first" to "stakeholders", the original processes can no longer meet the new strategic objectives, and need to be optimized, adjusted, or even add some new processes.

4) Capability. The effective implementation of the process needs to have the ability to match, including human resources, information resources, and organizational resources. In this regard, the PP draws on the "learning and growth" concept and model of the BSC.

5) Stakeholders' contribution. Enterprises identify and satisfy stakeholders' needs, then realize stakeholders' satisfaction, and ultimately obtain stakeholders' contribution. For example, investors and creditors provide capital to the enterprise; customers provide orders and markets; suppliers provide high-quality products and services; employees contribute higher labor productivity; and the government provides policy support, and more, and they decide how much to contribute to the enterprise according to the degree of satisfaction of their needs.

2.3.3 Corporate performance evaluation based on corporate innovation theory

2.3.3.1 Corporate innovation theory

Schumpeter (1912) put forward the "innovation theory", which belongs to the category of economics and evolves into two branches of technological innovation economics and institutional innovation economics. Since then, for a long period of time, technological innovation has always been at the core of innovation research, until Stata (1989) pointed out that the real bottleneck of enterprise development is management innovation rather than the traditional sense of technological innovation, and enterprise innovation theory has been studied in depth. Drucker (1999) introduced the concept of "innovation" into the field of management, further developing the theory of enterprise innovation. After decades of development, enterprise innovation theory has formed a relatively complete theoretical system and three theoretical branches, namely, technological innovation theory, institutional innovation theory, and management innovation theory (Lin & Peng, 2009).

1)Technological Innovation Theory

Schumpeter's "innovation theory" essentially belongs to the theory of technological

innovation, emphasizing the contribution of technological progress to economic growth. Since the 1950s, Western scholars have conducted in-depth research on the relationship between technological progress and economic growth and produced rich theoretical results.

Solow (1951), a representative of the neoclassical school, put forward the “two-step theory” of technological innovation, which believes that the two steps to realize technological innovation include the source of new ideas and the realization and development of the subsequent stages. Solow (1957) also put forward the concept of "Solow residual", that is, Solow residual (the results of technological progress) = economic growth rate - capital contribution rate-labor contribution rate. According to this formula, Solow calculated that about 88% of the total manufacturing output of the U.S. during the period of 1909-1949 was attributed to technological progress (Y. B. Li & Zhu, 2002).

Freeman and Medoff (1984) defined technological innovation as the entire process of technical, technological and commercialization which leads to the realization of markets for new products and the commercial application of new technological processes and equipment, and is the first commercial transformation of new products, processes, systems and services.

2) Institutional Innovation Theory

Schumpeter's innovation theory did not discuss institutional innovation in depth, but Davis and North (1970) developed the innovation theory and put forward the institutional innovation theory, which considers institutional innovation as a change in the existing system that refers to innovations in the organization of the economy or the way of business management, which can enable the innovators to obtain additional benefits. These systems include all types of political and economic systems, such as the financial system, the banking system, the tax system, the educational system, the trade union system, and others. The corporate system is also one of the components.

J. Wei (2006), a scholar in China, conducted a study on corporate system innovation, and divided corporate system innovation into six aspects, namely, property rights system innovation, corporate governance structure innovation, organizational structure innovation, management system innovation, personification system innovation and contract system innovation. He believes that the main body of corporate system innovation is the enterprise itself, but the government must adopt strong measures to promote corporate system innovation.

3) Management Innovation Theory

For a long time, the research on innovation mainly focuses on the field of technological innovation, and there is not much research on the connotation and role of management innovation. In the 1980s, Stata (1989) pointed out that the real bottleneck of enterprise

development is management innovation rather than technological innovation in the traditional sense, which initiates management innovation research, and many studies on management innovation have emerged since then.

Regarding the connotation of management innovation, Damanpour and Evan (1984) and others believe that management innovation refers to the organizational structure or process changes resulting from the implementation of new management practices or concepts, such as team production, supply chain management, or quality management system. Benghozi (1990) compared and analyzed management innovation with technological innovation and market innovation, and separated management innovation from the category of market and technology. Armbruster et al. (2008) categorized innovation into technological product innovation, technological service innovation, technological process innovation and non-technological process innovation, of which non-technological process innovation is management innovation. Chang and Gao (1994) regard management innovation as the radiation of organizational innovation at the operational level. Overall, there is no unified definition about management innovation in terms of theoretical research so far. In management practice, combined with the classification of corporate innovation in the third and fourth editions of the Oslo Manual, in addition to product innovation and organizational innovation, management innovation includes two types of marketing innovation and process innovation.

Regarding the role of management innovation, Stata (1989) argues that the real reason for the decline of many American companies in the 1980s was the problem of management innovation. Hamel (2006) emphasizes the significance of management innovation in terms of improving the efficiency of resource use, enhancing the core competitiveness of firms and forming an entrepreneurial class. Ichniowski et al. (1995) argue that management innovation increases productivity, improves product quality, and maintains competitiveness. According to the findings of Leseure et al. (2004), many governments have identified management innovation as an important driver of sectoral or national productivity improvement, for example, the UK Department of Trade and Industry and the Porter Report emphasized that the failure to achieve optimal management innovation is the main factor contributing to the relatively low productivity levels in the UK.

2.3.3.2 Survey and Statistics of International Innovation

The fundamental driving force of modern economic development is technological progress and innovation, and the innovation capacity, innovation level, and innovation performance of a country or region need to be measured using scientific methods. At present, relevant

international organizations have developed several tools for innovation surveys and statistics to investigate the total volume and structure of innovation activities to comprehensively reflect the characteristics and patterns of innovation activities (H. Deng & Zeng, 2011). The tools of innovation measurement include Frascati Manual, Oslo Manual and other international standards on innovation statistics.

1) Frascati Manual

The Frascati Manual (FM) is a programmatic document on statistical measurement of sci-tech activities, especially on research and experimental development (R&D), which was first published by the Organization for Economic Cooperation and Development (OECD) in 1963 and has been revised and improved six times since then, becoming an authoritative guideline for countries around the world to conduct measurement and analysis of sci-tech activities (J. H. Li, 2018). FM 1963 categorizes R&D activities into three specific forms, namely basic research, applied research and experimental development.

2) Oslo Manual

The Oslo Manual, OECD's foundational document guiding work on innovation statistics, has undergone three editions since its release in 1992, and a fourth official edition was released in 2018. The four editions of the Oslo Manual reflect different understandings of innovation at different times in history.

The survey of innovations covered in the first edition of the Manual (OECD, 1992) included only product and process innovations and did not yet extend it to services; the second edition (OECD, 1997) redefined TPP innovations (i.e., technological product innovations and process innovations) and added a new definition of organizational innovations; the third edition (OECD, 2005) classified innovations according to innovation objectives into two types, one involving demand (including product and marketing innovation) and the other involving cost (including process and organizational innovation); and the fourth edition (OECD, 2018) simplified the original four types of innovation into two main types: product innovation and business process innovation.

2.3.3.3 International/Regional Innovation Indices

At present, innovation indices are widely used internationally to evaluate the innovation capacity of a certain country/region, resulting in several internationally influential evaluation systems, and some innovation indices are of guiding significance to the evaluation of corporate innovation capacity and performance, such as the European Innovation Scoreboard (EIS), the Global Innovation Index (GII), and the Global Competitiveness Inde.

1) The European Innovation Scoreboard (EIS)

The European Innovation Scoreboard (EIS) is used to quantitatively compare the innovation performance of EU member states. Since the European Commission (2002) published its first EIS in 2002, the indicators have been revised from the initial 18 indicators to 25, with four relatively large adjustments, in 2003, 2008, 2010 and 2017. The current evaluation indicators include 4 primary indicators (framework conditions, innovation investment, innovation activity, and innovation impact), 10 secondary indicators (human resources, research system, innovation environment, financial support, business investment, innovative firms, linkages, intellectual property, employment impact and sales impact) and 25 tertiary indicators.

2) The Global Innovation Index

The Global Innovation Index (GII) was established in 2007 by the World Intellectual Property Organization (WIPO) and others to reflect an economy's overall level of innovation. The GII is divided into two categories of indicators, inputs and outputs, with corresponding sub-parameters under each parameter, which are composed of separate indicators, with the latest report for 2020 showing 80 specific indicators.

3) The Global Competitiveness Index

The Global Competitiveness Report (GCR), which has been published by the World Economic Forum since 1979, is used to evaluate and rank the economic performance of individual countries. The report's indicator system is divided into four dimensions, namely, enabling environment, human capital, market, and innovation ecosystem, and each system dimension has several pillar indicators, with sub-pillar indicators and specific indicators under each pillar indicator, and the 2019 GCI has a total of 12 pillars, 23 sub-pillars, and 103 specific indicators (World Economic Forum, 1979).

2.3.3.4 Enterprise innovation ability evaluation system

Before the 21st century, domestic and foreign academics' evaluation of corporate independent innovation capability mainly focused on technological innovation capability (H. Li, 2015). Harris et al. (1983) and Porter (1990) studied corporate independent innovation capability from the perspective of corporate strategy and competitive advantages, emphasizing the importance of technology in improving the competitive advantage of enterprises. Adler and Shenhar (1990), Guan and Ma (2003), and Burgelman et al. (1996) studied the independent innovation capability of enterprises from the perspective of the structure of their technological capabilities. Ransley and Rogers (1994) assessed the best R&D practices of enterprises from seven aspects, including technological strategy.

Starting from the 21st century, scholars began to pay attention to the research on the evaluation system of enterprise innovation ability. Romijn and Albaladejo (2002) uses two indicators, namely the number of patents and the product innovation index, to measure the innovation ability of enterprises. Caloghirou et al. (2004) uses the indicators of the proportion of sales of significantly improved and new products to measure the innovation ability of 558 enterprises in the EU. In 2005, the National Bureau of Statistics (NBS) released the Analysis Report on the Independent Innovation Capacity of Chinese Enterprises, which put forward a system of evaluation indicators for the independent innovation capacity of enterprises from the perspective of technological innovation capacity.

Long et al. (2023) use bibliometrics and thematic modeling to analyze the current status of the research on the evaluation index system of technological innovation in China's enterprises, and the study shows that the evaluation system mainly focuses on four dimensions, namely, innovation input capability, innovation output capability, innovation environment support capability, and innovation management capability, and each dimension contains a number of subject terms, basically covering all elements of technological innovation and the whole process.

H. J. Cao et al. (2009) construct a “model of corporate independent innovation process”, which considers that corporate independent innovation is a continuous cycle of accumulation process, and five aspects, including innovation awareness, innovation input capacity, innovation output capacity, innovation activity management capacity, and innovation mode, are the main factors affecting corporate independent innovation capacity.

Pang et al. (2011) use Michael Porter's Diamond Model Theory to construct a corporate innovation development index evaluation system containing 12 sub-factors and 58 evaluation indices from four aspects, including innovation foundation, innovation capability, innovation activities and innovation performance.

The Ministry of Science and Technology of China (2016), on the basis of fully referring to the research results of innovation capability evaluation abroad and combining innovation composition (including product innovation, process innovation, organizational innovation and marketing innovation) and innovation value chain (including innovation input, innovation output and commercialization of innovation results), has constructed a system including innovation input capability, collaborative innovation capability, intellectual property capability and innovation driving capability The indicator system of corporate innovation capability including 4 primary indicators, 12 secondary indicators and 24 tertiary indicators is constructed, and a report on the evaluation of innovation capability of Chinese enterprises is published annually since 2016.

Edison (2012) categorizes innovation into three types: initial innovation, flow innovation and source innovation, and believes that source innovation is the source of enterprise development, which is the top priority of enterprise innovation strategy. Z. G. Zhang and Lin (2021) refer to Xie's "source innovation" theory, based on bibliometrics and rooted theory, establish a first-class manufacturing enterprise innovation ability evaluation system, including three dimensions of source innovation, core innovation, and chain innovation, with a total of 10 categories if subcategories of performance indexes, and suggest that China's manufacturing enterprises layout in advance of the source innovation, core innovation, chain innovation to promote the development of enterprises.

2.4 Comparative study on evaluation dimensions of diverse performance evaluation systems

In Sections 2.1 to 2.3 of this chapter, we successively conduct a literature study on five types of management concepts/tools and the corresponding corporate performance evaluation systems, aiming to explore a new scorecard model that can adequately cover the requirements of these management concepts/tools, and replace the traditional BSC as a new performance management system that's fully compatible with the PEM, and transforms the "stakeholder needs" into a "stakeholder satisfaction". The five types of management concepts/tools are:

1) the BSC,
2) the PEM,
3) Sustainable Development and ESG Rating,
4) the Stakeholder Theory and the PP, and
5) the Corporate Innovation Theory and Corporate Innovation Capability Rating System.

The BSC developed by Robert Kaplan and David Norton consists of four dimensions: financial, customer, internal processes, and learning and growth, which are subdivided into nine dimensions: financial, customer, operations management, customer management, innovation, regulatory and social, human capital, information capital, and organizational capital.

Based on the above nine dimensions of the BSC, the author compares the evaluation dimensions of the other four types of management concepts/tools and forms an integrated performance evaluation system with 12 dimensions by adding and combining them (see Annex A "Comparison of Evaluation Dimensions of Various Performance Evaluation Systems"). The 12 dimensions are:

1) Finance (investor),

2) Sustainable development,
3) Customers,
4) Workforce,
5) Suppliers/Partners,
6) Rule makers/Community,
7) Operation,
8) Innovation,
9) ESG,
10) Human capital,
11) Information capital, and
12) Organizational capital.

The distribution of each dimensional performance indicator in each of the five categories of management concepts/tools is presented next.

2.4.1 Comparative study on performance indicators in finance/investor dimension

By examining the MBNQA "Criteria for Performance Excellence" (2021-2022), the Chinese National Quality Award standard "Evaluation Criteria for Performance Excellence" (CQA, 2004), the European Quality Award EFQM Excellence Award (EFQM, 2022), the Balanced Scorecard (Meyer, 2003), and the Performance Prism (Neely et al., 2002), the author finds a total of 24 financial/investor performance indicators (see Annex B, "Comparison of Financial/Investor Dimensions Performance Indicators"), and distills them into four categories.

1) Profitability,
2) Solvency,
3) Operating capacity, and
4) Development capability.

Through comparative analysis, the indicator systems of the five types of performance management models all cover the above four categories of financial indicators to different degrees.

2.4.2 Comparative study on performance indicators in sustainability dimension

The concept of sustainability has been described in detail earlier, and the current common way of measuring corporate performance is through various ESG ratings, while ISS sustainability reports will be added in the future (see section 2.3.2). The author finds through research (see

Annex C, “Comparison of Sustainability Dimension Performance Indicators”) that the US, Chinese, and European quality award standards, the BSC, and the PP have some sporadic ESG indicators, but none of them place “sustainability” indicators next to “financial” ones. The concept of “sustainable development” has not been fully implemented in these performance management models.

2.4.3 Comparative study on performance indicators in customer dimension

We continue comparing these five types of performance management models and finds a total of 14 customer-based performance indicators (see Annex D, “Comparison of Customer Dimension Performance Indicators”), which are distilled into three categories.

1) Customer satisfaction,
2) Customer fit, and
3) Customer contribution.

Through comparative analysis, it can be found that “customer contribution” indicators mainly concentrate on the PP, which is an important feature of this model that is different from other models.

2.4.4 Comparative study on performance indicators in employee dimension

The five types of performance management models refer to a total of 12 workforce-based performance indicators (see Annex E, “Comparison of Workforce Dimension Performance Indicators”), which are distilled into three categories.

1) Workforce satisfaction,
2) Workforce fit, and
3) Workforce contribution.

Through comparative analysis, it can be found that although the “workforce contribution” category is a unique classification proposed by the PP, all three types of quality awards in the U.S., China, and Europe involve related indicators. However, in the BSC model, there are no indicators for workforce satisfaction, workforce fit or workforce contribution, but only “human capital readiness” under the dimension of “human capital”, which indicates that the BSC considers employees as a kind of “human capital”. This indicates that the BSC treats employees as a kind of “human capital” rather than “stakeholders”, which reveals a major deficiency in the “stakeholder” theory of the model.

2.4.5 Comparative study on performance indicators in supplier/partner dimension

The five types of performance management models refer to a total of nine Supplier/Partner performance indicators (see Annex Table F, "Comparison of Supplier/Partner Dimension Performance Indicators"), which the author has distilled into two categories.

1) Supplier/Partner Satisfaction, and
2) Supplier/Partner Contribution.

Through comparative analysis, it can be found that most models focus on "supplier/Partner contribution" more than "supplier/Partner satisfaction", and only the PP gives equal attention, which reflects the model's "stakeholder-centered" value orientation. This reflects the "stakeholder-centered" value orientation of the model.

2.4.6 Comparative study on performance indicators in rule maker/community dimension

The author compiles the nine rule maker/community dimension performance indicators proposed by the PP (see Annex G, "Comparison of Rule maker /Community Dimension Performance Indicators") and groups them into two categories.

1) Rule maker/Community Satisfaction, and
2) Rule maker /Community Contribution.

The comparative analysis reveals that, except for the PP, the other performance management models do not pay enough attention to the "stakeholder" category of rule maker /community.

2.4.7 Comparative study on performance indicators in operation dimension

Through the study of five types of performance management models, the author identifies a total of 23 performance indicators in the operation category (see Annex H, "Comparison of Operations Dimension Performance Indicators") and distills them into five categories.

1) Product service/Production,
2) Product sales/Service delivery,
3) Risk management,
4) Customer/market development, and
5) Customer relationship management.

Through comparative analysis, the indicator systems of the five types of performance management models all cover the above five categories of operational indicators to varying

degrees. However, in comparison, the US, China, the European quality awards and the PP pay less attention to the latter three categories of indicators, and only the BSC pays sufficient attention to all indicators.

2.4.8 Comparative study on performance indicators in innovation dimension

The PP is largely devoid of innovation-type indicators and is therefore excluded from the comparison. In addition, three additional sources of comparison are added: the Oslo Manual (OECD, 2018), the European Innovation Scoreboard (European Commission, 2002), and the Chinese Corporate Innovation Capability Report (MoST, 2016). Through a comparative analysis of the seven types of performance management models, the author identifies a total of 35 performance indicators (see Annex I "Comparative of Innovation Dimension Performance Indicators") and distills them into seven categories.

1) Innovation inputs,
2) Innovation capability (1): workforce skills,
3) Innovation capability (2): intellectual property capability,
4) Innovation synergy,
5) Innovation activities,
6) Innovation output (1): product innovation, and
7) Innovation output (2): business process innovation.

The comparative analysis shows that the three quality award models focus more on "innovation output" and "innovation activities" of product innovation, while the BSC basically focuses only on "innovation activities", which lacks theoretical support and is not systematic enough compared with international and domestic famous enterprise innovation performance evaluation systems.

2.4.9 Comparative study on performance indicators in ESG dimension

This comparison adds the MSCI ESG evaluation system to the five common performance management models. The reason for choosing MSCI instead of other ESG evaluation systems is that since June 2018, China's A-shares have been officially included in the MSCI Emerging Markets Index and MSCI Global Index, which have a wide application base in China. Through a comparative analysis of six types of performance management models, the author identifies a total of 41 performance indicators and distills them into 13 types (see Annex J, "Comparison of ESG Dimension Performance Indicators"), including five types of environmental (E), five

types of social (S) and three types of corporate governance (G).

1) Environment (1): Climate change,
2) Environment (2): Energy and resources,
3) Environment (3): pollutant emissions,
4) Environment (4): negative environmental events,
5) Environment (5): Environmental governance opportunities,
6) Society (1): Employment,
7) Society (2): Community support,
8) Society (3): Product liability,
9) Society (4): Stakeholder Controversies,
10) Society (5): Social responsibility opportunities,
11) Corporate governance (1)： governance responsibilities,
12) Corporate governance (2)： legal responsibility, and
13) Corporate governance (3)： Business Ethics.

Compared with the MSCI ESG evaluation system, the Chinese and American quality award models have more performance indicators in environmental (E), social (S) and corporate governance (G) aspects, but the European quality award, BSC and PP have seriously insufficient indicators in social (S) and corporate governance (G) aspects.

2.4.10 Comparative study on performance indicators in human capital dimension

This comparison is made on the basis of five common performance management models. In total, the author compiles 15 performance indicators (see Annex K, “Comparison of Human Capital Dimension Performance Indicators”) and distills them into three categories.

1) Workforce competencies and quantitative capabilities,
2) Workforce climate and equity, and
3) Workforce learning and development.

The comparative analysis shows that the BSC has only one performance indicator (human capital readiness) related to workforce competencies and capabilities, and does not consider employees as an important “stakeholder”, which indicates that the BSC is a product of the “shareholders’ interest first” era. In addition, the PP has only three performance indicators, which is not particularly “people-oriented” compared to the three types of quality award models.

2.4.11 Comparative study on performance indicators in information capital dimension

This comparison is made on the basis of five common performance management models. In total, the author compiles nine performance indicators (see Annex L, "Comparison of Information Capital Dimension Performance Indicators") and distills them into two categories.

1) Information capital, and
2) Organizational knowledge.

The comparative analysis finds that the PP does not have any relevant indicators, the BSC is second, and the European Quality Award model has few relevant indicators, while only the Chinese and American quality award models cover almost all indicators.

2.4.12 Comparative study on performance indicators in organizational capital dimension

This comparison is made on the basis of five common performance management models. In total, the author compiles eight performance indicators (see Annex M, "Comparison of Organizational Capital Dimension Performance Indicators") and distills them into three categories.

1) Culture,
2) Leadership, and
3) Strategy Synergy.

The comparative analysis shows that the European Quality Award model does not have any relevant indicators, the PP is second, the American Quality Award model has few relevant indicators, and only the Chinese Quality Award model and the BSC cover almost all the indicators.

2.4.13 Summary

Through the comparative analysis of the above twelve dimensions, it can be found that there are obvious differences in the implementation of sustainability concept, stakeholder concept, and corporate innovation concept among these five types of performance management models

First, we define the following three terms:

- Missing: there are essentially no corresponding indicators and no reflection of the core values of the relevant management philosophy;
- Inadequate: there are some or a few corresponding indicators and no adequate

reflection of the core values of the relevant management philosophy;

- Appropriate: the setting of indicators basically fits the core values and requirements of the relevant management philosophy.

Then, the following conclusions are drawn:

1) In terms of sustainable development theory and performance evaluation, the index Settings of BSC and other four types of performance management models are "inadequate ". Although BSC has set some sporadic indicators in ESG aspects, it does not elevate the “sustainability” performance of enterprises to the same level as “financial” performance.

2) In terms of stakeholder theory and performance evaluation, BSC related indicators are "missing", even employees are treated as "human resources" rather than "stakeholders"; the PP is “tailor-made” for this theory, and the index is set "appropriate"; while the other three types of quality award modes have " inadequate " in the setting of indicators.

3) In terms of corporate innovation theory and performance evaluation, PP is "missing" related indicators; the indicators in other 4 types of performance management mode are set as "inadequate ", among them, three types of quality award models only involve "innovation output" and "innovation activities". While the BSC only focuses on "innovation activities" and lacks theoretical support and is seriously lacking in systematization compared with the international and domestic famous enterprise innovation performance evaluation system

2.5 Reflection on literature review

Through literature research, the author points out in section 2.1.3 that the BSC is deficient in three areas in meeting the performance management needs of various types of enterprises (especially manufacturing enterprises) in the 2020s: it does not reflect the business concept of sustainable development; the stakeholder perspective is not broad enough; and the focus on innovation is not sufficient.

In section 2.2.2.3, the author points out that there are three difficulties when enterprises construct performance measurement systems based on the Evaluation Criteria for Excellence Performance: the criteria do not give specific tools or methods; comprehensive and integrated evaluation methods (e.g., AHP) are often highly subjective; and there is a lack of top-level design and selection mechanisms for KPI.

In section 2.2.4, the author points out that although the combination of the PEM (Performance Excellence Model)with concepts/tools such as the BSC has solved some of the problems, there are still two problems to be solved: first, the lack of a top-level design and

selection mechanism for KPI; and second, the lack of an independent scorecard system that can fully fit the PEM.

In order to address the above issues, the author has conducted a literature review on the "sustainability theory," the "stakeholder theory," and the "corporate innovation theory" and the various corporate performance evaluation mechanisms that accompany these theories in section 2.3, respectively, and lays the theoretical foundation for the establishment of a new scorecard model that goes beyond the BSC and the PP and is fully compatible with the PEM.

In Section 2.4, the author breaks down and integrate the evaluation dimensions involved in the five common performance management models, extracts 12 dimensions, and analyzes the differences in performance indicators among the models according to each dimension, and further analyzes the differences among these five models and the "sustainability theory", the "stakeholder theory" and the "corporate innovation theory" in terms of their fit to provide directions for the construction of a new scorecard model.

Chapter 3: Construction of PESC Model

3.1 Construction principle of PESC evaluation indicator system

In order to construct a performance evaluation system for manufacturing industry based on Evaluation criteria for Performance Excellence – the PESC, while incorporating the "Sustainability Theory", the "Stakeholder Theory" and the "Corporate Innovation Theory", should follow the principles as follows,

1) The Principle of Systematization. The Performance Excellence Model (PEM) is widely recognized as an effective tool or method for integrated organizational performance management, which covers all aspects of business management, with obviously systematic and structured characteristics. Therefore, when constructing the corresponding performance evaluation system, the selection and combination of various evaluation indicators must also reflect the systematic and structured characteristics. The Balanced Scorecard (BSC) has a stable structure and has been widely recognized and adopted, so this study builds a new performance evaluation system – the PESC on the basis of the BSC.

2) The Principle of Science. The Science of the performance evaluation system comes from a corresponding theoretical and practical foundation. The new performance evaluation system – PESC is based on the BSC and incorporates the "sustainability theory", the "stakeholder theory" and the "Corporate Innovation Theory", which is advanced. However, as to the specific application, the selection of indicators and the design of weights must be combined with the actual situation of countries, regions and industries, so as to scientifically and accurately reflect the connotation, target, characteristics, current situation, and rules of the high-quality development of China's manufacturing industry.

3) The Principle of Universality. The PESC of the performance excellence evaluation system in the manufacturing industry should be universally applicable, and the selection of indicators must be typical, so that it can reflect the actual situation of enterprises that have introduced the PEM, and in the meantime provide performance improvement guidelines for enterprises that have not introduced the PEM. Therefore, at the construction stage of performance indicators, the experts participating in the survey must be from a wide range of fields; at the survey stage of performance indicators application, the number of participating

enterprises must be large enough and not limited to a certain type of enterprises.

4) The Principle of Measurability. The indicators of the Performance Excellence Evaluation System in the manufacturing industry should be clearly defined and be measurable for users' understanding and application. The indicators should come from various performance evaluation standards, the BSC, and performance evaluation systems related to theories such as the "sustainability theory", the "stakeholder theory", and the "corporate innovation theory". As these indicators are widely used in different situations, their measurability can be guaranteed.

5) The Principle of Independence. There are different dimensions horizontally and different levels vertically among the indicators of performance excellence evaluation in the manufacturing industry. When constructing the indicator system, the indicators should be decomposed layer by layer into multiple sub-indicators and lower-layer indicators according to certain rules, and ensure that the indicators at the same level are mutually exclusive. Those that do not comply with the principle of independence should be eliminated or the indicator system should be reorganized.

6) The Principle of Consistency. The principle of consistency emphasizes that the indicators at the upper level have a containment relationship with the indicators at the lower level, and the realization of the indicators at the lower level can effectively promote the realization of the indicators at the upper level, to achieve the ultimate performance goal. When setting and decomposing the indicators, the excellence performance indicator system in the manufacturing industry should adopt consistent standards to ensure that the indicators between different levels of the same dimension have a causal logical relationship.

3.2 Construction framework of PESC evaluation indicator system

3.2.1 Preliminary selection of evaluation indicator System

There are two tasks in the preliminary selection of indicators for the Performance Excellence Evaluation System in the manufacturing industry: first, to determine the framework or structure of the evaluation indicator system; and second, to screen the specific indicators of the evaluation indicator system. Referring to the four levels of "Finance", "Customer", "Internal Process" and "Learning and Growth" and nine dimensions of the BSC, the Performance Excellence Scorecard (PESC) still adopts the structure of four levels, but are adjusted to "corporate value," "stakeholders," "internal processes," and "learning and growth, while the number of dimensions has been increased to 12, with the content of each dimension substantially adjusted. The basic

framework of the new PESC is shown in Figure 3.1.

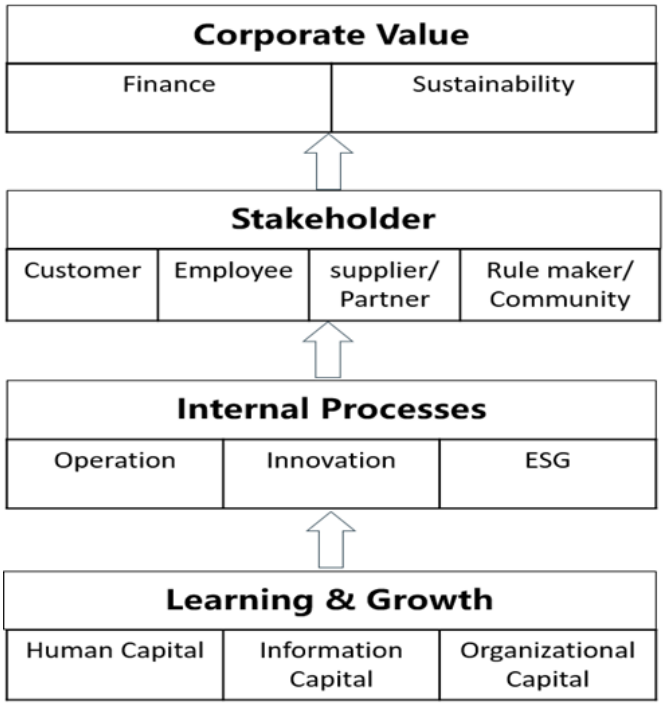

Figure 3.1 Framework of PESC Model

The four levels and 12 dimensions of the PESC are briefly described as follows.

1) The Level of Corporate Value

This level includes the dimensions of "Finance" and "Sustainability". The " Finance" dimension is derived from the "Financial Dimension" of the original BSC, while the "Sustainability" dimension is new and comes from the evaluation of sustainable development performance under the concept of sustainability. The evaluation indicators can be the ESG rating results or the performance indicators required to be disclosed in future ISS corporate sustainability reports.

According to the work plan of the IFRS Foundation, with the addition of sustainability-related financial information disclosure, the future financial reports will consist of two parts: "Financial Statements" and "Sustainability-related Financial Information Disclosure". The new reports will no longer be monolithic standardized corporate financial reports, but dual standardized corporate value reports (S. Z. Huang, 2021). The PESC adjusts the "finance" dimension to the "corporate value" dimension, which adheres to the trend of corporate financial reporting.

2) The Level of Stakeholders

This level includes dimensions of "customer", "workforce", "supplier/partner", and "rule maker/community". On the one hand, it expands the "customer" perspective of the original BSC; and on the other hand, it incorporates the stakeholder classification of the Performance Prism

(PP).

By adjusting the "customer" level to the "stakeholder" level, the limitation of theoretical hypothesis of "shareholder primacy" of the BSC is effectively addressed, and the new scorecard model is based on the "stakeholder" theory.

3)The Level of Internal Processes

This level includes three dimensions, i.e., "Operations", "Innovation", and "ESG". Among them, "Innovation" and "ESG" dimensions are derived from the "Innovation" and "ESG" dimensions of the BSC respectively, but they have been substantially adjusted to include more types of performance indicators.

After the adjustment, the new scorecard model incorporates the latest "corporate innovation concept" and "ESG concept", which effectively makes up for the lack of the above two types of management theories in the BSC.

4) The Level of Learning and Growth

This level includes three dimensions of "Human Capital", "Information Capital" and "Organizational Capital", which are consistent with the original BSC, yet with significant adjustments in the content of the indicators. Take the "human capital" dimension as an example, previously there was only one "human capital readiness", but after the adjustment, indicators like "workforce capability and capacity", "workforce climate and rights", and "workforce management" have been added.

In addition, the requirements of the "Leadership", "Strategy" and "Measurement, Analysis and Knowledge Management" categories of the Performance Excellence Model were broken down into "Organizational Capital" and "Information Capital" dimensions of the new scorecard to ensure that the latter is fully aligned with the core values and standards of the former.

As a result of these adjustments, a new scorecard model with 4 levels, 12 dimensions, and 48 categories of performance indicators (or issues) was constructed, which is fully compatible with the PEM- the PESC. The framework of the PESC indicator system is shown in Annex N.

The differences among the newly constructed PESC, the Evaluation Criteria for Performance Excellence (CQA, 2004), and the BSC in terms of setting of indicators are described in Annex O, from which, we can find that,

1) Compared with PESC (CQA, 2004) has totally 33 categories of indicators (or issues) that are satisfied or partially satisfied and 15 categories of indicators (or issues) that are completely missing in 48 categories of performance indicators (or issues), with a match of 68.8%. The missing indicators (or issues) are mainly focused on: ESG performance, customer contribution, stakeholder/community satisfaction and contribution, operational risk

management, innovation (workforce skills), collaborative innovation, business process innovation, climate change, negative environmental events, environmental governance opportunities, stakeholder disputes, social responsibility opportunities, culture, and strategic synergy.

2) Compared with the PESC, the BSC has totally 29 categories of indicators (or issues) that meet or partially meet the 48 categories of performance indicators (or issues), and 19 categories of indicators (or issues) completely missing, with a match of 60.4%. The missing indicators (or issues) are mainly focused on: solvency, ESG performance, workforce satisfaction, fit and contribution, rule maker/community contribution, innovation investment, innovation capability (including workforce skills and IP capability), collaborative innovation, business process innovation, climate change, product responsibility, stakeholder disputes, social responsibility opportunities, governance responsibility, business ethics, workforce equities and atmosphere, and workforce learning and growth.

3.3.2 Filtering of evaluation indicator system

In order to ensure a more representative evaluation indicator system, we screen the proposed preliminary indicators by questionnaire survey in response to the results of literature review. The questionnaire survey is to be conducted in two rounds, and the same 20 government quality award evaluation experts are invited to participate in both rounds. The questionnaires are designed using a five-point Likert scale and conducted online (wenjuan.com). After each round of survey, "consistency evaluation" is conducted according to the pre-defined screening principles, and only those indicators that pass the screening process could be included in the final indicator system. The screening process consists of the following steps:

Step 1: Designing Questionnaire;

Step 2: Survey (round 1);

Step 3: Consistency Testing;

Step 4: Adjusting Indicators, Revising Questionnaire;

Step 5: Survey (round 2);

Step 6: Consistency Testing;

Step 7: Finalizing Index System.

3.2.2.1 Principle of indicator filtering

When constructing various categories of evaluation indicator systems, a common method is to design questionnaires and use the Likert scale method for expert opinion consultation. In this

process, we need to develop suitable criteria to eliminate those that unimportant indicators as well as those on which experts have not reached consensus.

The importance of an indicator is usually measured with a "mean value". For example, on a five-point Likert scale, "very important," "important," "average," "unimportant" "very unimportant" respectively represent points 5, 4, 3, 2, and 1, or 1.0, 0.8, 0.6, 0.2, and 0, then the mean value of 4 (or 0.8) means that an indicator is important, and if the mean value is 3.5 (or 0.7), that indicator is "more important "(between "important" and "average").

Whether experts "reach consensus" on the importance of an indicator is usually measured by the "coefficient of variation". However, there is no unanimous opinion on the range of the "coefficient of variation" that represents the "consensus" among experts. We have analyzed the literature and compiled the criteria for indicator selection for the questionnaires using the five-point Likert scale, as shown in Table 3.1 below.

Table 3.1 Indicator screening criteria of the five-point Likert scale used by different scholars

No	Author	Criteria for Indicator Selection (A and B)		Research Field
		Average Value (A)	Coefficient of Variation (B)	
1	C. Wang and Sun (2019)	≥0.8	<0.2	Hospital Innovation Evaluation System
2	L. N. Chen and Zhang (2017)	≥0.8	<0.25	Hospital Innovation Evaluation System
3	Tan (2019)	>3	<0.25	Landscape evaluation system
4	Yao (2022)	≥4	<0.25	Hospital Quality Evaluation System
5	P. Liu (2022)	≥4	<0.25	Physical Quality Evaluation System
6	X. Y. Jiang (2022)	>3	<0.20	Transportation Operation Evaluation System
7	W. S. Chen (2022)	>3.5	<0.20	University Performance Evaluation System
8	Hou and Wang (2016)	>3.5	<0.20	University Students' Credit Evaluation System
9	X. Wang (2016)	>3.5	<0.35	Enterprise Innovation Evaluation System

Considering that the survey on expert opinion is conducted at two stages in this study, in which the first stage is conducted using the Likert scale; and the second stage using the Analytic Hierarchy Process (AHP), the selection criteria at this stage can be set without being too strict, and the indicator selection criteria will be specified as: mean value (A) $\geqslant$ 3.5 and coefficient of variation (B) < 0.25.

3.2.2.2 Judging panel for indicator filtering

To guarantee the professionalism and authority of the survey results, the participants of the survey are all senior experts in the theoretical research and application of the PEM, including

government quality award assessors, university professors, and senior executives of enterprises involved in quality award declaration, among which quality award assessors account for more than 80%. The relevant information of the experts can be found in the "Expert Information List" (see Annex P).

3.2.2.3 Procedure of indicator filtering

a) First Round of Survey.

According to Annex N "Framework of PESC Indicator System", we design the "Questionnaire on Performance Excellence Evaluation System (Round 1)" (see Annex Q), using the five-point Likert scale, and conduct a survey with 20 experts. The opinion is solicited on "wenjuan.com", and the return rate of the questionnaires is 100%.

The "mean value" and "coefficient of variation" of the collected questionnaires are calculated to assess whether an indicator should be "included" or "excluded". The lowest mean value is "E13 Stakeholder Dispute" (3.75 points) and the highest coefficient of variation "C6 Rule maker/Community" (0.23 points). All indicators meet the selection criteria: mean value (A) $\geqslant$ 3.5 and coefficient of variation (B) < 0.25. The detailed calculation results are shown in Annex S, " The Screening results of the PESC indicator system ".

In addition, some experts actively give feedback and suggest adding some indicators, such as indicators of "brand management" and "digitalization/intelligence" categories.

b) Second Round of Survey

According to the experts' suggestion, we update the questionnaire - "Questionnaire on Performance Excellence Evaluation System (Round 2)" (see Annex R), adding indicators of "brand management" and "digitalization/intelligence" categories, and collect opinions from these 20 experts again. The survey is still conducted on “wenjuan.com” with the same return rate of the questionnaires, 100%.

The "mean value" and "coefficient of variation" are calculated for the returned questionnaires to assess whether an indicator should be "included" or "excluded". There are totally 61 categories of the 2nd/3rd/4th category of indicators, among which the lowest mean value is still “E11 Stakeholder Dispute” (3.90 points) and the highest coefficient of variation "E11 Community Support" (0.21 points). All indicators pass the selection process again. The calculation results are shown in Annex S.

3.2.3 Finalized indicators

Based on the results of two rounds of surveys on expert opinion, we adjust the “Framework of

the PESC Indicator System" (see Annex N), the result of the previous literature review, to form the final indicator system (see Annex T). Compared with the framework before adjustment (see Annex N), the changes in the adjusted framework of PESC indicator system (Annex T) are mainly reflected in the addition of two categories – "brand management" and "digitalization/intelligence" indicators, which also indirectly verifies the adequacy and validity of the previous literature study

Chapter 4: Study on Combined Weighting of PESC Based on AHP-EM

4.1 Selection of weighting methods

The current weighting methods in the multi-objective decision-making process are generally divided into subjective and objective weighting methods. The weighting results of the subjective weighting method are related to the evaluators' knowledge, experience and preferences, and have a certain degree of subjectivity, and the repeatability and reproducibility of the data are a bit poor. The assignment results of the objective weighting method depend entirely on the actual observed data, but these objective data are closely related to the sampling program and sample quality. If the sampling program is not reasonably designed, or the quality of the sampling process is not guaranteed, it will also lead to bias in the weighting results.

To solve the problems above, the combination of subjective and objective weighting methods is usually adopted, which can effectively overcome the shortcomings of both subjective and objective weighting methods, and make the weighting results closer to the objective reality and more persuasive. The AHP – EM is a combination of subjective and objective weighting methods, and this study adopts this method for the weighting of the PESC.

4.2 Weighting procedure of AHP-EM

4.2.1 AHP weighting

The Analytical Hierarchy Process (AHP) is a method that combines quantitative analysis with qualitative analysis, which was mainly applied to operations research in the early days, and later extended to many fields, and has been widely used in the weighting of indicators in various types of performance evaluation systems. The analysis process of the method is as follows:

1) Determining the indicator system (or constructing a hierarchical model)

To use the AHP for system analysis, the first step is to group and stratify the factors included, i.e., each factor constituting the system is grouped according to certain rules and stratified according to the subordination. The first layer of indicators is usually called the target layer, and the middle layer the indicator layer, which can be further developed or decomposed

according to the research objectives.

2) Constructing the judgment matrix

The AHP adopts a "two-by-two" approach to compare the importance of each factor to determine the weight. Before the comparison, the corresponding judgment matrix needs to be constructed (see Table 4.1):

Table 4.1 Judgment matrix

A_k	B_1	B_2	…	B_n
B_1	b_{11}	b_{12}	…	b_{1n}
B_2	b_{21}	b_{22}	…	b_{2n}
…	…	…	…	…
B_n	b_{n1}	b_{n2}	…	b_{nn}

In Table 4.1, A is the target layer, B1 to Bn are the factor layers to be compared, and bij is the relative importance of Bi to Bj for Ak. the importance is divided into five levels, usually bij takes 1, 2, 3, ..., 9 and their reciprocals, the meaning of which is:

bij=1, indicating that Bi is as important as Bj;

bij=3, indicating that Bi is slightly important to Bj;

bij=5, indicating that Bi is obviously important to Bj;

bij=7, indicating that Bi is strongly important to Bj;

bij=9, indicating that Bi is absolutely important to Bj.

The intermediate values of the judgment of two neighbors are 2, 4, 6, and 8.

The judgment matrix meets formula 4.1:

$$\mathbf{B_{ii} = 1,\ b_{ij} = \frac{1}{b_{ji}},\ i, j = 1, 2, \cdot\cdot, n} \tag{4.1}$$

Therefore, for the nth-order judgment matrix, we only need to give values for the elements of the matrix.

3) Hierarchical single ranking

Hierarchical single ranking refers to obtaining the ranking weights of the relative importance of the factors of the same level for the factors of the previous level by calculating the characteristic roots and eigenvectors of the judgment matrix. For judgment matrix B, the calculation meets formula 4.2:

$$\mathbf{BW = \lambda max W} \tag{4.2}$$

In this equation, λmax is the maximum characteristic root of B, and W is the regularized eigenvector corresponding to λmax; the component Wi of W is the weight value of the corresponding factor single ranking.

4) Consistency testing

When evaluating a number of factors in the "two-by-two comparison", there may be

inconsistency in the "importance" determination, so it's necessary to test the consistency index (CI) of the judgment matrix, and the equation is 4.3:

$$\mathbf{CI}=\frac{\lambda_{max}}{n-1} \tag{4.3}$$

When CI=0, the judgment matrix has full consistency, and the larger the CI, the worse the consistency of the matrix. To test the consistency of the judgment matrix, it is necessary to compare the CI with the average consistency index RI. the R values are shown in Table 4.2:

Table 4.2 Average RI of Matrices of Order 1-9

Order	1	2	3	4	5	6	7	8	9
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45

When the order is greater than 2, the ratio of the consistency index (CI) of the judgment matrix to the average consistency index (RI) of the same order is called the random consistency ratio of the judgment matrix, which is written as CR, i.e. formula 4.4:

$$\mathbf{CR = CI/RI} \tag{4.4}$$

When CR < 0.1, the judgment matrix has satisfactory consistency, otherwise, the judgment matrix needs to be adjusted.

5) Hierarchical total ranking

Calculating the weights of all factors at a given level with respect to the relative importance of the highest level is called "hierarchical total ranking". This process is carried out sequentially from the highest level to the lowest.

4.2.2 Entropy method weighting

In the information theory, entropy is a measure of uncertainty or randomness, and the entropy value is inversely proportional to the information obtained, the greater the uncertainty, the smaller the entropy value, and the smaller the uncertainty, the larger the entropy value. The weighting method based on this principle is Entropy Method (EM), which is an objective weighting method and its analysis process is as follows:

1) Constructing the data evaluation matrix. Let m be the number of enterprises to be evaluated and n be the number of evaluation indicators, then the initial evaluation matrix is shown in formula 4.5:

$$\mathbf{X}=(x_{ij})_{mn} \tag{4.5}$$

Where: $1 \leqslant i \leqslant m$，$1 \leqslant j \leqslant n$.

2) Data standardization. In general, the evaluation indicators have different dimensions, so the data need to be standardized first. The calculation formula is as follows in 4.6 and 4.7:

$$\textbf{Positive indicator: Vij=(Xij-Xmin)/(Xmax-Xmin)} \tag{4.6}$$

Negative indicator: Vij=(Xmax-Xij)/(Xmax-Xmin) (4.7)

where: Xmin is the minimum value of the ith indicator and Xmax is the maximum value of the ith indicator.

3) Data normalization. The standard matrix Pij is obtained with the following formula 4.8:

$$\mathbf{P_{ij}=\frac{V_{ij}}{\sum_{i=1}^{m} V_{ij}}} \quad (4.8)$$

4) Calculating the entropy value of each indicator. The formula is 4.9:

$$\mathbf{e_j=-k\sum_{i=1}^{m} P_{ij}\, lnP_{ij}} \quad (4.9)$$

5) Calculating the variability coefficient of each indicator. The formula is 4.10:

$$\mathbf{g_j=1-e_j,\ j=1,\ 2,\ldots,\ n} \quad (4.10)$$

6) Calculating the weight of each indicator. The formula is 4.11:

$$\mathbf{S_j=\frac{g_j}{\sum_{j=i}^{m} g_j}} \quad (4.11)$$

4.2.3 Combined weighting of AHP-EM

1) Calculating the combination weight coefficient

The difference coefficient method is used to calculate the respective proportions of the subjective and objective weights, as shown in formula 4.12:

$$\mathbf{W=\alpha W_1+\beta W_2} \quad (4.12)$$

Where: W is the combination weight; W1 and W2 are the weights derived from the entropy weight method and the AHP method, respectively; α and β are the proportion of each weight, and their calculation formula is 4.13:

$$\mathbf{a=\frac{n}{n-1}\left[\frac{2}{n}(p_1+2p_2+\cdots+np_n)-\frac{n+1}{n}\right]} \quad (4.13)$$

where: P(i=1,2,...n) is the vector of subjective weights in the ascending order, and n is the number of evaluation factors.

2) Calculating the combination weight result

The AHP weight calculation results and entropy weight calculation results are substituted into the formula, and the final combination weight is obtained.

4.3 Construction of hierarchical structure model and design of questionnaire

4.3.1 Hierarchical structure model of PESC indicator system

The hierarchical structure model is constructed according to the identified performance excellence evaluation indicator system (see Annex T). This model is composed of "Objective (A) → Primary Indicators (B) → Secondary Indicators (C) → Tertiary Indicators (D) → Level-4 Indicators (E)" (see Figure 4.1).

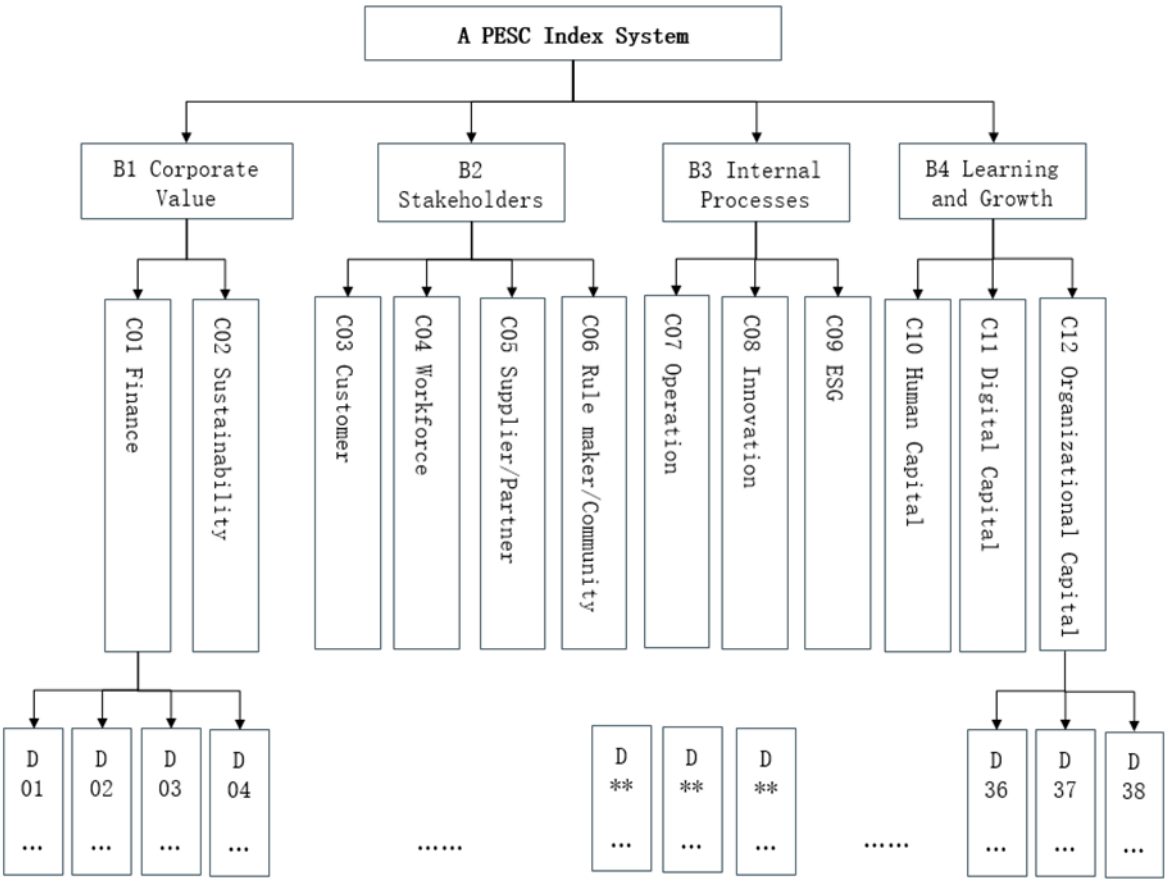

Figure 4.1 PESC Hierarchical Structure Model (Level-4 Indicators Omitted)

4.3.2 Design of questionnaire (used for expert opinion survey)

The questionnaire is designed according to the PESC indicator system (see Annex T), and the "Questionnaire on the Importance of Performance Excellence Evaluation System Indicators" is formed (see Annex U).

4.3.3 Design of questionnaire (used for self-evaluation of enterprise management maturity)

According to the newly constructed “Framework of the PESC Model”(see Annex T), the questionnaire is designed, and after several rounds of adjustment and testing, the final version of the "Business Management Maturity Questionnaire for Advanced Manufacturing Enterprises in the Greater Bay Area" is formed (see Annex V). The questionnaire consists of two main parts:

Part A: Respondents are asked to score (0, 1, 2, 3, 4 or 5) the maturity of the processes and results involved in the 50 categories of performance indicators in the PESC, with single-choice questions, for a total of 50 questions. The evaluation guidelines are as follows:

0 point: No proper method——No evidence of systematic approach, no results, bad results, or unintended consequences;

1 point: Responsive method——Systematic approach based on problems or corrections; little data of improved results;

2 point: Performance indicators defined——Defining intended results (performance indicators);

3 point: Systematic method established——Transferring results through planning and developing methods;

4 point: Focusing on continuous improvement——Assessing and improving impacts to ensure the intended results;

5 point: Best operation level——Strongest comprehensive improvement process; best results for level comparison confirmed.

Part B: From the 50 categories of performance indicators, 12 specific indicators (corresponding to the 12 dimensions of the PESC) are selected and the respondents are asked to answer whether their organizations have developed the corresponding indicators, with "yes-or-no" questions. There are 12 questions in total.

Among the 12 questions in Part B, there are 2 questions that are basically the same as the 2 questions in Part A (only the descriptions are different), and the respondents can be assessed by the "consistency" of their answers to the 2 questions.

4.4 Weighting process and outcome of PESC evaluation indicators

4.4.1 Weighting process and outcome of AHP

4.4.1.1 Weighting process of AHP-based PESC evaluation indicators

1) Distributing questionnaires to experts

An online questionnaire survey is conducted to experts on www.wjx.cn. The survey respondents are still experts from the first and second rounds. However, since the survey results (judgment matrix) of 4 experts could not pass the consistency test, we expand the survey respondents to 28 and finally collect 20 valid questionnaires. See Annex M for expert information.

2) Calculating the weight vector of each expert (or each questionnaire) and conducting the consistency test

Statistical Product and Service Software Automatically (SPSSAU) belongs to the website of Beijing Qingshi Technology Co., Ltd, which is a paid online data analysis software. For each returned questionnaire, we construct 21 judgment matrices, and a total of 21*20=420 judgment matrices are constructed. Importing the data into the online SPSSAU, we obtain the results of hierarchical analysis (including weight values, maximum eigenvalues and CI values) and consistency test results for each judgment matrix.

3) Adjusting judgment matrices

Referring to the adjustment scheme provided by the YAAHP software, we use both "maximum directional improvement" and "minimum change" to adjust the judgment matrix with random consistency ratio (CR) $\geqslant$ 0.1, in which the questionnaires of 8 experts could not meet the consistency requirements even after adjustment, which were taken as "invalid" questionnaires.

4) Calculating the average weights of each indicator for 20 experts

The questionnaire results show that each expert formed 21 judgment matrices and 71 indicator weights, and the weights of each indicator are summed up and averaged to obtain the weight of each indicator of the PESC.

5) Calculating the compound weights of each indicator, and performing single ranking and total ranking

The weights of the bottom-level indicators are multiplied by the weights of the higher-level indicators one by one to obtain the compound weights of each indicator in the whole indicator system, and the single ranking and total ranking are performed.

4.4.1.2 Weighting outcome of AHP-based PESC evaluation indicators

(1) Single hierarchical arrangement of individual expert's evaluation indicators

This round of survey among experts collects a total of 20 valid questionnaires, each generates 21 judgment matrices, a total of 420 judgment matrices. In order to save space, we choose the feedback questionnaire of expert with the number "007", and take the criterion layer A-B and indicator layer B-C as examples to illustrate the weight vector calculation and consistency test of each questionnaire. Detailed calculation and consistency test procedures are shown in Annex W.

(2) Single hierarchical arrangement of all expert's evaluation indicators

Referring to the steps in 4.4.1.2.1, the evaluation results (21 judgment matrices) of the remaining 19 experts are respectively ranked in a single ranking (including consistency tests), and the average of 71 indicators of 20 experts is calculated to derive the weights of each indicator (see Annex X).

(3) Calculation of compound weights, single hierarchical arrangement, and total ordering of all indicators

The "average" of each indicator is taken, and the weight of the bottom level (E or D) indicators is multiplied by the weight of the higher-level indicators one by one to get the weight of each indicator in the whole indicator system, see Annex Y.

4.4.2 Weighting process and outcome of entropy value assignment

4.4.2.1 Sample selection

The survey is conducted among representatives of advanced manufacturing enterprises in the Greater Bay Area that are above scale (annual sales revenue greater than RMB 20 million). The Greater Bay Area includes nine cities in Guangdong Province other than Hong Kong and Macau, including Guangzhou, Shenzhen, Foshan, Dongguan, Jiangmen, Zhongshan, Zhuhai, Zhaoqing and Huizhou. The scope of advanced manufacturing industry is defined and explained in the "13th Five-Year Plan for the Development of Advanced Manufacturing Industry in Guangdong Province" (see Section 1.1.1.2).

To ensure that the survey results are true and valid, the respondents of the questionnaires should have a basic understanding of the current status of the performance evaluation system in their organizations, so the following positions are targeted: quality managers, quality directors, vice presidents of quality (or chief quality officers), performance managers (directors), human resources managers, directors of the president's offices (or general manager's offices),

production plant managers, operations directors, division (or product line) general managers, and presidents).

Since the questionnaires are sent to a specific group of people, it is difficult to collect the them, so there are no special requirements for the surveyed enterprises, as long as they meet the following three conditions: a) above the scale; b) in the Greater Bay Area; and c) in the advanced manufacturing industry. The goal is to collect more than 300 valid questionnaires.

4.4.2.2 Survey

Several inspection, testing, certification, and consulting organizations are commissioned to conduct the survey, which adopts the online survey at www.wjx.cn. The survey period began on November 21, 2022 and ended on January 13, 2023, lasting 55 days in total.

4.4.2.3 Effectiveness evaluation of returned questionnaires

To ensure the validity of the questionnaires, all the returned ones are evaluated for validity according to the following rules, and as long as one of them is not met, the questionnaire is "invalid".

1) Consistency of answers <50% (the questionnaire is divided into two parts, with 2 questions in Part A expressed in another way in Part B, and at least the answer to 1 question in these two parts should be consistent);

2) The proportion of respondents' choosing the same option (or number) exceeds 70% of all choices; or all "4" or "5" (unless it is a government quality award-winning enterprise);

3) Respondents' answer time is <5 minutes, i.e. 300 seconds. After the pre-test, the time for respondents to complete the questionnaire carefully is 8 minutes, i.e. about 480 seconds.

A total of 726 questionnaires are collected in this survey, and after validity assessment, there are 384 invalid copies, 8 repeatedly filled-out copies, and 334 valid copies. The reasons and distribution of invalid questionnaires are shown in Table 4. 3.

Table 4.3 Reasons and distribution of invalid questionnaires

Type	Reason	Number (copies)	Proportion
Invalid Type A	Identical IP	84	21.9%
	Non-manufacturing Industry	15	3.9%
	Enterprises beyond the Greater Bay Area	13	3.4%
	Wrong Corporate Information	7	1.8%
	Dependent Corporations	6	1.6%
	Enterprises Below Scale	4	1.0%
Amount		129	33.6%
Invalid Type B	The proportion of choosing the same option exceeds 70% (or all choosing 4 or 5)	160	41.7%
	Consistency of answers < 50%	80	20.8%
	Too short answering time (< 300 seconds)	15	3.9%

Amount	255	66.4%
Total	384	100.0%

Considering the tendency of respondents to "underestimate" or "overestimate" the corporate management maturity of their enterprises, 34 questionnaires with the highest 5% and lowest 5% scores are excluded, and finally 300 questionnaires are kept for this study.

4.4.2.4 Weighting outcome

For the 300 valid questionnaires collected, the indicators of the PESC Evaluation System are assigned weights according to the steps of the Entropy Method in Section 4.2.2, and the results are shown in Table 4.4 below:

Table 4.4 Entropy weights of PESC indicators based on Entropy method

No.	Information Entropy （e_j）	Diversity Factor （g_j）	Entropy Weight （S_j）
D1	0.9882	0.0118	0.0162
D2	0.9896	0.0104	0.0142
D3	0.9862	0.0138	0.0190
D4	0.9896	0.0104	0.0143
D5	0.9792	0.0208	0.0285
D6	0.9915	0.0085	0.0116
D7	0.9810	0.0190	0.0261
D8	0.9912	0.0082	0.0121
D9	0.9894	0.0106	0.0145
D10	0.9886	0.0114	0.0156
D11	0.9888	0.0112	0.0153
D12	0.9896	0.0104	0.0143
D13	0.9907	0.0093	0.0128
D14	0.9781	0.0219	0.0300
D15	0.9808	0.0192	0.0263
D16	0.9849	0.0151	0.0207
D17	0.9874	0.0126	0.0172
D18	0.9900	0.0100	0.0137
D19	0.9814	0.0186	0.0255
D20	0.9805	0.0195	0.0267
D21	0.9777	0.0223	0.0305
D22	0.9875	0.0125	0.0171
E1	0.9855	0.0145	0.0198
E2	0.9829	0.0171	0.0235
D24	0.9858	0.0142	0.0195
D25	0.9783	0.0217	0.0298
E3	0.9860	0.0140	0.0192
E4	0.9827	0.0163	0.0238
E5	0.9825	0.0175	0.0240
E6	0.9850	0.0150	0.0205
E7	0.9845	0.0155	0.0213
E8	0.9836	0.0164	0.0225
E9	0.9843	0.0157	0.0215
E10	0.9891	0.0109	0.0149
E11	0.9839	0.0161	0.0220
E12	0.9884	0.0116	0.0160
E13	0.9837	0.0163	0.0223
E14	0.9846	0.0154	0.0211

4.4.3 Combined weighting process and outcome of AHP-EM

4.4.3.1 Calculation of combined weights

The entropy weight a=0.561809 and AHP weight β=0.438191 are obtained according to the formula.

4.4.3.2 Outcome of combined weights

The entropy weights (a) and AHP weights (β) are calculated by substituting the results into the formula to finally obtain the combination weights, as shown in Annex Z.

4.5 PESC weighting outcome analysis

4.5.1 Analysis of TOP20 PESC KPIs in combined weighting

4.5.1.1 Ranking of PESC KPIs

Based on the analysis results of the AHP-EM, the 50 categories of performance indicators included in the PESC are ranked according to their weights in Annex AA.

4.5.1.2 Analysis of TOP20 KPIs ranking

As is shown in Annex AA, when establishing a performance measurement system for manufacturing enterprises in China, priority should be given to the following Top 20 indicators (with a cumulative weight of 56.74%):

1) D5 ESG Rating Results (6.441%);
2) D1 Profitability (5.749%);
3) D2 Operating Capability (3.512%);
4) D7 Customer Engagement (3.084%);
5) D4 Development capability (3.019%);
6) D6 Customer Satisfaction (2.889%);
7) D3 Solvency (2.811%);
8) D8 Customer Contribution (2.587%);
9) D14 Rule maker/Community Satisfaction (2.467%);
10) D30 Workforce Competencies & Quantitative Capabilities (2.345%);
11) D32 Workforce Learning & Development (2.327%);
12) D15 Rule maker /Community Contribution (2.289%);
13) D33 Digital Technology (2.271%);

14) D21 Operational Risk Management (2.234%);

15) D9 Workforce Satisfaction (2.231%);

16) D19 Product/Service Production (2.191%);

17) D34 Digitization/Intelligent (2.108%);

18) D36 Culture (2.107%);

19) D20 Product Sales/Service Delivery (2.072%);

20) D37 Leadership (1.998%)。

Further analysis of the PESC KPIs (Top 20) leads us to the following conclusions:

1) "ESG Rating Results" (D5) is at the top, and it is tied with the second place "profitability" (D1), which indicates that the corporate operation concept of "sustainable development" has become a consensus today;

2) Financial indicators are still the most weighted ones, with all four types of financial indicators in the top seven, among which three types of financial indicators are in the Top 5, namely "profitability" (D1), "operational capability" (D2) and "development capability" (D4), with shareholders clearly ranking first among all key stakeholders;

3) All among the customer indicators are in the top eight, with "customer engagement" (D7) in the Top 5 and ranking 4th, "customer satisfaction" (D6) 6th, and "customer contribution" (D8) in 8th, which shows that since the 21st century, although there are many new technologies, new modes, and new business models, the essence of "customer-centric" business has not changed;

4) Among the employee indicators, “workforce satisfaction” (D9) ranks 15th; among the human capital indicators, “workforce competencies & quantitative capabilities” (D30) ranks 10th and “workforce learning and development” (D32) 11th. The ranking of these indicators validates the importance of the “people-centered” business philosophy;

5) Among the rule maker/community indicators, “rule maker /community satisfaction” (D14) ranks 9th and “rule maker /community contribution" (D15) 12th, which reflects that the PESC has fully integrated the "stakeholder theory".

6) In addition, "digital technology" (D33) ranks 13th and "digitalization/intelligence" (D34) 17th, reflecting the importance of digital transformation for the development of traditional enterprises; "culture" (D36) ranks 18th and "leadership" (D37) 20th, reflecting the significant impact of "visionary leadership" on the long-term development of enterprises.

4.5.2 Analysis of TOP20 PESC KPIs ranking with two weighting methods

4.5.2.1 Indicators with consistent results of subjective weighting and subjective and objective comprehensive weighting

Indicators that are assigned by both the subjective assignment method (AHP) and the combined subjective and objective assignment method (AHP-EM), and the ranking results remain consistent, imply that experts' opinion has been fully validated in practice, and enterprises should pay great attention to these indicators when establishing performance excellence evaluation systems.

In Table 4.5, the rankings of indicators with serial numbers 1 to 10 are stable and consistent in the top 11 under both weighting methods; the rankings of indicators with serial numbers 11 to 15 fluctuate slightly, but they are also in the top 20.

Table 4.5 Consistent indicators with subjective weights and subjective-objective weights

No.	Indicator	AHP Weight		AHP- EM Weight	
		Weight	Ranking	Weight	Ranking
1	D5 ESG Rating Results	11.05%	1	6.44%	1
2	D1 Profitability	11.05%	2	5.75%	2
3	D2 Operating Capability	6.20%	3	3.51%	3
4	D6 Customer Satisfaction	5.10%	4	2.89%	6
5	D4 Development Capability	5.06%	5	3.02%	5
6	D8 Customer Contribution	4.36%	6	2.59%	8
7	D3 Solvency	3.98%	7	2.81%	7
8	D7 Customer Engagement	3.69%	8	3.08%	4
9	D30 Workforce Competencies &Capabilities	3.33%	9	2.35%	10
10	D32 Workforce Learning & Development	3.30%	10	2.33%	11
11	D9 Workforce Satisfaction	3.24%	11	2.23%	15
12	D37 Leadership	2.70%	12	2.00%	20
13	D36 Culture	2.11%	16	2.11%	18
14	D15 Rule maker/Community Contribution	1.85%	19	2.29%	12
15	D14 Rule maker/Community Satisfaction	1.80%	20	2.47%	9

4.5.2.2 Indicators with inconsistent results of subjective weighting and subjective and objective comprehensive weighting

In Table 4.6, there are two types of indicators, Type A indicators are those ranking in the Top 20 for subjective weights but not for comprehensive weights, and Type B indicators are those ranking in the Top 20 for comprehensive weights but not for subjective weights.

Table 4.6 Indicators with different subjective and subjective-objective weights

No.	Indicator (Type A)	AHP Weight		AHP- EM Weight	
		Weight	Ranking	Weight	Ranking
1	D11 Workforce Contribution	2.58%	13	1.99%	21
2	D12 Supplier/Partner Satisfaction	2.43%	14	1.87%	23
3	D10 Workforce Engagement	2.18%	15	1.83%	24
4	D13 Supplier/Partner Contribution	1.99%	17	1.59%	30

5	D31 Workforce Climate & Equity	1.94%	18	1.66%	28
No.	Indicator (Type B)	AHP-EM Weight		AHP Weight	
		Weight	Ranking	Weight	Ranking
1	D33 Digital Technology	2.27%	13	753%	31
2	D14 Operation Risk Management	2.23%	14	1.19%	26
3	D19 Product/Service Production	2.19%	16	1.73%	22
4	D17 Digitalization/Intelligence	2.11%	17	0.89%	30
5	D20 Product Sales/Service Delivery	2.07%	19	1.31%	24

Comparative analysis shows that all Type-A indicators belong to the "stakeholder" level, which reflect the "preference" of experts in performance excellence management, but they are not given enough attention in the actual management process of enterprises; all Type-B indicators belong to "internal process" level, which reflect that enterprises attach great importance to these indicators in the actual management process, but the experts give them a lower weight.

In short, in the process of assigning weights to the PESC indicators, the experts emphasize the importance of the "stakeholder" level indicators and give them more weight than the "internal process" level indicators; while in actual operation, enterprises obviously pay more attention to the "internal process" level indicators, and less attention to some "stakeholders" (e.g., suppliers/partners and employees' rights).

Chapter 5: Relativity Research on SEM-based PESC Indicators

5.1 Construction of PESC corporate management maturity evaluation model

The Structural Equation Modeling (SEM) is a statistical method to analyze the relationship between variables based on their covariance matrices, which is commonly used in validated factor analysis, higher-order factor analysis, path, and causality analysis, multitemporal design, monomorphic modeling, and multi-group comparison. Commonly used analysis software for SEM are LISREL, Amos, EQS, and MPlus. The SEM can be divided into measurement model and structural model, while the former refers to the relationship between indicators and latent variables, and the latter refers to the relationship between latent variables. The SEM analysis is usually divided into two main processes: model preparation and model construction, each of which can be subdivided into several steps.

5.1.1 Model preparation

1) Theoretical Construction. The structural equation model is a validation model that requires the construction of a theory before the model can be constructed. The PESC Indicator Framework" (see Annex T) established in Chapter 3 is the theoretical premise of this model.

2) Model Setting. The relationship among the variables to be studied is represented in the form of a roadmap and the hypotheses to be tested are presented.

3) Model identification. Model identification is a prerequisite for successful estimation of structural equation models. A commonly used judgment is the t-rule, which states that the parameters to be estimated freely should be smaller than the number of observed values used to generate the covariant structure.

4) Questionnaire design. Based on the ISO 9004 maturity evaluation model and the EFQM RADAR evaluation model, this study develops a PESC-based corporate management maturity evaluation model for manufacturing enterprises and uses it as the basis for questionnaire design.

5) Data collection. This study conducts a questionnaire survey for the representatives of advanced manufacturing enterprises above the scale in the Greater Bay Area, 334 valid questionnaires are collected, and 300 copies are selected for the model construction.

5.1.2 Model construction

1) Data preparation. Reliability analysis, validity analysis, and descriptive statistical analysis are performed on the collected data to determine whether the data meet the requirements for model construction; otherwise, the model fitting could not be carried out.

2) Model fitting. Commonly used model fitting methods include maximum likelihood (ML), weighted least squares (WLS), and the Bayesian Analysis. When carrying out the model fitting, model fit metrics need to be considered to determine how well the model explains the data.

3) Model testing. Model testing refers to testing whether the model can explain the data well. Commonly used tests include $\chi 2$ test, RMSEA test and CFI test. If the fitting index does not meet the requirements, the model needs to be modified.

4) Model modification. In the actual research, the model may have some parameters (e.g., chi-square degrees of freedom, RMSEA, CFI values) that do not meet the standards. If the reason is "bad measurement relationship" or "bad structure", the model can be modified and re-tested.

5) Model interpretation. The test structure of the hypotheses (or relationships between variables) constructed in the "model setting" phase needs to be explained for the tested models.

6) Determination of weights. The weight analysis of each level of the PSEC indicator system is conducted based on the path coefficients (or factor loadings) in the structural equation model, so as to determine the weights of the indicators at each level. Since the indicator weights have been determined by the AHP-EM in the previous chapter, this process is not repeated in this chapter.

5.2 Model setting

5.2.1 Setting latent variables and measurable variables

Based on the " Framework of PESC Model " established in Chapter 3 (see Figure 3.1), this thesis constructs a structural equation model using the 12 dimensions of PESC as latent variables and 50 categories of performance indicators (see Annex T for secondary and tertiary indicators) as measured variables (see Figure 5.1).

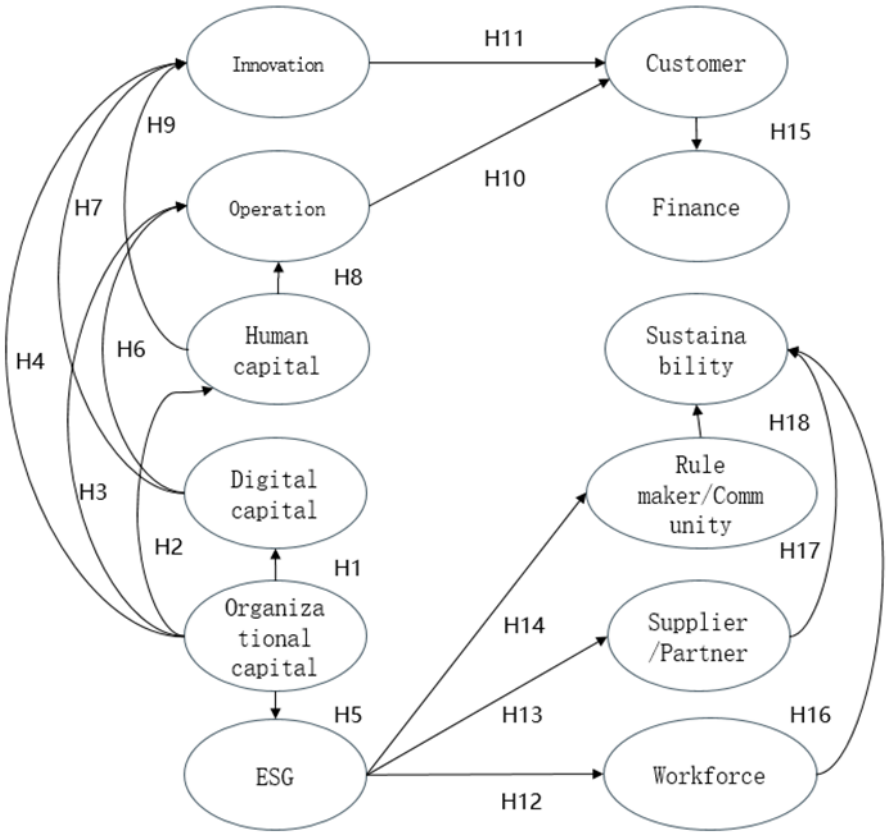

Figure 5.1 PESC Structural Equation Model

5.2.2 Hypothesis on relations among latent variables

H1: There is a direct positive effect between "organizational capital" and "digital capital";

H2: There is a direct positive effect between "organizational capital" and "human capital";

H3: There is a direct positive effect between "organizational capital" and "operations";

H4: There is a direct positive effect between "organizational capital" and "innovation";

H5: There is a direct positive effect between "organizational capital" and "ESG";

H6: There is a direct positive effect between "digital capital" and "operations";

H7: There is a direct positive effect between "digital capital" and "innovation";

H8: There is a direct positive effect between "human capital" and "operations";

H9: There is a direct positive effect between "human capital" and "innovation";

H10: There is a direct positive effect between "operations" and "customers";

H11: There is a direct positive effect between "innovation" and "customers";

H12: There is a direct positive effect between "ESG" and "employees";

H13: There is a direct positive effect between “ESG” and “suppliers/partners”;

H14: There is a direct positive effect between “ESG” and “Rule maker/community”;

H15: There is a direct positive effect between "customers" and "financial results";

H16: There is a direct positive effect between "employees" and "sustainability";

H17: There is a direct positive effect between "suppliers/partners" and "sustainability";

H18: There is a direct positive effect between "rule maker/community" and " sustainability".

5.3 Design of questionnaire

See Section 4.3.3 for "Design of Questionnaire (Used for self-evaluation of enterprise management maturity)".

5.4 Data collection

See Section 4.4.2 for "Sample Selection", "Survey" and "Effectiveness Evaluation of Returned Questionnaires".

5.5. Data Analysis

5.5.1 Descriptive statistics

Descriptive statistical analysis of the data is conducted by SPSS 22 and the following results are obtained (see Table 5.1):

Table 5.1 Descriptive statistics of sample data

Variable	Minimum value	Maximum value	Mean value	Standard deviation	Deviation	Kurtosis
D1	0	5	3.07	1.079	0.339	0.457
D2	0	5	3.18	1.057	0.331	0.468
D3	0	5	3.23	1.199	-.458	0.182
D4	0	5	3.32	1.071	-.699	0.094
D5	0	5	2.91	1.259	0.697	0.209
D6	0	5	3.47	1.039	0.523	-.305
D7	1	5	3.40	1.037	-.328	0.549
D8	0	5	3.38	1.032	0.446	-.323
D9	0	5	3.11	1.067	0.028	0.725
D10	0	5	3.11	1.064	0.399	0.136
D11	0	5	3.22	1.106	0.257	0.373
D12	0	5	3.22	1.07	0.307	0.325
D13	0	5	3.25	1.001	0.531	0.282
D14	0	5	2.94	1.339	0.456	0.597
D15	0	5	2.99	1.284	0.439	0.437
D16	0	5	3.23	1.22	0.737	0.055
D17	0	5	3.25	1.142	0.645	0.079
D18	0	5	3.31	1.067	-.502	0.195
D19	1	5	3.29	**0.960**	-.495	0.195
D20	1	5	3.42	1.036	-.484	-0.34

D21	1	5	3.30	1.052	-.443	0.547
D22	0	5	3.13	1.126	0.336	0.358
E1	0	5	3.04	1.173	0.328	0.564
E2	0	5	3.12	1.272	-.482	0.418
D24	0	5	3.04	1.166	0.391	-.633
D25	0	5	2.90	1.311	-.445	-.519
E3	0	5	3.05	1.161	0.311	-0.47
E4	0	5	2.99	1.221	0.497	-0.37
E5	0	5	3.16	1.315	0.509	**0.695**
E6	0	5	3.20	1.227	-.595	-.351
E7	0	5	3.33	1.278	-.725	0.161
E8	0	5	3.37	1.341	0.641	0.493
E9	0	5	3.29	1.278	-0.67	0.308
E10	0	5	3.29	1.109	0.386	0.318
E11	0	5	3.15	1.257	0.489	0.519
E12	0	5	3.43	1.159	0.711	0.131
E13	0	5	3.18	1.251	-.602	-.155
E14	0	5	3.21	1.247	0.574	0.397
E15	0	5	3.24	1.178	-.384	0.423
E16	0	5	3.44	1.202	-.562	0.331
E17	0	5	3.49	1.212	0.741	0.112
D30	0	5	3.02	1.031	-.482	-.078
D31	0	5	3.12	1.062	0.117	0.491
D32	0	5	3.13	1.092	0.345	0.558
D33	0	5	2.80	1.366	0.323	0.597
D34	0	5	2.77	1.272	0.428	-0.51
D35	0	5	3.02	1.192	-0.45	0.443
D36	0	5	3.06	1.191	0.517	0.391
D37	0	5	3.20	1.063	0.424	0.292
D38	0	5	3.13	1.12	0.482	0.192

The results of descriptive statistical analysis show that the observed values of each item of this questionnaire survey range from 0 to 5, the mean values from 2.77 to 3.49, the standard deviation from 0.96 to 1.366, the absolute value of maximum deviation is 0.741, and the absolute value of maximum kurtosis 0.695. According to Kline (2023) on judging whether the data is normally distributed, when the data's deviation and kurtosis are both 0, it is a standard normal distribution, and when the absolute value of the deviation of the data is <3 and the absolute value of the kurtosis is <10, the data is not normally distributed, but we can generally accept that it meets the construction conditions of the structural equation model. Therefore, the data collected by the questionnaire in this thesis can be used for the construction of the structural equation model.

5.5.2 Validity and reliability analysis

5.5.2.1 Reliability analysis

Cronbach's alpha coefficient is used as a method of assessing the reliability of the questionnaire, which is analyzed with SPSS 22 software, and the overall and dimensional alpha coefficients

of the questionnaire are shown in Table 5.2:

Table 5.2 Questionnaire reliability test (alpha coefficients of all dimensions)

dimension	alpha coefficient
Total Scale	0.971
C1 financial	0.763
C2 sustainability	无
C3 costumer	0.737
C4 employees	0.781
C5 suppliers/partners	0.755
C6 rule maker/community	0.812
C7 Operations	0.867
C8 Innovation	0.915
C9 ESG	0.949
C10 human capital	0.788
C11 digital capital	0.849
C12 organizational capital	0.829

Scholars commonly believe that the acceptable level of Cronbach's alpha coefficient is 0.8 for the total scale and 0.7 for the subscales. As shown in Table 5.2, the alpha coefficients of financial, customers, employees, supplier/partner, and human capital are greater than 0.7, which is in the acceptable range, and the rest of the dimensions are greater than 0.8, which indicates that the reliability is good; and the total scale's alpha coefficient is 0.971, indicating that the questionnaire is highly reliable.

5.5.2.2 Validity analysis

Validity analysis is a comprehensive judgment combining various indicators, including KMO value, Bartlett's spherical test, and factor loading coefficient value. It's generally considered that,

When KMO value $\geqslant$ 0.6, factor analysis can be done;

when KMO value $\geqslant$ 0.7, it's suitable for factor numerator;

when KMO value $\geqslant$ 0.8, it's very suitable for factor analysis;

and when KMO value $\geqslant$ 0.9, it's very suitable for factor analysis.

The Bartlett spherical test is used to observe the distribution of data and whether the variables are independent of each other. It is generally considered that when the P-value of significant probability of chi-square statistic is <0.5, the data is considered to pass the result validity test and can be analyzed by factor analysis.

The statistical significance of the factor loading coefficient value is the correlation coefficient (degree) between variable i and the public factor (dimension) j. The range is [-1,1], and the closer the absolute value is to 1, the more closely is the variable related to the public factor, which is commonly understood that the variable contributes enough information to the

public factor. According to Hair et al. (2009), acceptable loading coefficients are related to the sample size, as is shown in Table 5.3 below:

Table 5.3 Guidelines for identifying significant factor loadings based on sample size

Factor Loading	Sample Size Needed for Significance
.30	350
.35	250
.40	200
.45	150
.50	120
.55	100
.60	85
.65	70
.70	60
.75	50

Source: Hair et al. (2009)

This thesis performs the KMO and Bartlett's test first, and the results show (see Table 5.4) that the KMO value is 0.954 and the Bartlett's test of sphericity significance 0.000, indicating that factor analysis can be done with the data.

Table 5.4 KMO and Bartlett’s Test

KMO Quantity of Sampling Suitability		0.954
Bartlett's test of sphericity	Approximate Chi-square	10348.898
	variance	1225
	significance (p)	0

Second, exploratory factor analysis shows that the scale has good validity. Table 5.5 shows that a total of seven factors have eigenvalues above 1, and the proportion of variance explained by each factor ranges from 2.225% to 41.569%, with a cumulative total explained square contribution of 62.745%, which is significantly greater than 50%, suggesting that it is suitable for next-step factor analysis (M. L. Wu, 2013).

Table 5.5 Total variance explanation rate

Component	Initial Eigenvalues			Extraction Sums Of Squared Loadings			Rotation Sums Of Squared Loadings		
	Total	Variance Percentage	Accumulation	Total	Variance Percentage	Accumulation	Total	Variance Percentage	Accumulation
	20.784	41.569	41.569	20.784	41.569	41.569	8.32	16.64	16.64
	2.871	5.743	47.311	2.871	5.743	47.311	5.285	10.57	27.21
	2.579	5.159	52.47	2.579	5.159	52.47	5.011	10.022	37 232
	1.617	3.235	55.705	1.617	3.235	55.705	4.168	8.336	45.569
	1.252	2.505	58.21	1.252	2.505	58.21	2.953	5.905	51.474
	1.255	2.31	60.52	1.155	2.31	60.52	2.941	5.883	57.357
	1.112	2.225	62.745	1.112	2.225	62.745	2.694	5.388	62.745

.

Then, the maximum variance rotation method is used to restructure and simplify the initial factor loadings, and the rotated factor loading matrix is shown in Table 5.6. The table shows that, except for D6 (0.337) and D7 (0.369), the factor loadings of the other test questions are higher than 0.4. A total of 300 questionnaires are recovered in this study, and according to the requirements listed in Table 5.3, the factor loadings should be higher than 0.35, although D6 and D7 have low values (＜0.4), they can basically meet the requirements, and have strong theoretical support, and they are able to reflect the level of maturity of the "customer" dimension, so they should be retained.

Table 5.6 Rotated component matrix

Question	Component						
	1	2	3	4	5	6	7
D1	0.215	0.275	0.143	0.238	0.094	0.597	0.027
D2	0.081	0.377	0.072	0.165	0.14	0.62	0.123
D3	0.208	0.027	0.188	0.217	0.093	0.613	0.118
D4	0.173	0.257	0.01	0.172	0.302	0.594	0.087
D5	0.083	0.286	0.246	0.098	0.047	0.311	0.434
D6	0.284	0.001	0.218	0.337	0.206	0.341	0.199
D7	0.384	0.058	-0.052	0.369	0.38	0.258	0.296
D8	0.254	0.098	-0.065	0.43	0.269	0.382	0.094
D9	0.11	0.137	0.249	0.127	0.674	0.298	0.146
D10	0.223	0.111	0.042	0.326	0.63	0.131	0.232
D11	0.179	0.285	0.109	0.142	0.651	0.201	0.167
D12	0.17	0.064	0.143	0.279	0.329	0.074	0.597
D13	0.156	0.19	0.077	0.229	0.407	0.072	0.568
D14	0.323	0.147	0.216	0.333	0.161	0.21	0.487
D15	0.233	0.311	0.239	0.297	0.147	0.195	0.419
D16	0.134	0.376	0.261	0.475	0.149	0.196	0.302
D17	0.15	0.211	0.292	0.627	0.097	0.151	0.238
D18	0.228	0.176	0.205	0.629	0.119	0.27	0.021
D19	0.244	0.193	0.093	0.679	0.109	0.215	0.064
D20	0.175	0.202	0.105	0.643	0.199	0.127	0.178
D21	0.302	0.238	0.088	0.562	0.09	0.057	0.382
D22	0.128	0.659	0.238	0.213	0.098	0.077	0.21
E1	0.251	0.697	0.188	0.258	0.165	0.195	0.041
E2	0.209	0.71	0.155	0.173	0.146	0.099	0.117
D24	0.237	0.714	0.206	0.217	0.182	0.049	0.05
D25	0.246	0.64	0.346	0.068	0.03	0.222	0.194
E3	0.214	0.666	0.269	0.211	0.108	0.263	0.068
E4	0.334	0.637	0.265	0.045	0.112	0.228	0.056
E5	0.681	0.129	0.28	0.09	0.095	0.189	0.192
E6	0.695	0.157	0.253	0.104	-0.014	0.289	0.132
E7	0.773	0.101	0.095	0.142	0.098	0.257	0.117
E8	0.745	0.206	0.032	0.154	0.097	0.115	0.241
E9	0.687	0.232	0.215	0.064	0.066	0.126	0.221
E10	0.703	0.101	0.153	0.311	0.182	0.108	-0.066
E11	0.627	0.177	0.369	0.171	0.004	0.138	0.158
E12	0.714	0.115	0.199	0.228	0.148	0.069	0.057
E13	0.665	0.19	0.264	0.134	0.05	0.129	0.294
E14	0.629	0.295	0.279	0.069	0.235	0.064	0.279

E15	0.579	0.318	0.351	0.107	0.151	0.015	0.112
E16	0.709	0.232	0.118	0.235	0.192	0.052	-0.149
E17	0.699	0.18	0.212	0.205	0.189	0.023	-0.047
D30	0.359	0.124	0.481	0.106	0.342	0.034	0.292
D31	0.371	0.222	0.499	0.148	0.408	-0.041	0.151
D32	0.35	0.264	0.443	0.144	0.402	0.166	-0.041
D33	0.221	0.305	0.671	-0.031	-0.038	0.076	0.287
D34	0.279	0.379	0.578	0.037	-0.014	0.064	0.263
D35	0.3	0.248	0.661	0.091	0.056	0.19	0.072
D36	0.262	0.199	0.698	0.2	0.093	0.128	0.144
D37	0.23	0.253	0.606	0.359	0.145	0.088	-0.061
D38	0.243	0.198	0.713	0.196	0.161	0.072	-0.015

5.6 Model fitting

5.6.1 Introduction of fit index

The fit index is usually used to evaluate the fit of a particular structural equation model. The fit index is short for Goodness of fit statistic, which can be categorized into three types: absolute index, comparative index, and parsimony index.

Commonly used absolute fit indices include the chi-square variance ratio (χ^2/df), root mean square error of approximation (RMSEA), standardized root mean square residual (SRMR), goodness-of-fit index (GFI) and adjusted goodness-of-fit index (AGFI). The latter two indices are seldom used nowadays because the sample size (N) is too influential and various degrees of error can occur in different situations. χ^2/df is better when the value is close to 0, and is usually required to be <3; RMSEA is the most commonly used fit index, and is similar to the test of significance, which is considered to be a perfect fit if it is 0, a good fit if it is <0.05, quite a good fit if it is between 0.05 and 0.08, and 0.08 to 0.10 a fair fit. SRMR measures the mean of the residuals between the observed and predictor variables in the model. The smaller the value of SRMR, the better the fit of the model. Typically, the value of SRMR should be less than 0.08, otherwise the fit of the model needs to be reconsidered.

The fit indices commonly used are the comparative fit index (CFI) and the non-normalized fit index (NNFI). It is generally accepted that the model fit is better when CFI $\geqslant$ 0.9. NNFI, also known as TLI, is similar to CFI, and the model fit is acceptable when TLI $\geqslant$ 0.9.

Parsimony fit index is a type of indices derived from absolute and relative fit indices, which is used to penalize the model with many parameters, and the commonly used ones are Parsimony Gauge Fit Index (PGFI) and Parsimony Normalized Factor Index (PNFI), and when the values of PGFI and PNFI are >0.50, there is a good fit.

In this thesis, the following indices are used to assess the degree of model fit: χ^2/df, RMSEA,

SRMR, CFI, TLI, PGFI, and PNFI, and the acceptance criteria for each index are stipulated as follows according to the guidelines of M. L. Wu (2013) in the book Structural Equation Modeling - An Advancement in Amos Practice:

1) $x^2/df<3$;

2)RMSEA＜0.08;

3)SRMR＜0.08;

4)CFI＞0.9 and above;

5)TLI＞0.9 and above;

6)PGFI＞0.5 and above;

7)PNFI＞0.5 and above.

5.6.2 First fitting

Using the Amos24 software, the first fit based on the hypothetical model is performed to obtain model M1 (Figure 5.2), and the M1 fit indices are shown in Table 5.7.

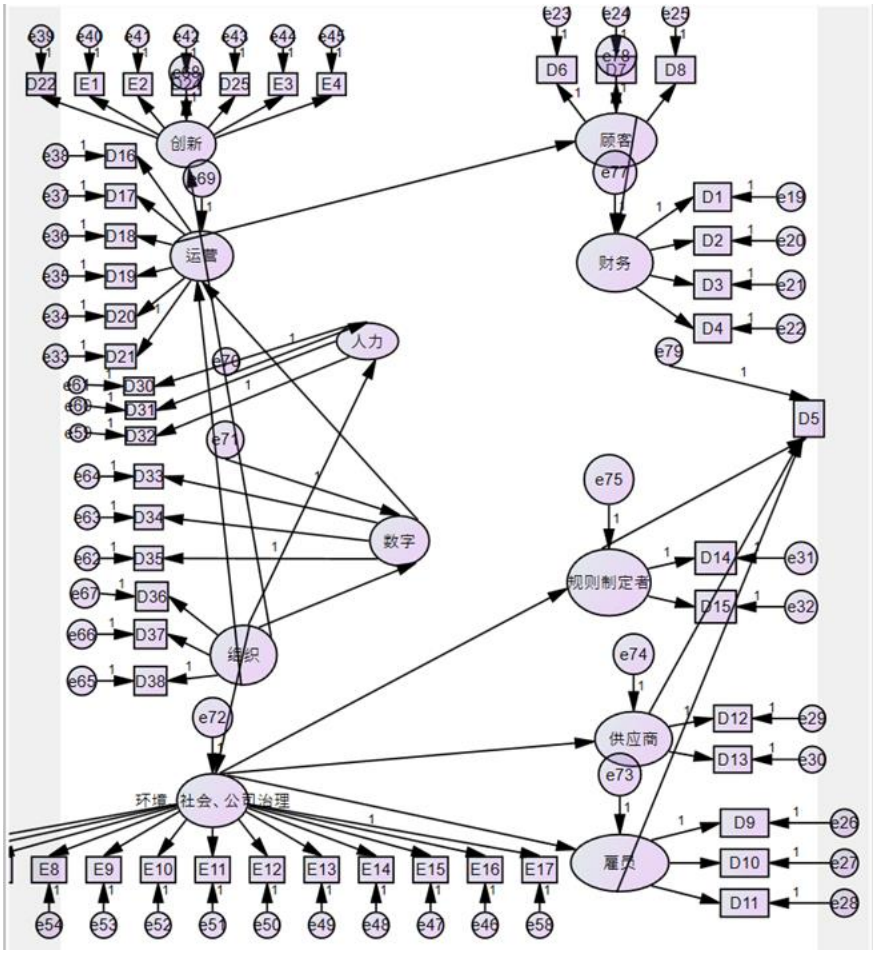

Figure 5.2 Fit model M1

Table 5.7 M1 fit indices

Fit Index	Acceptable Range	Actual Value	Fit
χ^2/df	＜3	2.254	pass
CFI	＞0.9	0.882	fail
NNFI（TLI）	＞0.9	0.872	fail
PGFI	＞0.5	0.693	pass
PNFI	＞0.5	0.744	pass
SRMR	＜0.08	0.0796	pass
RMSEA	＜0.08	0.065	pass

Table 5.7 above shows that both the Comparative Fit Index (CFI) and the Non-Normative Fit Index (NNFI) are less than 0.9, which does not meet the acceptance criterion, and the model fit fails.

In the structural equation model, the critical ratio (CR) of the difference values of the path coefficients is a commonly used statistical method to determine whether two path coefficients are significantly different. When the CR value is >2, there is a significant difference between the path coefficient and the null hypothesis; and when the CR value is ⩽2, there is no significant difference between the path coefficient and the null hypothesis. The M1 path coefficients are shown in Table 5.8:

Table 5.8 M1 path coefficients

Path	Estimate	S.E.	C.R.	P
Digital capital <---organizational capital	0.93	0.092	10.125	***
Human capital <--- organizational capital	0.955	0.084	11.331	***
Operations <--- organizational capital	1.856	0.48	3.863	***
Innovation <--- organizational capital	1.505	0.394	3.82	***
Operations <--- Digital capital	-0.34	0.101	-3.372	***
Innovation <--- Human capital	-0.743	0.4	-1.859	0.063
Operations <--- Human capital	-0.83	0.465	-1.784	0.074
Innovation <--- Digital capital	0.059	0.09	0.65	0.516
Customers <--- Operations	0.693	0.095	7.27	***
ESG<--- organizational capital	0.967	0.077	12.506	***
Customers <--- Innovation	0.103	0.063	1.62	0.105
Financial <--- Customers	0.982	0.115	8.522	***
Rule maker/community <---ESG	0.979	0.082	11.902	***
supplier/partner<---ESG	0.61	0.069	8.837	***
Employees <---ESG	0.642	0.064	10.03	***
Sustainability <---Rule maker/community	0.28	0.096	2.929	0.003
Sustainability <--- supplier/partner	0.163	0.131	1.243	0.214
Sustainability <--- Employees	0.344	0.133	2.587	0.01

Notes: *** stands for P ≤ 0.001; ** stands for P ≤ 0.01; and * stands for P ≤ 0.1 (same below).

Table 5.8 shows that the CRs for Innovation <-- Human Capital, Operations <-- Human Capital, Innovation <-- Digital Capital, Customers <-- Innovation, and Sustainability <-- Supplier/Partner are less than 2, indicating that there is no significant difference between the coefficients of these paths and the null hypothesis; in other words, there is no direct effect between these two-by-two variables.

5.6.3 Second fitting

Based on M1, M2 is obtained by fixing the path coefficients of "innovation<--digital capital" and "sustainability<--supplier/partner" to 0. The model fit indices of M2 are shown in Table 5.9.

Table 5.9 M2 fit indices

Fit Index	Acceptable Range	Actual Value	Fit
χ^2/df	＜3	2.250	pass
CFI	＞0.9	0.882	fail
NNFI (TLI)	＞0.9	0.872	fail
PGFI	＞0.5	0.696	pass
PNFI	＞0.5	0.747	pass
SRMR	＜0.08	0.080	pass
RMSEA	＜0.08	0.065	pass

Table 5.9 above shows that the CFI and the NNFI are still less than 0.9, which does not meet the acceptance criterion and the model fit fails.

The M2 path coefficients are shown in Table 5.10:

Table 5.10 M2 path coefficients

Path	Estimate	S.E.	C.R.	P
Digital capital <---organizational capital	0.938	0.091	10.275	***
Human capital <--- organizational capital	0.952	0.084	11.318	***
Operations <--- organizational capital	1.787	0.422	4.24	***
Innovation <--- organizational capital	1.519	0.372	4.083	***
Operations <--- Digital capital	-0.361	0.098	-3.694	***
Innovation <--- Human capital	-0.7	0.368	-1.9	0.057
Operations <--- Human capital	-0.738	0.389	-1.896	0.058
Innovation <--- Digital capital	0			
Customers <--- Operations	0.692	0.095	7.254	***
ESG<--- organizational capital	0.965	0.077	12.513	***
Customers <--- Innovation	0.104	0.064	1.632	0.103
Financial <--- Customers	0.982	0.115	8.522	***
Rule maker/community <---ESG	0.979	0.082	11.932	***
supplier/partner<---ESG	0.603	0.07	8.673	***
Employees <---ESG	0.642	0.064	10.041	***
Sustainability <---Rule maker/community	0.33	0.088	3.759	***
Sustainability <--- supplier/partner	0			
Sustainability <--- Employees	0.408	0.124	3.283	***

Table 5.10 shows that the CRs for Innovation<--Human Capital, Operations<--Human Capital, and Innovation<--Digital Capital are less than 2, indicating that these path coefficients are not significantly different from the null hypothesis; in other words, there is no direct effect between these two-by-two variables.

5.6.4 Third fitting

Based on M2, M3 is obtained by fixing the path coefficients of "innovation<--human capital", "operations<--human capital", and "innovation<--digital capital" to zero. The model fit indices

of M3 are shown in Table 5.11.

Table 5.11 M3 fit indices

Fit Index	Acceptable Range	Actual Value	Fit
χ^2/df	＜3	2.262	pass
CFI	＞0.9	0.880	fail
NNFI（TLI）	＞0.9	0.871	fail
PGFI	＞0.5	0.699	pass
PNFI	＞0.5	0.748	pass
SRMR	＜0.08	0.085	fail
RMSEA	＜0.08	0.065	pass

Table 5.11 above shows that the CFI and NNFI are still less than 0.9 and SEMR > 0.08, which fails to meet the acceptance criterion and the model fit fails.

The M3 path coefficients are shown in Table 5.12, and all path coefficients meet the criterion.

Table 5.12 M3 path coefficients

Path	Estimate	S.E.	C.R.	P
Digital capital <---organizational capital	0.939	0.09	10.373	***
Human capital <--- organizational capital	0.917	0.082	11.156	***
Operations <--- organizational capital	1.075	0.141	7.626	***
Innovation <--- organizational capital	0.845	0.079	10.646	***
Operations <--- Digital capital	-0.358	0.098	-3.644	***
Innovation <--- Human capital	0			
Operations <--- Human capital	0			
Innovation <--- Digital capital	0			
Customers <--- Operations	0.785	0.085	9.218	***
ESG<--- organizational capital	0.951	0.076	12.517	***
Customers <--- Innovation	0			
Financial <--- Customers	0.959	0.113	8.485	***
Rule maker/community <---ESG	0.975	0.082	11.922	***
supplier/partner<---ESG	0.598	0.069	8.618	***
Employees <---ESG	0.636	0.064	9.992	***
Sustainability <---Rule maker/community	0.331	0.088	3.775	***
Sustainability <--- supplier/partner	0			
Sustainability <--- Employees	0.408	0.124	3.298	***

5.6.5 MI model modification

MI modification index is a "repair" of the original model, which will not change the core hypothesis or structure of the model, so it is more widely used in practical research. This method allows the analysis software to output the proposed value of the MI modification index, and then combines with the index for model optimization, and the specific optimization method is divided into the establishment of covariance and the proposed relationship between the two kinds of influence. This study adopts the establishment of covariance relationship for model optimization.

5.6.5.1 MI indicators output by Amos

This study outputs MI indicator values according to the criterion "MI > 10" (see Table 5.13).

Table 5.13 Covariance relation -MI indicators

Residual	Relation	Residual	MI Value	Par Change
e73	<-->	e74	33.461	0.202
e78	<-->	e72	28.833	0.084
e74	<-->	e69	28.553	0.132
e74	<-->	e75	27.79	0.234
e73	<-->	e69	24.977	0.113
e75	<-->	e69	22.678	0.137
e24	<-->	e72	22.229	0.116
e77	<-->	e68	19.97	0.094
e65	<-->	e67	18.716	0.166
e27	<-->	e69	18.392	0.108
e73	<-->	e72	17.392	-0.096
e80	<-->	e81	17.199	0.068
e65	<-->	e66	16.211	0.144
e33	<-->	e44	16.083	-0.116
e20	<-->	e32	15.952	0.17
e75	<-->	e72	15.752	-0.116
e24	<-->	e27	15.541	0.15
e23	<-->	e43	14.578	0.155
e30	<-->	e73	14.496	0.125
e62	<-->	e71	14.351	-0.112
e73	<-->	e78	14.268	0.082
e80	<-->	e74	14.267	-0.107
e80	<-->	e75	13.857	-0.122
e20	<-->	e68	13.698	0.098
e72	<-->	e69	13.45	0.059
e65	<-->	e69	13.35	-0.09
e35	<-->	e43	13.287	-0.124
e81	<-->	e73	12.608	-0.074
e73	<-->	e71	12.031	-0.093
e73	<-->	e75	11.839	0.14
e72	<-->	e70	11.337	0.056
e63	<-->	e64	11.166	0.124
e31	<-->	e74	11.131	0.142
e73	<-->	e70	10.999	0.078
e63	<-->	e65	10.876	-0.123
e20	<-->	e38	10.861	0.138
e34	<-->	e35	10.479	0.102
e43	<-->	e67	10.311	0.126
e31	<-->	e69	10.003	0.087

5.6.5.2 Setting covariance relations

The modification of the covariance relationship is a step-by-step optimization process, which usually starts with the establishment of the relationship between the two items with very large MI values, and then the fitting indices are viewed and compared until the MI values are all smaller or the fitting indices are basically up to standard.

According to the MI value between variables, as well as its significance in theory and practice, this thesis sequentially establishes the residuals of employees and suppliers/partners (e73-e74), customers and ESG (e78-e72), rule maker/community and operations (e75- e69), employees and ESG (e73- e72), and financial and innovation (e77 -e68) as a bi-directional connection, resulting in model M4 (see Figure 5.3).

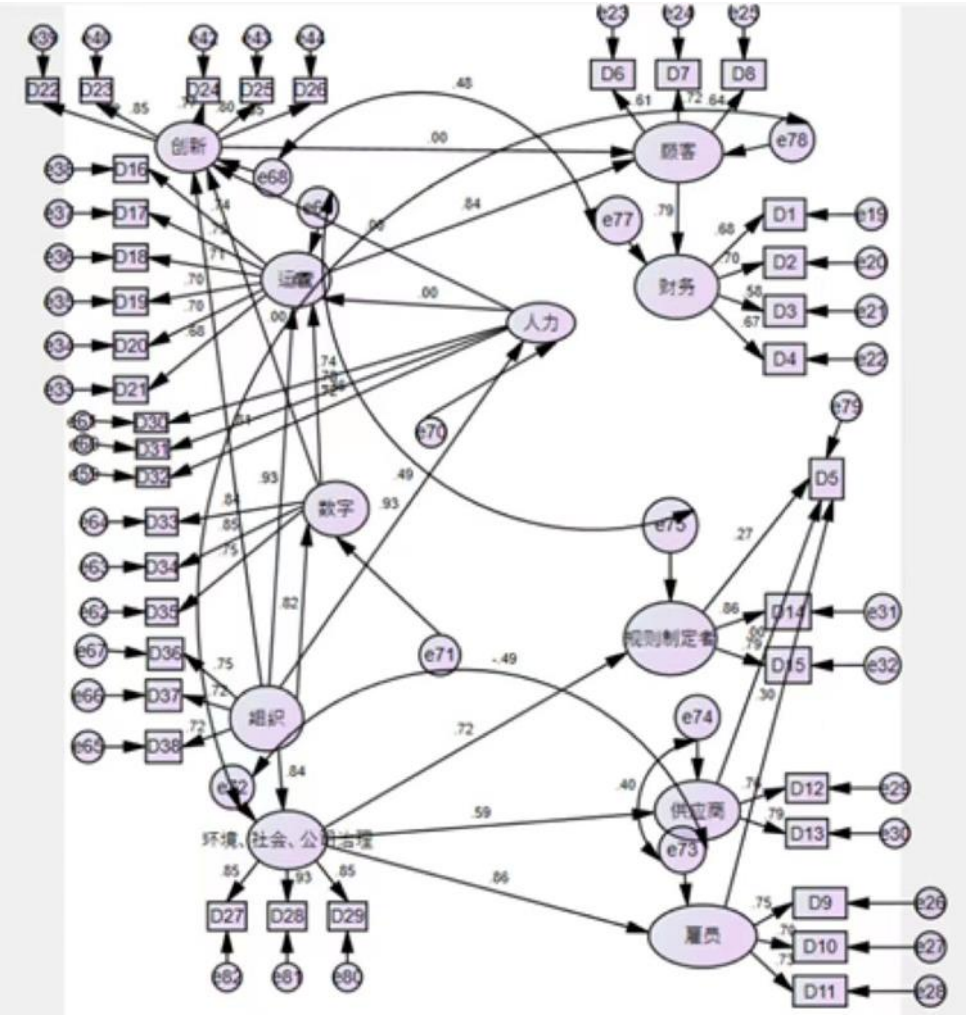

Figure 5.3 MI model modification

5.6.5.3 Modified MI model outcome

The fit indices modified using the MI model are shown in Table 5.14:

Table 5.14 M4 fit indices

Fit Index	Acceptable Range	Actual Value	Fit
χ^2/df	＜3	2.047	pass
CFI	＞0.9	0.902	pass
NNFI（TLI）	＞0.9	0.893	basically pass
PGFI	＞0.5	0.712	pass
PNFI	＞0.5	0.761	pass
SRMR	＜0.08	0.072	pass
RMSEA	＜0.08	0.059	pass

Table 5.14 above shows that, after the MI model modification, both CFI and SRMR, which previously failed, are significantly improved and meet the acceptance criterion. The NNFI (TLI) also improves to 0.893, which reaches the acceptance threshold. The NNFI (TLI), like the CFI, is a relative fit index, but it penalizes the model's complexity, and the more complex the model is, the lower the TLI is. Z. L. Wen et al. (2004) states that the main criticism of the TLI is that it has a large sample volatility, especially when the dummy model fits the sample data well. Many researchers have found this problem of high sample volatility of TLI in data simulation and believe that caution is needed when using it. Therefore, this thesis determines that the NNFI (TLI) basically passes. All indicators meet the acceptance criteria and the model fit passes.

The standardized path coefficient is usually applied to measure whether the measurable variables can better reflect the content and characteristics of the latent variables. M. L. Wu (2001) believes that, when the standardized path coefficient (β) between the latent variables is $\leqslant$0.2, the influence between the latent variables is small, and it can be disregarded; when β >0.2, it needs to be taken into consideration; when β> 0.4, it should be taken into consideration; and when β> 0.6, it must be given consideration. .

The M4 path coefficients are shown in Table 5.15. Standardized Regression Weights, Critical Ratio of Difference Values (CR), and Significance Test Results (P) all meet the requirements.

Table 5.15 M4 Path coefficients

Path	Estimate	S.E.	C.R.	P
Digital capital <---organizational capital	0.823	0.913	0.089	10.301
Human capital <--- organizational capital	0.930	0.915	0.082	11.184
Operations <--- organizational capital	0.928	0.97	0.121	8.033
Innovation <--- organizational capital	0.814	0.809	0.77	10.504
Operations <--- Digital capital	-0.358	-0.286	0.81	-3.509
Innovation <--- Human capital	0.000	0		
Operations <--- Human capital	0.000	0		
Innovation <--- Digital capital	0.000	0		
Customers <--- Operations	0.842	0.744	0.083	8.996
ESG<--- organizational capital	0.843	0.919	0.075	12.279
Customers <--- Innovation	0.000	0		
Financial <--- Customers	0.786	0.905	0.107	8.486
Rule maker/community <---ESG	0.717	0.931	0.079	11.805
supplier/partner<---ESG	0.594	0.553	0.068	8.193
Employees <---ESG	0.855	0.767	0.074	10.362
Sustainability <---Rule maker/community	0.271	0.296	0.087	3.395
Sustainability <--- supplier/partner	0.000	0		
Sustainability <--- Employees	0.303	0.48	0.127	3.777

5.6.5.4 Explanation of MI model modification

In order to solve the problem of substandard fitting of some indices, this study successively establishes a two-way connection between five sets of residuals and finally fits them successfully. The five MI modifications are explained one by one from the theoretical and practical aspects as follows:

1) Employees and supplier/partner (e73-e74)

The measured variables for "employees" include "workforce satisfaction", " workforce engagement" and " workforce contribution"; and the measured variables for "supplier/partner" are "supplier/partner satisfaction" and "supplier/partner contribution". Research has proven that in an organization, a high level of workforce satisfaction leads to a high level of customer satisfaction, and similarly, high workforce satisfaction increases supplier/partner satisfaction. In addition, an organization with high workforce contribution (e.g., level of rationalization, workforce productivity) also increases supplier/partner contribution (e.g., suppliers' improvement of quality, cost, lead time, innovation.). The standardized path coefficient of the residuals for this category is 0.40.

2) ESG and Customers (e72-e78)

Besides investors, governments, communities, media, and NGOs, more and more customers pay attention to the ESG performance of their suppliers and use it as an evaluation criterion for supplier access. Therefore, good ESG performance will result in high " workforce satisfaction" and high " workforce contribution" (e.g., long-term strategic partnership opportunities with customers). The standardized path coefficient of the residuals for this category is 0.65.

3) Operations and Rule maker/Community (e69-e75)

"Operational risk management" is an important measured variable of the latent variable "operations", with specific indicators such as "emergency response capability" and "business continuity", (e.g., response time, occurrence prevention, meeting standards, unforeseen event training results, supply chain security, public health, and natural disaster/emergency response), a few of which only have an impact within the organization, but the majority of which have an impact on the community of interest, which can lead to community complaints/reporting. The standardized path coefficient of the residuals for this category is 0.49.

4) ESG and Employees (e72-e73)

The hypothesis that there is a direct positive impact between ESG and employees has been verified, but there is still a standardized path coefficient of -0.49, indicating that there is a

mutual impact between these two. The “employee employment” indicator in the ESG dimension includes occupational health and safety incident rates, social security expenditures, human rights issues/labor standards, and the performance of these indicators directly affects the "workforce satisfaction" and " workforce engagement" indicators in the "employees" dimension (e.g., employee satisfaction, turnover of key employees, employee absenteeism, and average time of service).

5) Innovation and Financial (e68-e77)

The latent variable "innovation" includes measured variables of "innovation inputs" and "innovation outputs," with "innovation inputs" indicators (e.g. investment in innovation, R&D expenditure as a share of main business income,.) belonging to the "expense" category, while the indicators of "innovation output" (e.g. share of sales occupied by product innovation, profitability of product innovation, change in sales due to business process innovation, change in sales due to business process innovation, change in sales due to business process innovation) belonging to the "revenue" or "profit" indicators, which directly affect the "financial" of the enterprise. The standardized path coefficient for this category of residuals is 0.48.

5.7 Explanation of models

5.7.1 Analysis of measurement model (confirmatory factor model)

5.7.1.1 Verification outcome of measurement model

The standardized coefficients of the measured variables and their significance results after MI modification are shown in Table 5.16.

Table 5.16 Standardized path coefficients and significance test results of measured variables - latent variables

Latent variable	Measured variable	Path coefficient	P value
C1	D1	0.682	***
	D2	0.703	***
	D3	0.58	***
	D4	0.666	***
C2	D5	1	***
C3	D6	0.613	***
	D7	0.72	***
	D8	0.644	***
C4	D9	0.746	***
	D10	0.698	***
	D11	0.731	***
C5	D12	0.763	***
	D13	0.795	***

C6	D14	0.856	***
	D15	0.789	***
C7	D16	0.737	***
	D17	0.755	***
	D18	0.709	***
	D19	0.697	***
	D20	0.696	***
	D21	0.681	***
C8	D22	0.716	***
	D23	0.853	***
	D24	0.772	***
	D25	0.805	***
	D26	0.855	***
C9	D27	0.851	***
	D28	0.927	***
	D29	0.852	***
C10	D30	0.737	***
	D31	0.779	***
	D32	0.723	***
C11	D33	0.841	***
	D34	0.852	***
	D35	0.746	***
C12	D36	0.75	***
	D37	0.72	***
	D38	0.716	***

5.7.1.2 Analysis of verification outcome

According to M. L. Wu (2001), when the standardized path coefficient (β) of the measured variable to the latent variable is $\leqslant$ 0.6, the measured variable does not reflect the latent variable to an adequate degree and should be deleted. Table 5.16 above shows that the standardized coefficients and significance levels of the other 37 measurement variables and latent variables meet the requirements, except for solvency (D3), which has a slightly lower β value (0.560). Considering that solvency is an important indicator of "financial" performance in both theory and practice, this indicator is retained in this thesis.

5.7.2 Analysis of structure mode (latent variable model)

5.7.2.1 Verification outcome of structure model hypothesis

Corporate management is a complex system. For the 12 dimensions on the four levels of the PESC, a total of 18 hypotheses are proposed in this study, and it is verified that 12 hypotheses are accepted and 6 rejected, specific information is as follows:

H1: direct positive impact between “Organizational Capital" and “Digital Capital” ——not rejected;

H2: direct positive impact between “Organizational Capital” and “Human Capital” ——

not rejected;

H3: direct positive impact between “Organizational Capital” and “Operations” ——not rejected;

H4: direct positive impact between “Organizational Capital” and “Innovation” ——not rejected;

H5: direct positive impact between “Organizational Capital” and “ESG” ——not rejected;

H6: direct positive impact between “Digital Capital” and “Operations” ——rejected as negative impact;

H7: direct positive impact between “Digital Capital” and “Innovation” ——rejected as insignificant;

H8: direct positive impact between “Human Capital” and “Operations” ——rejected as insignificant;

H9: direct positive impact between “Human Capital” and “Innovation” ——rejected as insignificant;

H10: direct positive impact between “Operations” and “Customers” ——not rejected;

H11: direct positive impact between Innovation and “Customers” ——rejected as insignificant;

H12: direct positive impact between “ESG” and “Employees” ——not rejected;

H13: direct positive impact between “ESG” and “Suppliers/Partners” ——not rejected;

H14: direct positive impact between “ESG” and “Rule maker/Community” ——not rejected;

H15: direct positive impact between “Customers” and “Financial Results” ——not rejected;

H16: direct positive impact between “Employees” and “Sustainability” ——not rejected;

H17: direct positive impact between “Suppliers/Partners” and “Sustainability”——rejected as insignificant;

H18: direct positive impact between “Rule maker/Community” and “Sustainability” ——not rejected.

5.7.2.2 Analysis of verification structure

This study is based on the PESC, a modified BSC, and proposes 18 hypotheses for the relationship between the 12 dimensions of the PESC (containing a total of 50 categories of indicators), which are empirically studied with data from 300 valid questionnaires obtained from a large-scale survey, using the Structural Equation Analysis method. The results of the study affirm 12 hypotheses and rejects 6, and the conclusions include both consistency and

difference with the theory and practice, as follows:

1) "Organizational capital", like "human capital", "digital capital", "operations", "innovation" and "business". "Innovation" and “ESG”, has direct positive impact, and "Organizational Capital" is the only "exogenous variable" among the 12 latent variables, with the rest being "endogenous variables", which is highly consistent with theory and practice. “Organizational capital”, which includes culture, leadership and strategic synergy, is similar to the "engine" of an enterprise, which drives these 5 dimensions and produces superior financial performance and sustainable results.

2) The hypothesis that there is a direct positive impact between "digital capital" and "operations" is rejected, and the test shows that there is a degree of negative impact. After analyzing the measured variables of these two latent variables, the following conclusions are drawn: first, there is a causal relationship between the two variables: on the one hand, enterprises can achieve "cost reduction and efficiency" in operations through digital technology, and on the other hand, enterprises can increase digital business revenues by improving their operation modes; on the other hand, there are many variables in the measurement of "operations" that cover a wide range of topics, many of which are not clearly correlated with "digital capital" (e.g. "brand management", "customer/market development" and "customer relationship management").

3) The hypothesis that there is a direct positive impact between "digital capital" and "innovation" is rejected. The analysis concludes that "digital capital" (including the three measured variables of "digital technology," "digitization/intelligence," and "knowledge management") itself has a positive impact on "innovation output" (including product innovation and business process innovation), but the corporate "innovation inputs", "innovation capabilities" and "innovation synergy" can drive enterprises to increase their investment in "digital capital" and improve their digital/intelligent performance.

4) The hypothesis of a direct positive impact between "human capital" and "operations" is rejected. It is analyzed that: "employee competence and capacity" (e.g., "human capital readiness") is the prerequisite and guarantee of effective "operations" of the enterprise, which obviously has a direct positive impact; however, "employee climate and rights" and "employee learning and growth", while enhancing employee satisfaction, may be "health factors" rather than "motivators", and may not have a direct impact on "operational" performance.

5) The hypothesis that there is a direct positive impact between Operations and Customers is not rejected. Of the six categories of performance indicators in the "Operations" dimension, five are directly related to customers, except for "Operational Trend Management". Therefore,

improving the "Operations" indicators can significantly better "customer satisfaction" indicators. The results of many previous studies have shown that improvements in internal business processes are directly related to increased customer satisfaction, and this study reaffirms this conclusion.

6) The hypothesis that there is a direct positive impact between "Human Capital" and "Innovation" is rejected. Analysis shows that, except for the direct impact of "Employee Capability and Capacity" on "innovation capability", "innovation activity", and "innovation output", there's no obvious relatedness between other "Innovation" indicators, including "innovation input", "innovation synergy", and "innovation output", and "Human Capital" indicators, including "employee rights and climate" and "employee learning and growth".

7) The hypothesis that there is a direct positive impact between "innovation" and "customers" is rejected. Examining the five measured variables of "innovation", except for "innovation output" (mainly "product innovation"), which has a direct impact on "customer" performance, none of the other variables are directly related to "customer". Therefore, the direct positive impact of "innovation" on "customers" is insignificant.

8) The hypothesis that there is a direct positive influence between ESG and employees, suppliers/partners and rule maker /community is not rejected. ESG is the projection of the stakeholder theory on enterprises, while "Employees" "Suppliers/Partners" and "Rule maker/Community" are the most important stakeholders of the enterprise besides "Shareholders" and "Customers", and the theory has been validated during the questionnaire survey.

9) The hypothesis that there is a direct positive impact between "customers" and "financial results" is not rejected. It is the basic business logic that customers purchase products or services from an enterprise to bring revenue and profit to the enterprise; it is the viewpoint of the BSC that "financial" performance is generated because of "customer satisfaction"; and because "customer contribution" generates "financial" performance, which is the view of the PP, the hypothesis maintains consistency between the theoretical and the practical aspects.

10) The hypothesis that there is a direct positive impact between "employees" and "sustainability" is not rejected. In this thesis, "ESG rating results" is a measured indicator of " sustainability", and ESG includes "employee employment" indicators (e.g., occupational health and safety incident rates, social security expenditures and human rights issues/labor standards), which are related to "employees" dimension (e.g., employee satisfaction).

11) The hypothesis that there is a direct positive impact between "suppliers/partners" and " sustainability" is rejected. The measured indicator used for the "Sustainability" latent variable,

"ESG Evaluation Results," consists mainly of "Environmental," "Social," and "Corporate Social Responsibility". The rejection of this hypothesis is justified because the indicators for "suppliers/partners" are not included.

12) The hypothesis that there is a direct positive impact between "Rule maker/community" and " Sustainability" is not rejected. Indicators related to "Rule maker/community" such as community investment, number of penalties, number of complaints/reports by the community, number of awards and honors, employment contribution rate, and income from government subsidies, which have a direct impact on the performance of indicators of the "social" category of ESG, have a direct positive impact.

5.7.2.3 Future research plan

The PESC is a system used to measure the performance of all processes and results of corporate management, including 4 levels, 12 dimensions and 50 categories of indicators, and theoretically, there is a two-by-two correlation between the 12 dimensions, but it is too complicated to construct the model in this way and too many assumptions are proposed. In order to reduce the complexity of model construction, this study proposes a total of 18 path hypotheses based on theoretical research and practical experience.

After model validation, 6 hypotheses are finally rejected, among which 5 paths are proved to have "no direct positive impact" and 1 proved to have "negative impact".

In addition, in the MI modification stage, five sets of residuals are connected in both directions and finally fit, which implies that the latent variables corresponding to these residuals have a path relationship with each other, which may have a positive or negative impact, and may have a significant or non-significant impact.

Therefore, in future research, we can reconstruct the structural equation model, based on the original 18 hypotheses, delete the six hypotheses that have been proved to be untenable (H6, H7, H8, H9, H11 and H17, respectively), and add six hypotheses to be verified as follows and verify them:

1) There is a direct positive impact between operations and digital capital;

2) There is a direct positive impact between employees and suppliers/partners;

3) There is a direct positive impact between ESG and customers;

4) Operations have a direct positive impact with Rule maker/community;

5) Employees have a direct positive impact with ESG;

6) Innovation has a direct positive impact with financial.

Chapter 6: Analysis of PESC Corporate Management Maturity Evaluation of Advanced Manufacturing Enterprises in Greater Bay Area

6.1 Introduction of sample enterprise distribution

300 valid questionnaires are recovered this time. For the convenience of the study, we categorize the sample enterprises into five dimensions: business history, business scale, nature, listed or not, and won the government quality award or not.

1) The longest business history of the sample enterprises is 42 years (rounded, the same below), the shortest 1 year, and the average 16 years. Taking 6 years as a development stage, the sample enterprises are categorized into five intervals according to their "business history":

- Interval A: 0–6-year business history;
- Interval B: 7-12-year business history;
- Interval C: 13-18-year business history;
- Interval D: 19-24-year business history;
- Interval E: 24-year business history and more.

2) In accordance with the Measures for Classifying Large, Small, Medium and Micro Enterprises in Statistics (NBS, 2017), and with reference to industry practices, the sample enterprises are categorized into three types according to "enterprise size":

- Medium-sized enterprises: annual business revenue of 20 million ≤ Y < 400 million RMB;
- Large-sized enterprises: annual business revenue of 400 million ≤Y<5 billion RMB;
- Extra-large enterprises: annual business revenue > 5 billion RMB.

3) The sample enterprises are categorized into four types according to their nature: private enterprises, foreign-funded enterprises, joint ventures, and SOEs.

4) The sample enterprises are categorized into "listed companies" and "non-listed companies" according to whether they are listed (at home or abroad).

5) The sample enterprises are categorized into "award-winning enterprises" and "non-award-winning enterprises" according to whether they have introduced the PEM and won

government quality awards (including national, provincial, municipal, and district/county government quality awards).

The distribution of different types of sample enterprises is shown in Annex AB.

6.2 Outcome of sample enterprise management maturity ratings

6.2.1 Overall rating outcome

The “PESC Corporate Management Maturity" evaluation model is used to score each of the 300 sample enterprises and the average score is 57.77%. Based on five dimensions, namely, "business history", "business scale", "business nature", "listed or not", and "award-winning or not", the average scores of each type of enterprise are calculated, and the following conclusions are drawn:

1) The corporate maturity is positively correlated with the business history, and the longer the business history, the higher the maturity level. There is a large increase from Interval A to Interval B, and another large increase from Interval D to Interval E (see Figure AC.1 in Annex AC);

2) The corporate maturity is positively correlated with the business scale, with a large increase in maturity as business scale grows from medium to large, and another large increase as business scale grows from large to extra-large (see Figure AC.2 in Annex AC);

3) Among enterprises of different natures, the SOEs have the highest maturity, followed by joint ventures, foreign-funded enterprises, and private enterprises the lowest. The gap between private enterprises and foreign-funded and state-owned enterprises is obvious (see Figure AC.3 in Annex AC);

4) Listed enterprises have a high level of maturity, while unlisted ones low, and the difference between the two is obvious (see Figure AC.4 in Annex AC);

5) Enterprises that have won government quality awards have higher maturity levels, while non-awarded enterprises have lower maturity levels, and the difference between the two is obvious (see Figure AC.5 in Annex AC).

6.2.2 Influence of various factors on Top20 indicator maturity

In order to further understand the impact of different factors on the maturity of a single indicator in the PESC system, the scores of the Top 20 indicators are analyzed on a comparative basis. In the same dimension, the range (R) is calculated to understand the gap between the "best

performance" and "worst performance" of the sample enterprises, and the variance rate is calculated to assess the size of the difference between the two, where: (R) = Xmax-Xmin; and difference ratio (X) = R/5*100%. The results are as follows:

1) Room for improvement in Top 20 indicators for enterprises in Interval A (vs. enterprises in Interval E)

Figure AD.1 (see Annex AD) shows that the business history has a significant impact on the maturity of all Top 20 indicators, with the indicator with the greatest room for improvement being "ESG rating" (D5), by 16.10%, and the indicator with the least room for improvement being "digitalization/intelligence" (D34), by 6.12%.

2) Room for improvement for medium-sized enterprises on Top 20 indicators (vs. extra-large enterprises)

Figure AD.2 (see Annex AD) shows that the growth of enterprise size has a significant impact on the maturity of all Top 20 indicators. The indicator with the greatest room for improvement is "Rule maker/Community Contribution" (D15), by 22.8%, followed by "ESG Rating" (D5), by 20.42%, and the indicator with the least room for improvement is "Workforce Learning and Capacity" (D30), by 3.74%.

3) Room for improvement for private enterprises on Top 20 indicators (vs. benchmark enterprises)

Figure AD.3 (see Annex AD) shows that the maturity performance of Top 20 indicators varies by the business nature. In contrast to the benchmark enterprises (including SOEs or foreign-funded enterprises), the indicator with the greatest room for improvement for private enterprises is "Rule maker/community satisfaction" (D14), by 17.56%; the indicator with the smallest room for improvement is "product sales/service provision" (D20), by 4.14%.

4) Room for improvement of non-listed enterprises on the Top 20 indicators (vs. listed enterprises)

Figure AD.4 (see Annex AD) shows that the indicator with the greatest room for improvement for non-listed enterprises in contrast to listed enterprises is "ESG rating results" (D5), by 13.34%; and the indicator with the least room for improvement is "customer contribution" (D8), by 2.84%.

5) Room for Improvement on Top 20 indicators for non-award-winning enterprises (vs. award-winning enterprises).

Figure AD.5 (see Annex AD) shows that, in contrast to award-winning enterprises, the indicator with the greatest room for improvement for non-award-winning enterprises is "ESG rating results" (D5), by 12.18%, while the indicator with the least room for improvement is

"workforce competence and capacity" (D30), by 0.44%.

6.3 Analysis of influencing factors on corporate management maturity

Figure AC-1 (see Annex AC) shows that the corporate management maturity of enterprises in Interval A is 52.81%, and the maturity of enterprises in Intervals B, C, and D all progressively increases, and finally the maturity of enterprises in Interval E reaches 61.93%; in other words, the maturity of a start-up enterprise has increased by 9.12% after at least 18 years of development.

Figure AC-2 (see Annex AC) shows that when a medium-sized enterprise develops into a extra-large enterprise, its maturity increases from 55.14% to 64.96%, which is a total increase of 9.92%.

Based on the above scoring data, the degree of maturity improvement of enterprises is categorized into five tiers as follows:

- Level 1–general improvement: maturity improvement level L < 3%;
- Level 2–obvious improvement: maturity improvement 3%≤L＜6%;
- Level 3–significant improvement: maturity improvement 6%≤L＜9%;
- Level 4–very significant improvement: maturity improvement 9%≤L＜12%;
- Level 5–extreme significant improvement: maturity improvement L＞12%。

According to Figures AD-1 to AD-5 (see Annex AD), we organize the impact of the four development paths of "business history", "scale growth", "public listing" and "introduction of the PEM" on the maturity on the Top 20 indicators (see Table 6.1), and find that there are large differences in the impact of different paths on the Top 20 indicators.

Table 6.1 The impact of different development paths on the maturity of TOP20 key performance indicators

Dimension of Impact		Business History					the Growth of Scale					Listed					Introduction of PEM				
Top 20 Indicators	Impacts	Level 1	Level 2	Level 3	Level 4	Level 5	Level 1	Level 2	Level 3	Level 4	Level 5	Level 1	Level 2	Level 3	Level 4	Level 5	Level 1	Level 2	Level 3	Level 4	Level 5
D5	ESG Rating Results					★					★					★					★
D1	Profitability					★					★			★				★			
D2	Operating Capability				★						★				★				★		
D7	Customer Fit			★					★				★				★				
D4	Development capability			★					★				★						★		
D6	Customer Satisfication				★					★				★				★			
D3	Solvency					★			★				★				★				
D8	Customer Contribution				★					★		★					★				
D14	Rulemaker/Community Satisfaction					★					★			★				★			
D30	Workforce Capabilities & Capacity			★				★						★			★				
D32	Workforce Learning & Growth			★				★						★				★			
D15	Rulemaker/Community Contribution					★					★					★				★	
D33	Digital Technology				★					★						★			★		
D21	Operational Risk Management					★					★				★			★			
D9	Workforce Satisfaction			★						★				★					★		
D19	Product/Service Production					★			★					★				★			
D34	Digitization/Intelligence			★							★					★				★	
D36	Culture			★						★				★					★		
D20	Product Sales/Service Delivery			★					★				★					★			
D37	Leadership			★						★				★					★		

6.3.1 Influence of corporate operation length on maturity improvement

“Business history” impacts all Top 20 indicators by more than a "significant improvement", with 100% of indicators achieving Level 3 and above, and 35% of indicators achieving Level 5, seven in total, in order of magnitude:

a) D5 ESG Rating Results (16.10% ↑);
b) D14 Rule maker/Community Satisfaction (13.46% ↑);
c) D15 Rule maker/Community Contribution (12.92% ↑);
d) D3 Solvency (12.60% ↑);
e) D1 Profitability (12.52% ↑);
f) D21 Operational Risk Management (12.12%);
g) D19 Product/Service Production (12.06% ↑).

6.3.2 Influence of corporate scale growth on maturity improvement

“Scale Growth” impacts 90% of the Top 20 indicators with a "significant improvement" or above, 18 indicators at Level 3, and 35% (7 indicators) at Level 5, which are:

a) D15 Rule maker/Community Contribution (22.74% ↑);
b) D5 ESG Rating Results (20.42% ↑);
c) D2 Operational Capability (16.68% ↑);
d) D14 Rule maker/Community Satisfaction (14.84% ↑);
e) D1 Profitability (14.60% ↑);
f) D21 Operational Risk Management (14.44% ↑);
g) D34 Digitalization/Intelligence (12.90% ↑)。

6.3.3 Influence of listing on corporate maturity improvement

“Public Listing” has a "significant improvement" or above impact on 75% of the Top 20 indicators, with 15 indicators at Level 3, and 20% (4 indicators) at Level 5, in the following order:

a) D5 ESG Rating Results (13.34% ↑);
b) D34 Digitalization/Intelligence (12.70% ↑);
c) D33 Digital Technology (12.42% ↑);
d) D15 Rule maker/Community Contribution (12.04% ↑)。

6.3.4 Influence of enterprises claiming Government Awards on maturity improvement

The “Introduction of the PEM” has an impact of "significant improvement" or above on 45% of the Top 20 indicators, with 9 indicators at Level 3, and 5% (only 1 indicator) at Level 5, namely:

D5 ESG Rating Results (12.18% ↑)。

6.3.5 Other factors

There are six categories of Top 20 indicators that are "Significantly Impacted" by the each development path of enterprises, i.e., the maturity is “significantly” improved or even higher:

a) D5 ESG Rating Results;
b) D2 Operational Capability;
c) D9 Employee Satisfaction;
d) D37 Leadership;
e) D36 Culture;
f) D15 Rule maker/Community Contribution.

6.4 Suggestion on corporate management maturity improvement

To summarize, among the four types of corporate development paths, "business history" plays the most obvious role in improving the maturity of enterprises, "scale growth" ranks the second, "listing" is the third, and "introduction of the PEM" plays the least role. However, the time spent on the four paths is exactly the opposite, with the shortest time invested in "introduction of the PEM", the second shortest in "listing", and the longest time spent from Interval A to Interval E.

In fact, the continuous operation of the enterprise, to achieve scale growth, and to realize the public listing, itself does not aim at maturity improvement, is not a means, but the "introduction of the PEM" is a means. However, it is not as effective as the first three paths to improve the maturity of the enterprise. So, how to improve its efficiency?

We believe that the PEM is equivalent to a "flooding irrigation" approach in improving the maturity of enterprises. The Evaluation Criteria Performance Excellence do not tell enterprises how to design or select KPIs, and it is necessary to establish processes and goals in six categories and several sub-categories, and to realize the "general improvement" of all processes, which leads to a longer time needed for the overall improvement, consumes more corporate resources, and the short-term results are not obvious. On the other hand, the PESC is a kind of

"dripping irrigation" method, which can accurately identify the most important performance indicators and processes of the enterprise, realize "precise improvement", and quickly improve the maturity of the key processes and their performance in a shorter period of time. Therefore, the introduction of the PESC is a brand new path that can help enterprises realize the "precise" improvement of the management maturity.

To ensure that the PESC can be effectively utilized in corporate management practices, we have developed a PESC application research Method with twelve steps for corporates reference:

Step 1: Management Determination

If the PEM is compared to an express train on its way to the temple of performance excellence, then the PESC is the operating system that drives the train. The decision to adopt the PESC for performance improvement depends on management's commitment. Management support is the most important step of successful PESC implementation.

Step 2: Formation of the PESC Action Team

The PESC Action Team consists of members from the corporate decision-making level (top management) and executive level (key middle management). In addition, some of the corporate key stakeholders should also join this working group, including key shareholders, customers, suppliers/partners, employees, government agencies and community representatives.

Step 3: Learning the PESC System

Action team members need to systematically learn the core concept of the PESC, the structure, the process of indicator value assignment, and the logic of composition, so as to lay the foundation for the correct application of the PESC.

Step 4: Discussing the KPI system

On the basis of the existing indicator system (50 types of indicators) of the PSEC, combined with industry characteristics, corporate vision and other information, the necessary adjustments are made to the types and number of indicators, and then the Likert scale (or other tools) is utilized to conduct one or more rounds of discussion by the action team members and form the unique PESC performance indicator system.

Step 5: Scoring/Determining Weights

For the new PESC performance indicator system, the AHP (or other methods) is used, and the team members are asked to make a "two-by-two" comparison of the importance of all the indicators, calculate the weights of all the indicators in accordance with the corresponding procedures, and rank them according to their weights, listing the Top 20, Top 10 or Top 5 indicators that are applicable to the enterprise.

Step 6: Maturity self-evaluation

Using the PESC Corporate Management Maturity Assessment Model, asking the action team to conduct a maturity self-evaluation to identify their strengths, weaknesses, and opportunities for improvement in the areas of RADAR (Results, Approaches, Deployments, Assess & Refine) for each of the KPIs.

Step 7: Developing a short- to medium-term PESC implementation plan (from pilot to rollout)

In response to improvement opportunities, the action team needs to discuss and identify: what is the goal of the improvement? What methods (or tools) will be used to make the improvement? Should it be piloted first or fully rolled out? From which segment (or region) to pilot? After repeated discussions, the enterprise should finally form a short- to medium-term PESC implementation plan.

Step 8: Setting goals and indicators

Departments responsible for implementing improvements should set goals and indicators for improvement topics, such as “introducing the MSCI ESG evaluation system and reaching the AAA level within three years”, or “adjusting supplier cooperation policies and conducting supplier satisfaction surveys”.

Step 9: Planning and developing tools or methods

Objectives are achieved through processes. Processes refer to the various methods used and improved by the enterprise. In order to achieve the desired goals, some processes require the introduction of management tools; some processes require the development of methods by the enterprise itself, which the enterprise needs to select correctly according to the principles of “adaptability” and “effectiveness”, considering its operating environment.

Step 10: Implementation, Measurement, Evaluation and Performance Improvement

Responsible departments implement specific tools or methods, measuring, evaluating, and reporting KPI results to management on a regular basis, and taking effective measures to implement improvements. The corporate PESC action team is required to follow up and periodically review the "short and medium-term PESC implementation plan".

Step 11: Using the PESC for strategy development and deployment

The initiation or trial implementation of the PESC can happen at any point in time and in any department or link, but ultimately it has to be integrated into the corporate strategic management system and used for strategy formulation and deployment. At this point, the application of the PESC has landed from project management to the strategic management process of the enterprise, thus entering a new stage.

Step 12: Continuous Improvement of the PESC System

The PESC is a dynamic approach. Repeating the above eleven steps, and continuously learning and improving this "train of performance excellence" operating system in the application process, the plan can be realized, the performance can be "precisely improved", various types of "shortcomings" can be gradually made up for, and the "overall improvement" of corporate management performance can be realized.

Chapter 7: Conclusions and Expectations

7.1 Research conclusions

7.1.1 Review of research questions

Various performance excllence models (or standards of quality awards) give the indicator systems for evaluating the corporate management maturity from different dimensions, but what are the key indicators for dozens or even hundreds of indicators? How much does each category of indicators contribute to the result? What are the interrelationships between the various categories of indicators (e.g., what are the driving indicators and what are the result-oriented ones)? The standards do not provide specific answers.

Aiming at the problems in the actual process of standardization and award evaluation of the PEMs (and various quality award standards), this thesis takes the advanced manufacturing enterprises in the Greater Bay Area as the research object and carries out theoretical and empirical research, aiming at solving the following two problems, so as to improve the effect of the application of the PEM in enterprises:

Q1: What are the factors (or KPIs) that impact the corporate management maturity of advanced manufacturing enterprises in the Greater Bay Area? What is their contribution?

Q2: What is the correlation between the factors (or KPIs) affecting the corporate management maturity of advanced manufacturing enterprises in the Greater Bay Area? How do they interact with each other?

7.1.2 Main research results

This thesis made comparative study on different performance evaluation systems (e.g., the PEM, the BSC, the PP, Sustainability Evaluation, and Corporate Innovation Performance Evaluation), explored key factors affecting corporate management maturity, and constructed a new performance evaluation system - the Performance Excellence Scorecard (PESC), and empowered the PESC indicator system with the AHP-EM to determine the contribution of performance indicators to the operation maturity.

Based on the research of the contribution (or weight) of key factors (or KPIs), this thesis aimed to investigate the correlation between the indicators of each dimension of the new

performance evaluation system, the PESC, by means of the SEM and to find out the causal relationships and priorities among them, so as to formulate corresponding short-, medium-, and long-term action plans for enterprises, and to carry out "precise" and "efficient" performance improvement. The main results of this study are summarized as follows:

1)Performance Excellence Scorecard (PESC) Framework Proposed Through Literature Research

This study conducts a comparative study on the implementation performance of five types of common performance management tools (including the BSC, the PP, the U.S. MBNQA, the EFQM Quality Award, and the Chinese National Quality Award) on the three major management theories (including the sustainability theory, the stakeholder theory, and the corporate innovation theory), points out the lack or insufficiency of the various types of tools in the setup of comprehensive performance indicators, and, on the basis of the basic structure of the BSC, builds a performance evaluation system with four levels, 12 dimensions, and 50 types of performance indicators applicable to economic organizations - the Performance Excellence Scorecard.

When establishing the Performance Excellence Model in China, enterprises commonly use the Balance Score Card (BSC)for the formulation and decomposition of performance indicators. However, the BSC is a tool developed in the 1990s, and due to its historical limitations, it can no longer effectively meet the requirements of the core values and guidelines of the PEM, while the PESC can be used to replace the BSC for the establishment of the performance measurement system of the PEM in enterprises because of the following advantages:

a) Integrating the sustainability theory, the stakeholder theory, the corporate innovation theory, and its corresponding corporate performance management tools with the BSC, this not only covers all the indicators in the nine dimensions of the four dimensions of the BSC, namely, "financial", "customer", "internal process" and "learning and growth", but also adds new dimensions and types of indicators to form a new performance measurement system that surpasses the BSC.

b) The PESC has realized a full fit with the PEM, and the related indicators not only cover seven categories of the PEM, i.e., "Leadership", "Strategy", "Customers", "Operations", "Measurement, Analytics and Knowledge Management", and "Results", but also, on the basis of the latter, has strengthened the indicators of some categories, including ESG indicators, stakeholder indicators, and corporate innovation indicators, which can be directly combined with the PEM for the formulation and development of strategic objectives.

c) The PESC is not a simple variant of the BSC or a random patchwork of indicators, but

is based on the most advanced corporate management concepts currently. For example, the PESC replaces the "financial" perspective of the BSC with the "corporate value" perspective, including "financial" and "sustainability" dimensions, which is in line with the direction of the financial reporting reform being carried out by the IFRS Foundation. Furthermore, the "customer" perspective has been replaced by the "stakeholder" perspective, which represents the replacement of the "shareholder first" theory by the "stakeholder theory"; and the "ESG" dimension has replaced the "regulations and social processes", and "corporate innovation" instead of "innovation", all reflect that the PESC has a deep theoretical foundation and is in line with the latest development trends.

2)Weights of PESC Indicators Set Through Interviews with Experts and Questionnaires

For the initially constructed performance evaluation system, the Likert scale method, the AHP, and expert interview method are used to determine the subjective weights of the indicators, the Entropy Method is used to analyze the 300 questionnaires recovered and determine the objective weights of the indicators, and the AHP-EM is used for the comprehensive assignment of the weights to determine the final weights of the measured indicators. The experts who participate in this interview are all the domestic well-known quality award evaluation experts, and the enterprises which participate in this questionnaire survey are all from the advanced manufacturing industries in Guangdong-HongKong-Macau Greater Bay Area, so the resulting performance evaluation system (and weights) is widely representative and can effectively guide manufacturing enterprises to establish their own performance evaluation system.

3)Exploring Relations Among Indicators in 12 PESC Dimensions Through Modeling and Analysis of SEM

The PESC consists of 4 levels, 12 dimensions and 50 types of indicators. What kind of correlation exists between these indicators? This thesis takes 12 dimensions as latent variables and 50 types of indicators as measured variables, proposes 18 path hypotheses of the relationship between latent variables, and establishes structural equation model based on them and carries out analysis. Through the structural model validation analysis, while identifying 12 paths with direct positive impact, 6 path relationships that can be further studied are found. The results of this study can help enterprises clarify the relationship between various types of indicators and accurately identify the leading and lagging indicators.

4)Constructing PESC Maturity Evaluation Model, and Conducting Empirical Study on Advanced Manufacturing Enterprises in Greater Bay Area

A “PESC Corporate Management Maturity” evaluation model is constructed in the study. The scoring rules of which are based on the scoring ideas of the EFQM “RADAR” model and

the maturity evaluation model of ISO9004. Compared with the complex scoring system of the Evaluation Criteria for Performance Excellence (CQA, 2004), the scoring system of the PESC is simpler and more practical, and the enterprises can use this model to carry out self-evaluation and continuously improve their management maturity.

The self-evaluation results and horizontal and vertical comparisons can help enterprises exactly find out the improvement effectiveness of each KPI and their position in the industry, and point out the direction for the next stage of improvement.

In addition, based on the "PESC Corporate Management Maturity" evaluation model, local governments at all levels, industrial associations and social organizations can evaluate the maturity of a sample enterprise in a specific region, industry or group of enterprises on the basis of evaluating the maturity of a single enterprise, and form a “Quality Management Index (QMI)”. Through horizontal and vertical comparisons, the QMI can be used in the following areas:

a) Evaluating the effectiveness of governments at all levels in promoting the Government Quality Award.

b) Measuring the standard of corporate management of a region/industry/group of enterprises.

Based on the "PESC Corporate Management Maturity" evaluation model, this study carries out questionnaire design, survey on advanced manufacturing enterprises in the Greater Bay Area， and analysis more than 300 valid questionnaires accordingly to obtain the overall maturity of the sample enterprises and the individual maturity of some indicators; and analyzes the factors affecting the management maturity of the enterprises from the dimensions of their business history, business scale, business nature, listed or not, and winning government's quality awards or not. Based on the results of the statistical analysis, this thesis gives suggestions for improving the maturity of corporate management, and concludes that: "introducing the PEM" is like "flooding irrigation", which is committed to the "general improvement" of various performance indicators; while "introducing the PESC" is similar to "dripping irrigation", which is committed to "precise improvement" of KPIs.

7.2 Research deficiencies and expectations

Although this study has achieved certain research results and has a certain value of popularization and application, we also find some problems and shortcomings in the research

process, and hope to solve these problems in the future research, to further enhance the quality and value of the research results.

7.2.1 Research deficiencies

Deficiencies in this study are as follows:

1) In the stage of expert opinion survey, the three rounds of questionnaires are conducted on www.wjx.cn, and some experts were not familiar with the application of the AHP, and there were logical errors in the "two-by-two comparisons" of the importance of the indicators, which resulted in the failure of the consistency test and the need to increase the number of new experts in the research. Therefore, when conducting expert opinion surveys in the future, it is necessary to appropriately increase the training or tips on the application of relevant research tools.

2) Since the experts in the survey are mainly in the Greater Bay Area cities, and the types of indicators designed in the questionnaire are also mainly in the advanced manufacturing industry, the output PESC indicator system and weights are relatively applicable to the advanced manufacturing industry in the Greater Bay Area. Therefore, if it is proposed to apply the results of this research to other specific regions or industries, further targeted research needs to be conducted.

3) In the process of corporate management maturity survey, the method of "one enterprise, one questionnaire" (i.e., one questionnaire for each enterprise) is adopted, which may result in the questionnaire not being able to accurately or objectively reflect the reality of the enterprises, due to the limitations of the enterprises being surveyed. Although a large sample of 300 questionnaires can analyze and evaluate the overall situation of the sample enterprises, it is not quite appropriate if a specific questionnaire is used to evaluate the corporate management maturity of a specific enterprise.

4) Corporate operation is a very complex system, and the corporate performance measurement system has a lot of "subsystems". The use of structural equation model to analyze the relationship between these "subsystems" will undoubtedly face great challenges. In this thesis, the 12 dimensions of the PESC are used as latent variables and 50 categories of performance indicators are used as measured variables for modeling, and the model has been fitted three times and corrected by MI five times before it is finally fitted successfully. The results of model validation find that some of the path assumptions were not valid, and that there may be positive direct impacts between some latent variables that were not assumed, suggesting that the relationships between the latent variables are very complex and need to be addressed

in future research.

7.2.2 Expectations

In view of the problems and deficiencies in the study, the following aspects can be improved in the future:

1) Before carrying out the expert opinion survey, providing necessary training and tips to the experts for some specialized survey tools, and strengthening the exchange and communication with the experts on the relevant research subjects;

2) Further subdividing industries (or regions) and conducting in-depth research on the PESC indicator system and its weights according to industry categories (or regions), to enhance the degree of recognition and adoption of relevant research results by enterprises;

3) When carrying out self-evaluation of the corporate management maturity, selecting personnel at different levels and in different positions in the same enterprise is suggested to conduct multi-person surveys on different issues, to further enhance the accuracy of the evaluation results.

4) Reconstructing the structural equation model, deleting the assumptions that are not valid based on the original path relationship assumptions, and adding assumptions that may have a relationship for re-verification and analysis.

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Annex A: Comparison of Evaluation Dimensions of Various Performance Evaluation Systems

No.	Diverse Performance Evaluation Systems					Integrated Performance Evaluation System	Notes
	BSC	PP	Sustainability	Corporate innovation	PEM		
1	Finance	Investors			Outcome (Finance)	Finance	Annex A
2			Sustainability		Leader	Sustainability	Annex B
3	Customers	Customers			Customers	Customers	Annex C
4		Workforce			Workforce	Workforce	Annex D
5		Suppliers/Partners			Operation	Suppliers/Partners	Annex E
6		Rule makers/Community			Leader	Rule makers/Community	Annex F
7	Operation Management Client Management				Operation Customers	Operation	Annex G
8	Innovation			Innovation Input Innovation Capacity Collaborative Innovation Innovative Activities Innovation Output	Strategy	Innovation	Annex H
9	Regulations and Society		Environment Society Governance		Leader Leader Leader	ESG	Annex I

10	Human Capital	Workforce	Human Capital	Annex J
11	Information Capital	Measure, Analysis & KM	Information Capital	Annex K
12	Organizational Capital	Leader Strategy	Organizational Capital	Annex L

Annex B: Comparison of Financial/Investor Dimensions Performance Indicators

No.	Indicator	Category of Indicator	Source of Indicator				
			BNQA 2021-2022	Chinese Quality Award GB/T19580: 2012	European Quality Award	BSC	PP
1	Stock Price	Profitability			●		
2	Net income per share (dividends)	Profitability			●		●
3	Return on Investment（ROI)	Profitability	●	●	●	●	●
4	Return on Capital	Profitability			●		
5	Asset Utilization /Total Asset Contribution Ratio / Return on Net Assets	Profitability	●	●	●	●	
6	Operating profit/total profit/gross profit	Profitability	●	●	●	●	●
7	Segment (or customer) profit	Profitability	●			●	●
8	Main business income/sales	Profitability		●	●	●	●
9	Earnings before interest and tax	Profitability			●		●
10	Cash Flow	Profitability	●				●
11	Non-operating income	Profitability		●			
12	Marginal contribution margin	Profitability			●		
13	Gearing ratio	Solvency	●	●			●
14	Working Capital Turnover / Inventory Turnover	Operating capacity	●	●		●	●
15	Days of cash on hand	Operating capacity	●			●	
16	Capital Utilization	Operating capacity	●			●	
17	Accounts receivable recovery rate	Operating capacity	●	●	●	●	●
18	Cost/expense control	Operating capacity		●			
19	Budget Accuracy	Operating capacity		●			
20	Capital preservation and appreciation rate/profit growth rate/revenue growth rate	Development capability	●	●	●		
21	Market or market share growth (business growth rate)	Development capability	●	●		●	●
22	New market results/new market areas and exports	Development capability	●	●			
23	E-commerce sales revenue	Development capability		●			
24	Market share (or market share / market ranking)	Development capability	●	●	●		●

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Annex C: Comparison of Sustainability Dimension Performance Indicators

No.	Indicator	Category of Indicator	Source of Indicator				
			BNQA 2021-2022	Chinese Quality Award GB/T19580: 2012	European Quality Award	BSC	PP
1	MSCI ESG Rating	ESG Rating	/	/	/	/	/
2	Sustainalytics ESG Rating	ESG Rating	/	/	/	/	/
3	Thomson Reuters ESG Rating	ESG Rating	/	/	/	/	/
4	FTSE Russell EGS Rating	ESG Rating	/	/	/	/	/
5	Vigeo Eiris ESG Rating	ESG Rating	/	/	/	/	/
6	AMAC ESG Rating	ESG Rating	/	/	/	/	/
7	SSIIS ESG Rating	ESG Rating	/	/	/	/	/
8	STGF ESG Rating	ESG Rating	/	/	/	/	/
9	ISS Sustainable Development Report	Non-financial Indicator	/	/	/	/	/

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Annex D: Comparison of Customer Dimension Performance Indicators

No.	Indicator	Category of Indicator	Source of Indicator				
			BNQA 2021-2022	Chinese Quality Award GB/T19580：2012	European Quality Award	BSC	PP
1	Customer satisfaction	Customer satisfaction	●	●	●	●	●
2	Level of customer complaints	Customer satisfaction					●
3	Timely response rate of customer complaints (customer complaint response time)	Customer satisfaction		●	●		
4	Effective resolution rate of customer complaints (effective resolution time of customer complaints)	Customer satisfaction		●	●		
5	Customer engagement (Customer loyalty)	Customer engagement	●	●	●		●
6	Customer Churn Rate	Customer engagement					●
7	Customer Retention Rate	Customer engagement		●	●	●	
8	Customer referral rate (referral organization)	Customer engagement		●	●		
9	Segmented customer profit contribution (customer benefit margin/customer profit margin)	Customer contribution				●	●
10	Customer Lifetime Value	Customer contribution					●
11	Repeat purchase value	Customer contribution					●
12	Level of customer suggestions/contribution of customer improvement suggestions	Customer contribution					●
13	Percentage of nonprofit customers	Customer contribution				●	
14	Number of strategic customers or number of quality customers	Customer contribution				●	

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Annex E: Comparison of Workforce Dimension Performance Indicators

No.	Indicator	Category of Indicator	Source of Indicator				
			BNQA 2021-2022	Chinese Quality Award GB/T19580：2012	European Quality Award	BSC	PP
1	Workforce satisfaction	Workforce satisfaction	●	●	●		●
2	Workforce turnover rate	Workforce satisfaction		●	●		●
3	Workforce Promotion Rate	Workforce satisfaction		●			
4	Workforce Compensation Growth Rate	Workforce satisfaction		●			
5	Workforce Occupational Health and Safety	Workforce satisfaction		●			
6	Workforce engagement（Workforce loyalty/dedication）	Workforce engagement	●	●	●		
7	Workforce Absence Rate	Workforce engagement		●	●		●
8	Average time of service	Workforce engagement					●
9	Sales/value added/output (productivity) per capita	Workforce contribution		●	●		●
10	Rationalization recommendation level	Workforce contribution		●			●
11	Total Labor Productivity	Workforce contribution		●			
12	Tax rate per capita	Workforce contribution		●			

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Annex F: Comparison of Supplier/Partner Dimension Performance Indicators

No.	Indicator	Category of Indicator	Source of Indicator				
			BNQA 2021-2022	Chinese Quality Award GB/T19580: 2012	European Quality Award	BSC	PP
1	Average spend per supplier trend (key supplier revenue growth)	Supplier/Partner satisfaction		●			●
2	Average time to retain suppliers (service time)	Supplier/Partner satisfaction					●
3	Proportion of value purchased through a single source/number or proportion of strategic alliances	Supplier/Partner satisfaction		●		●	●
4	Number of overdue supplier payments	Supplier/Partner satisfaction					●
5	Contribution to organizational performance (e.g., procurement cost reduction rate)	Supplier/Partner Contribution	●	●		●	●
6	Level of supplier complaints/satisfaction with supplier performance	Supplier/Partner Contribution	●				●
7	Incoming lot qualification rate / degree of quality non-conformity	Supplier/Partner Contribution	●	●		●	●
8	Timely delivery rate / number of late deliveries (promised/requested)	Supplier/Partner Contribution	●	●		●	●
9	Apply new ideas from suppliers (number of innovations from suppliers)	Supplier/Partner Contribution	●		●	●	●

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Annex G: Comparison of Rule maker/Community Dimension Performance Indicators

No.	Indicator	Category of Indicator	Source of Indicator				
			BNQA 2021-2022	Chinese Quality Award GB/T19580:2012	European Quality Award	BSC	PP
1	Legitimacy (e.g., level of violation handling/fines to sales)	Rulemaker/Community Satisfaction					•
2	Fairness (e.g. monopolistic or anti-competitive behavior)	Rulemaker/Community Satisfaction					•
3	Safety (e.g. complaints or reports of safety from customers/employees/local residents)	Rulemaker/Community Satisfaction					•
4	Truthfulness (e.g. tax transparency/disclosure compliance/truthfulness in advertising, etc.)	Rulemaker/Community Satisfaction					•
5	Jobs (e.g. employment contribution rate/level of direct or indirect employment resolved)	Rulemaker/Community Satisfaction					•
6	Wealth (e.g. asset tax rate/community investment/pro bono giving)	Rulemaker/Community Satisfaction	•	•	•	•	•
7	Rules (e.g., market regulatory soundness)	Rulemaker/Community Contribution					•
8	Reasons (e.g. local government support)	Rulemaker/Community Contribution					•
9	Support (e.g., community public advocacy)	Rulemaker/Community Contribution					•

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Annex H: Comparison of Operations Dimension Performance Indicators

No.	Indicator	Category of Indicator	Source of Indicator				
			BNQA 2021-2022	Chinese Quality Award GB/T19580:2012	European Quality Award	BSC	PP
1	Reduction of production costs (operating costs/unit output costs/proportion of each type of cost)	Product/service Produce	●	●	●	●	
2	Continuous process improvement (first pass rate/cost of quality/scrap rate, etc.)	Product/service Produce	●	●	●	●	●
3	Improving the degree of process responsiveness (production cycle time/processing time/processing efficiency, etc.)	Product/service Produce	●	●	●	●	●
4	Improving fixed asset utilization (output/productivity utilization efficiency/equipment failure rate, etc.)	Product/service Produce	●	●	●	●	
5	Reducing service costs (e.g. logistics costs)	Product sales/Service delivery				●	
6	Quick response delivery to customers (delivery lead time / on-time delivery rate, etc.)	Product sales/Service delivery		●	●	●	●
7	Improving quality (repair satisfaction rate / troubleshooting time / number and frequency of customer complaints)	Product sales/Service delivery		●	●	●	●
8	Managing financial risk (bad debt ratio/inferior debt ratio/losses from exchange rate fluctuations, etc.)	Risk management				●	
9	Managing operational risk (backlog/production capacity required ratio of existing and backlogged orders, etc.)	Risk management				●	
10	Managing technical risk (technical ranking of products or processes, etc.)	Risk management				●	
11	Emergency response capability (response time/preventing occurrence/meeting standards/unexpected event training results, etc.)	Risk management	●				
12	Business Continuity (e.g. supply chain security/public health/natural disaster/emergency response, etc.)	Risk management	●				
13	Customized mass marketing (customer response rate to marketing campaigns)	Customer/market development				●	●
14	Acquisition of new customers (win rate / lead conversion rate / cost per new customer acquired, etc.)	Customer/market development		●		●	
15	Developing dealer/distributor relationships (dealer scorecard)	Customer/market development				●	
16	Market share / market ranking	Customer/market development	●	●			
17	Business / market share growth rate	Customer/market development	●	●			
18	New market areas and exports	Customer/market development	●	●			
19	E-commerce revenue	Customer/market development		●			
20	Cross-selling customers (cross-selling revenue)	Customer relationship management				●	
21	Solution sales (after-sales service revenue/profit)	Customer relationship management				●	
22	Partnering with customers (number of single-source contracts)	Customer relationship management				●	
23	Evaluation, recognition and awarding by customers and independent evaluation agencies	Customer relationship management		●			

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Annex I: Comparison of Innovation Dimension Performance Indicators

No.	Indicator	Category of Indicator	Source of Indicator						
			BNQA 2021-2022	Chinese Quality Award GB/T19580-2012	European Quality Award	BSC	the Chinese Corporate Innovation Capability Report (Ministry of Science and Technology of China 2016)	the Oslo Manual (OECD)	the European Innovation Scoreboard (EIS, 2018)
1	Innovation funding input	Innovation inputs					●	●	
2	R&D expenditure as a percentage of main business revenue	Innovation inputs		●			●	●	
3	The proportion of R&D expenditure of R&D institutions to R&D expenditure of enterprises	Innovation inputs					●		●
4	Innovation spending per capita	Innovation capability (1): workforce skills						●	
5	R&D personnel as a proportion of employed persons	Innovation capability (1): workforce skills					●	●	
6	Proportion of doctoral and master's degree holders among R&D personnel in enterprises	Innovation capability (1): workforce skills					●	●	●
7	Number of patent applications per billion (or million) Yuan of R&D investment	Innovation capability (2): intellectual property capability					●		●
8	Proportion of enterprise invention patent applications in the number of patent applications	Innovation capability (2): intellectual property capability					●		
9	Trademark ownership of 10,000 employed persons in enterprises	Innovation capability (2): intellectual property capability					●		●
10	Number of effective invention patents for 10,000 employed persons in enterprises	Innovation capability (2): intellectual property capability					●		
11	Patent ownership transfer and licensing income	Innovation capability (2): intellectual property capability			●		●		●
12	Share of universities and research institutes in the external expenditure of R&D in enterprises	Collaborative innovation					●		●
13	External expenditure on science and technology activities as a percentage of total science and technology activities	Collaborative innovation							●
14	Ratio of expenditure on purchase of domestic technology to expenditure on introduction of technology	Collaborative innovation					●		
15	Ratio of expenditure on digestion and absorption to expenditure on introduction of technology	Collaborative innovation				●	●		
16	Number of technology or product partners/number of joint venture projects in new markets	Collaborative innovation			●				
17	New product design success rate/project approval rate	Innovation activities		●	●	●			
18	Number of items entering each product development process	Innovation activities				●			
19	New product/project development cycle	Innovation activities		●		●			
20	Project Development Costs	Innovation activities				●			
21	New product launch cycle	Innovation activities			●	●			
22	Number of new products launched or commercialized	Innovation activities		●		●			
23	Share of sales occupied by product innovation	Innovation output (1): product innovation	●	●			●	●	●
24	New product exports as a proportion of new product sales revenue	Innovation output (1): product innovation		●			●	●	●
25	Number of product innovations / patented products / new products or services / number of scientific and technological progress awards	Innovation output (1): product innovation	●	●				●	
26	Profitability of product innovation	Innovation output (1): product innovation						●	
27	Market share of product innovation (percentage of total sales in the market for similar products)	Innovation output (1): product innovation						●	
28	Number of PCT international invention patent applications entering the national phase	Innovation output (1): product innovation					●		●
29	Number of IPR registrations / number of citations / number of foreign registered trademarks	Innovation output (1): product innovation		●	●	●	●	●	
30	Percentage of company personnel impacted by innovation	Innovation output (2): business process innovation						●	
31	Sales changes due to business process innovation	Innovation output (2): business process innovation						●	
32	Productivity gains from business process innovation	Innovation output (2): business process innovation	●				●	●	
33	Cost reduction/energy reduction due to business process innovation	Innovation output (2): business process innovation					●	●	
34	Process time improvement due to business process innovation	Innovation output (2): business process innovation						●	
35	Product quality improvement due to business process innovation	Innovation output (2): business process innovation						●	

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Annex J: Comparison of ESG Dimension Performance Indicators

No.	Indicator	Category of Indicator	Source of Indicator					
			BNQA 2021-2022	Chinese Quality Award GB/T19580-2012	European Quality Award	BSC	PP	MSCI
1	Reducing carbon emissions	Environment (1): Climate change	•		•			•
2	Energy and resource consumption (e.g. energy and water consumption of 10,000 Yuan output value)	Environment (2): Energy and resources	•	•	•	•		•
3	Resource Utilization	Environment (2): Energy and resources	•	•	•	•		•
4	Alternative methods to save resources	Environment (2): Energy and resources	•		•			•
5	Waste reduction and waste utilization	Environment (3): pollutant emissions	•		•			•
6	Emission of waste water, waste gas, noise, waste residue	Environment (3): pollutant emissions		•	•	•	•	•
7	Extent of non-compliance with environmental regulations/number of environmental incidents or losses	Environment (4): negative environmental events				•	•	
8	Use of renewable energy resources and recycled water (utilization of resources such as raw materials)	Environment (5): Environmental governance opportunities	•		•			•
9	Advanced work practices for global use (e.g., environmental design/clean production)	Environment (5): Environmental governance opportunities	•			•		•
10	Occupational health and safety accident/incident rate	Society (1): Employment	•	•	•	•	•	•
11	Employee Hiring Diversity	Society (1): Employment				•		•
12	Human Rights Issues / Labor Standards	Society (1): Employment						•
13	Community investment (level of support given to local communities)	Society (2): Community support	•		•	•	•	
14	Community investment (level of investment in local infrastructure)	Society (2): Community support					•	
15	Philanthropic support (e.g. donation amount)	Society (2): Community support	•	•	•		•	
16	Level of direct/indirect employment resolved	Society (2): Community support					•	
17	Privacy and Data Security	Society (3): product liability						•
18	Chemical safety	Society (3): product liability						
19	Product quality and safety accidents	Society (3): product liability		•				
20	Emergency preparedness and response (e.g., recalls, etc.)	Society (3): product liability		•				
21	Controversial material procurement	Society (4): Stakeholder Controversies						•
22	Ways of social communication	Society (5): Social responsibility opportunities						•
23	Access to Health Care	Society (5): Social responsibility opportunities						•
24	Access to Financing	Society (5): Social responsibility opportunities						•
25	Opportunities for employee nutritional care	Society (5): Social responsibility opportunities						•
26	Board of Directors (percentage of independent directors)	Corporate governance (1): governance responsibilities	•	•				•
27	Shareholders (shareholders' and other related parties' interests)	Corporate governance (1): governance responsibilities						•
28	Wages, dividends, benefits, etc.	Corporate governance (1): governance responsibilities						•
29	Accounting and Auditing (internal and external audit results and their utilization)	Corporate governance (1): governance responsibilities	•	•				•
30	Corruption and instability	Corporate governance (2): legal responsibility						•
31	Anti-competitive behavior	Corporate governance (2): legal responsibility						•
32	Tax Transparency	Corporate governance (2): legal responsibility						•
33	Information Disclosure Compliance	Corporate governance (2): legal responsibility		•				
34	Number of incidents of ethical violations	Corporate governance (3): Business Ethics	•	•				•
35	Results of a survey on employees' perceptions of organizational ethics	Corporate governance (3): Business Ethics	•					
36	Usage of the ethics hotline	Corporate governance (3): Business Ethics	•					
37	Results of the ethical review audit	Corporate governance (3): Business Ethics	•					
38	Survey indicators of ethical compliance and integrity	Corporate governance (3): Business Ethics	•	•				
39	Assessment of the integrity of the organization by customers, suppliers and related organizations	Corporate governance (3): Business Ethics	•	•				

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Annex K: Comparison of Human Capital Dimension Performance Indicators

No.	Indicator	Category of Indicator	Source of Indicator				
			BNQA 2021-2022	Chinese Quality Award GB/T19580-2012	European Quality Award	BSC	PP
1	Human Capital Readiness	Wiorkforce competencies and quantitative capabilities	●			●	
2	Simplifying the number of management levels and positions	Wiorkforce competencies and quantitative capabilities	●	●			
3	Number of participants in improvement teams/formation of cross-functional teams	Wiorkforce competencies and quantitative capabilities		●	●		
4	Changes in the ratio of management staff	Wiorkforce competencies and quantitative capabilities		●			
5	Employee Insurance Costs	Wiorkforce climate and equity	●	●	●		
6	Number of days off for employees	Wiorkforce climate and equity		●	●		
7	Employee benefit expenses	Wiorkforce climate and equity	●	●	●		●
8	Employee participation (number of technical innovations, rationalization proposals and QC teams)	Wiorkforce climate and equity		●	●		
9	Number of various types of recognition and awards for employees	Wiorkforce climate and equity		●	●		
10	Training time and financial investment per capita	Workforce learning and development		●	●		●
11	Employee Training Satisfaction	Workforce learning and development		●			
12	Comparison of employee performance before and after training	Workforce learning and development		●	●		●
13	Cross-training / Job Rotation	Workforce learning and development	●	●			
14	Career development (career planning results)	Workforce learning and development	●	●	●		
15	Leadership/Key Position Succession Planning	Workforce learning and development	●	●			

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Annex L: Comparison of Information Capital Dimension Performance Indicators

No.	Indicator	Category of Indicator	Source of Indicator				
			BNQA 2021-2022	Chinese Quality Award GB/T19580:2012	European Quality Award	BSC	PP
1	Information capital readiness	IT	•			•	
2	Amount of investment in information systems	IT		•			
3	Development and application of software systems	IT		•			
4	Reliability indicators of information technology systems (hardware and software)	IT	•	•			
5	Security indicators of information technology systems (hardware and software)	IT	•	•			
6	Ease of use indicators for information technology systems (hardware and software)	IT	•	•	•		
7	Knowledge management (indicators on accumulation, sharing and application of knowledge assets)	Organizational knowledge	•	•	•		
8	Best practices (metrics in identification and promotion)	Organizational knowledge	•	•		•	
9	Organizational learning (number of learning teams or projects/value created, etc.)	Organizational knowledge	•				

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Annex M: Comparison of Organizational Capital Dimension Performance Indicator

No.	Indicator	Category of Indicator	Source of Indicator				
			BNQA 2021-2022	Chinese Quality Award GBT19580:2012	European Quality Award	BSC	PP
1	Customer-centric: percentage of understanding customers (survey)	Culture	●			●	●
2	Core Value: Readiness of Employee Evolution (survey)	Culture	●			●	●
3	Leadership Gap: Percentage of Key Factors above the Bottom in Capability Model	Leadership				●	
4	Strategic Target Realization Rate	Leadership		●			
5	Plan Implementation Rate	Leadership		●			
6	KPI Realization Rate	Leadership		●			
7	Strategic Awareness: Percentage of Employees Who Can Identify the Organization's Strategic Priorities	Strategic Synergy				●	●
8	Strategic Synergy: Percentage of Employees Whose Goals and Incentives Are Linked to the BSC	Strategic Synergy				●	

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Annex N: Framework of the PESC Indicator System

primary indicator	secondary indicator	tertiary indicator	optional indicator
1. Corporate Value	1.1 finance	1.1.1 Profitability	See Annex A
		1.1.2 Operating Capability	
		1.1.3 Solvency	
		1.1.4 Development capability	
	1.2 sustainability	1.2.1 ESG Performance/ISS Sustainability Report	See Annex B
2. Stakeholders	2.1 customers	2.1.1 Customer Satisfaction	See Annex C
		2.1.2 Customer Fit	
		2.1.3 Customer Contribution	
	2.2 workforce	2.2.1 Workforce Satisfaction	See Annex D
		2.2.2 Workforce Fit	
		2.2.3 Workforce Contribution	
	2.3 supplier/partner	2.3.1 Supplier/Partner Satisfaction	See Annex E
		2.3.2 Supplier/Partner Contribution	
	2.4 rule makers/community	2.4.1 Rule maker/Community Satisfaction	See Annex F
		2.4.2 Rule maker/Community Contribution	
3. Internal Processes	3.1 operation	3.1.1 Customer/Market Development	See Annex G
		3.1.2 Customer Relationship Management	
		3.1.3 Product/Service Production	
		3.1.4 Product Sales/Service Delivery	
		3.1.5 Operational Risk Management	
	3.2 innovation	3.2.1 Innovation Input	See Annex H
		3.2.2 Innovation Capability（1）： Workforce Skills	
		3.2.3 Innovation Capability（2）： IP capability	
		3.2.4 Innovation Activities	
		3.2.5 Collaborative Innovation	
	3.2 innovation	3.2.6 Innovation Output（1）： Product Innovation	

3.3 ESG	3.2.7 Innovation Output（2）：Business Process Innovation 3.3.1 Environment（1）：Climate Change 3.3.2 Environment（2）：Energy & Resources 3.3.3 Environment（3）：Pollutant Emissions	See Annex I

Annex N: Framework of the PESC Indicator System (Continued)

primary indicator	secondary indicator	tertiary indicator	optional indicator
3. Internal Processes	3.3 ESG	3.3.4 Environment（4）：Negative Environmental Events	See Annex I
		3.3.5 Environment（5）：Environmental Governance Opportunities	
		3.3.6 Society（1）：Employment	
		3.3.7 Society（2）：Community Support	
		3.3.8 Society（3）：Product Liability	
		3.3.9 Society（4）：Stakeholder Controversies	
		3.3.10 Society (5)：Social Responsibility Opportunities	
		3.3.11 Governance（1）：Governance Responsibility	
		3.3.12 Governance（2）：Legal Responsibility	
		3.3.13 Governance（3）：Business Ethics	
4. Learning & Growth	4.1 human capital		
		4.1.1 Workforce Capabilities & Capacity	See Annex J
		4.1.2 Workforce Equities & Atmosphere	
		4.1.3 Workforce Learning & Development	
	4.2 information capital	4.2.1 IT	See Annex K
		4.2.2 Organizational Knowledge	
	4.3 organizational capital	4.3.1 Culture	See Annex L
		4.3.2 Leadership	
		4.3.3 Strategic Synergy	

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Annex O: Indicator Setting Comparison of PESC, GB/T19580:2012 & BSC

Performance Excellence Scorecard (PESC)		GB/T19580:2012	BSC
1.1 Finance	1.1.1 Profitability	4.7.4 Financial Outcome	Financial
	1.1.2 Operating Capability	4.7.4 Financial Outcome&4.7.5 Resource Outcome	Financial
	1.1.3 Solvency	4.7.4 Financial Outcome	missing
	1.1.4 Development Capability	4.7.4 Financial Outcome	Financial
1.2 Sustainability	1.2.1 ESG Performance/ISS Sustainability Report	missing	missing
2.1 Customers	2.1.1 Customer Satisfaction	4.7.3.2 Customer Outcome	Customer
	2.1.2 Customer Fit	4.7.3.2 Customer Outcome	Customer
	2.1.3 Customer Contribution	missing	Customer
2.2 Workforce	2.2.1 Workforce Satisfaction	4.7.5 Resource Outcome	missing
	2.2.2 Workforce Fit	4.7.5 Resource Outcome	missing
	2.2.3 Workforce Contribution	4.7.5 Resource Outcome	missing
2.3 Suppliers/Partners	2.3.1 Supplier/Partner Satisfaction	4.7.5 Resource Outcome	Internal Process
	2.3.2 Supplier Contribution	4.7.5 Resource Outcome	Internal Process
2.4 Rule maker & Community	2.4.1 Rule maker/Community Satisfaction	missing	Internal Process
	2.4.2 Rule maker/Community Contribution	missing	missing
3.1 Operation	3.1.1 Customer/Market Development	4.7.3.3 Market Outcome&4.7.6 Process Validity Outcome	Internal Process
	3.1.2 Customer Relationship Management	4.7.3.2 Customer Outcome	Internal Process
	3.1.3 Product/Service Production	4.7.2 Product/Service Outcome &4.7.6 Process Validity Outcome	Internal Process
	3.1.4 Product Sales/Service Delivery	4.7.2 Product/Service Outcome &4.7.6 Process Validity Outcome	Internal Process
	3.1.5 Operational Risk Management	missing	Internal

3.2 Innovation	3.2.1 Innovation Input	4.7.5 Resource Outcome	Process missing
	3.2.2 Innovation Capability（1）：Workforce Skills	missing	missing
	3.2.3 Innovation Capability（2）：IP Capability	4.7.5 Resource Outcome	missing
	3.2.4 Innovation Activities	4.7.6 Process Validity Outcome	Internal Process
	3.2.5 Collaborative Innovation	missing	missing
	3.2.6 Innovation Output（1）：Product Innovation	4.7.5 Resource Outcome	Internal Process
	3.2.7 Innovation Output（2）:Process Innovation	missing	missing
	3.3.1 Environment（1）：Climate Change	missing	missing
	3.3.2 Environment（2）：Energy & Resources	4.7.7 Leader-related Outcome	Internal Process
	3.3.3 Environment（3）：Pollutant Emissions	4.7.7 Leader-related Outcome	Internal Process
	3.3.4 Environment（4）：Negative Environmental Events	missing	Internal Process
	3.3.5 Environment（5）：Environmental Governance Opportunities	missing	Internal Process
	3.3.6 Society（1）：Employment	4.7.7 Leader-related Outcome	Internal Process
	3.3.7 Society（2）：Community Support	4.7.7 Leader-related Outcome	Internal Process

Annex O: Indicator Setting Comparison of PESC, GB/T19580:2012 & BSC (Continued)

Performance Excellence Scorecard (PESC)		GB/T19580:2012	BSC
3.3 ESG	3.3.8 Society（3）：Product Liability	4.7.7 Leader-related Outcome	missing
	3.3.9 Society（4）：Stakeholder Controversies	missing	missing
	3.3.10 Society (5)：Social Responsibility Opportunities	missing	missing
	3.3.11 Governance（1）：Governance Responsibility	4.7.7 Leader-related Outcome	missing
	3.3.12 Governance（2）：Legal Responsibility	4.7.7 Leader-related Outcome	Internal Process
	3.3.13 Governance（3）：Business Ethics	4.7.7 Leader-related Outcome	missing
4.1 Human Capital	4.1.1 Workforce Capabilities & Capacity	4.7.5 Resource Outcome	Learning & Growth
	4.1.2 Workforce Equities & Atmosphere	4.7.5 Resource Outcome	missing
	4.1.3 Workforce Learning & Development	4.7.5 Resource Outcome	missing
4.2 Information Capital	4.2.1 IT	4.7.5 Resource Outcome	Learning & Growth
	4.2.2 Organizational Knowledge	4.7.5 Resource Outcome	Learning & Growth
4.3 Organizational Capital	4.3.1 Culture	missing	Learning & Growth
	4.3.2 Leadership	4.7.7 Leader-related Outcome	Learning & Growth
	4.3.3 Strategy Synergy	missing	Learning & Growth

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Annex P: List of Expert Information

S/N	Name	Code	Work unit	Work City	Occupation	Post	Social Appointments	Participation in research rounds		
								Round 1	Round 2	Round 3
1	Mr. Liu	001	Shenzhen Institute of Advanced Quality Management Technology	Shenzhen	Quality Research	Dean	quality award assessor	●	●	●
2	Mr. Xie	002	Shunde Xinke Electronics Co., Ltd.	Foshan	Engineer	General manager assistant	quality award assessor	●	●	★
3	Mr. Guo	003	Academic Committee of Shenzhen Quality Innovation Technology Allia	Shenzhen	Quality Management	Chairman of the Academic Committe	quality award assessor	●	●	●
4	Mr. Wen	004	Shenzhen Weixiangkongjian Technology Co., Ltd.	Shenzhen	Management	Manager	quality award assessor	●	●	★
5	Mr.Chen	005	University of Electronic Science and Technology of China	Chengdu	Teaching	Professor		●	●	●
6	Mr.Wang	006	Shenzhen Hengyuanhao Information Technology Co., Ltd.	Shenzhen	Quality Management	Quality Manager	quality award assessor	●	●	●
7	Mr.Chen	007	Shenzhen Zhuobiao Corporate Management Consulting Co., Ltd.	Shenzhen		Partner	quality award assessor	●	●	●
8	Mr. Li	008	Dongguan Xinzhidian Technological Service Co., Ltd.	Dongguan	Corporate Strategy Servi	General Manager	quality award assessor	●	●	●
9	Mr.Huang	009	Shenzhen Excellent Think Tank Corporate Consulting Ltd.	Shenzhen	Management Consulting	General Manager	quality award assessor	●	●	●
10	Ms. Tan	010	China Railway Major Bridge Engineering Group Co., Ltd., Shenzhen B	Shenzhen	Engineering Design	Quality Manager	quality award assessor	●	●	●
11	Mr.Huang	011	China Skyaero Engine Maintenance Co., Ltd.	Chongqin	Professional Manager	General Manager		●	●	●
12	Mr.Wang	012	Xihua University	Chengdu	Teaching	Teacher	Consultant	●	●	★
13	Ms. Li	013	Hebei Institute of Product Quality Supervision and Inspection	Shijiazhuang	Research Management	Technical Leader	quality award assessor	●	●	●
14	Mr.Gao	014	China Stone Management Consulting Ltd.	Jinan	Management Consulting	Partner	Consultant	●	●	●
15	Mr.Wang	015	Shunde Product Quality Association, Foshan	Foshan	Quality Technical Servic	President	quality award assessor	●	●	★
16	Mr.Yang	016	Pearl River Piano, Guangzhou	Guangzhou	Quality Management	Consultant	quality award assessor	●	●	●
17	Mr.Huang	017	Guangdong Jian'an Testing	Guangzhou	Quality Management	Vice President	quality award assessor	●	●	●
18	Mr.Yang	018	Guangzhou Robustly Security Technology Development Co., Ltd.	Guangzhou	Manufacturing	Vice President	quality award assessor	●	●	●
19	Ms. Li	019	Shenzhen Huarui Medical Technology Co., Ltd.	Shenzhen	Quality Management	Vice President	quality award assessor	●	●	●
20	Mr.Zhu	020	Beijing Tianyizheng Authentification Center, Guizhou Branch	Zunyi	Auditing	General Manager	quality award assessor	●	●	●
21	Mr.Huang	021	Shenzhen Pegasi Excellence Corporate Management Consulting Ltd.	Shenzhen	Management Consulting	General Manager	quality award assessor	/	/	●
22	Mr.Liu	022	Guangdong University of Business Studies	Guangzhou	Teaching	Professor	quality award assessor	/	/	●
23	Mr.Yin	023	Foshan Institute of Quality and Standardization	Foshan	Management Consulting	Vice Dean	quality award assessor	/	/	●
24	Mr.Yang	024	Centre Testing International	Shenzhen	Quality Management	Vice President	quality award assessor	/	/	●
25	Ms. Yang	025	Lee Kum Kee (Xinhui) Food Co., Ltd.	Jiangmen	Technician	R&D Manager	quality award assessor	/	/	★
26	Ms. Chen	026	Guangzhou Association of Standardization	Guangzhou	Standardization	President	quality award assessor	/	/	★
27	Mr.Huang	027	Foshan Institute of Quality and Standardization	Foshan	Quality Management	Dean	quality award assessor	/	/	★
28	Mr.Fan	028	South China Agricultural University	Guangzhou	Teaching	Director	quality award assessor	/	/	★

Remarks: ● This means that the experts were involved in the questionnaire and the result is "valid"; ★ This means that the experts were involved in the questionnaire but the result is "innvalid"

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Annex Q: Questionnaire on Performance Excellence Evaluation System (Round 1): Excerpt

Dear Expert,

Thank you very much for your participation in this questionnaire survey. The purpose of this survey is to establish a performance indicator system that fully matches Chinese manufacturing enterprises, in line with the Criteria for Performance Excellence (GB/T19580:2012), and is consistent with the management concepts of sustainable development, stakeholders and corporate innovation, etc. Now, we would like to ask your opinion on the necessity of setting each indicator.

Thank you for your active participation!

Name: Employer: Occupation: Position:

No.		Types of Indicators	Review of Necessity				
			very necessary (5)	necessary (4)	uncertain (3)	not quite necessary (2)	negligible (1)
Q1	**What do you think is the necessity of setting the following indicators when constructing the comprehensive performance evaluation system for a leading, high-performing Chinese manufacturing enterprise?**						
	Q1-01	Finance（including indicators of profitability, operational capability, solvency, and developmental capability, etc.）	○	○	○	○	○
	Q1-02	Sustainability（e.g. MSCI ESG Rating, Sustainalytics ESG Rating and Thomson Reuters ESG Rating, etc.）	○	○	○	○	○
	Q1-03	Customer（including indicators of customer satisfaction， customer engagement and customer contribution, etc.）	○	○	○	○	○
	Q1-04	Workforce（including indicators of workforce satisfaction, workforce engagemen and workforce contribution, etc.）	○	○	○	○	○
	Q1-05	Supplier/Partner（including indicators of Supplier/Partner satisfaction and Supplier/Partner contribution, etc.）	○	○	○	○	○
	Q1-06	Rule maker/Community（including indicators of Rule maker/Community satisfaction and Rule maker/Community contribution, etc.）	○	○	○	○	○
	Q1-07	Operations（including indicators of Customer/market development, Customer relationship management, Product/service Produce, Product sales/Service delivery and Risk management, etc.）	○	○	○	○	○
	Q1-08	Innovation（including indicators of Innovation inputs, Innovation capability, Innovation activities, Collaborative innovation and Innovation output, etc.）	○	○	○	○	○
	Q1-09	ESG（including indicators of climate change, energy and resources, pollutant emissions, employment, community support, governance responsibilities, legal responsibility, and Business Ethics, etc.）	○	○	○	○	○
	Q1-10	Human Capital（including indicators of Workforce competencies and quantitative capabilities, Workforce climate and equity and Workforce learning and development, etc.）	○	○	○	○	○
	Q1-11	Information Capital（including indicators of IT and Organizational knowledge, etc.）	○	○	○	○	○
	Q1-12	Organizational Capital（including indicators of Culture, Leadership and Strategic Synergy, etc.）	○	○	○	○	○
	Note:	Is it necessary to add some indicators of other dimensions? Or to remove some inappropriate indicators above? Please specify (if "Yes" is selected):	No	○		Yes	○

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Annex R: Questionnaire on Performance Excellence Evaluation System (Round 2): Excerpt

Dear Expert,

Thank you very much for your participation in this questionnaire survey (The second round). The purpose of this survey is to establish a performance indicator system that fully matches Chinese manufacturing enterprises, in line with the Criteria for Performance Excellence (GB/T19580:2012), and is consistent with the management concepts of sustainable development, stakeholders and corporate innovation, etc. Based on the feedback from experts, two types of indicators (i.e. brand management, digitalization/intelligence) have been added to this round of survey, and a few indicators have been adjusted in terms of description. Now, we would like to ask your opinion on the necessity of setting each indicator.

Thank you for your active participation!

Name: Employer: Occupation: Position:

No.		Types of Indicators	Review of Necessity				
			very necessary (5)	necessary (4)	uncertain (3)	not quite necessary (2)	negligible (1)
	What do you think is the necessity of setting the following indicators when constructing the comprehensive performance evaluation system for a leading, high-performing Chinese manufacturing enterprise?						
Q1	Q1-07	Operations (including indicators of Brand management,Customer/market development, Customer relationship management, Product/service Produce, Product sales/Service delivery and Operational Risk management, etc.)	○	○	○	○	○
	Q1-11	Digital Capital (including indicators of Digital technology, Digitization/Intelligent and Organizational knowledge, etc.)	○	○	○	○	○
Q3	Q1-03-02	Customer engagement (e.g. Customer loyalty, Customer Involvement Rate, Customer Churn Rate, Customer Retention Rate, Customer referral rate, etc.)	○	○	○	○	○
	Q1-03-03	Customer contribution (e.g. Percentage of revenue from repeat customer purchases , Revenue share of strategic customers, Number of quality customers, etc.)	○	○	○	○	○
Q6	Q1-06-01	Rulemaker/Community Satisfaction (e.g. Community Investment, Number of punished, Number of complaints/reports by the community, Employment contribution rate, etc.)	○	○	○	○	○
	Q1-06-02	Rulemaker/Community Contribution (e.g. Government subsidy income, Number of commendations/ honors/positive reports received, etc.)	○	○	○	○	○
	Note:	Is it necessary to add some indicators of other dimensions? Or to remove some inappropriate indicators above? Please specify (if "Yes" is selected):	No	○		Yes	○
Q7	Q1-07-01	Brand Management (e.g. Brand promotion input, Number of registered trademarks, Brand awareness/reputation/loyalty, Brand Value, etc.)	○	○	○	○	○
Q9	Q1-09-06	Society: Employment (e.g. Occupational health and safety accident/incident rate, Social Security Expenses, Human Rights Issues / Labor Standards, etc.)	○	○	○	○	○
	Q1-09-07	Society: Community support (e.g. Taxation per unit of land, Public Welfare Support Input, Level of direct/indirect employment resolved, etc.)	○	○	○	○	○
	What's your opinion on the necessity of setting the following indicators about Digital Capital indicators, when constructing the above comprehensive performance evaluation system?						
Q11	Q1-11-01	Digital/ICT Capital (e.g. ICT capital readiness, Amount of investment in ICT systems, Reliability, Security and Easiness of ICT systems, etc.)	○	○	○	○	○
	Q1-11-02	Digitalization/Intelligence (e.g. Digital business revenue growth rate/ratio, Digitally driven cost reduction and efficiency, etc.)					

Notes: the two rounds of questionnaires are basically the same, and only the revised parts are listed out (see the underlined parts).

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Annex S: The Screening Results of the PESC Indicator System

S/N	secondary indicator	tertiary indicator	Level-4 indicator	1st Round			2nd Round		
				arithmetic average	coefficient of variation	Is it consistent?	arithmetic average	coefficient of variation	Is it consistent?
1	C1 finance			4.90	0.06	Y	4.90	0.06	Y
2	C2 sustainability			4.15	0.11	Y	4.30	0.13	Y
3	C3 customer			4.90	0.09	Y	4.70	0.12	Y
4	C4 workforce			4.60	0.11	Y	4.50	0.11	Y
5	C5 supplier/partner			4.50	0.11	Y	4.40	0.15	Y
6	C6 rule makers/community			3.90	0.23	Y	4.00	0.21	Y
7	C7 operation			4.60	0.13	Y	4.75	0.11	Y
8	C8 innovation			4.85	0.07	Y	4.90	0.06	Y
9	C9 ESG			4.20	0.14	Y	4.35	0.17	Y
10	C10 human capital			4.50	0.13	Y	4.50	0.13	Y
11	C11 digital capital			4.25	0.15	Y	4.35	0.13	Y
12	C12 organizational capital			4.60	0.13	Y	4.55	0.11	Y
13		D1 Profitability		5.00	0.00	Y	5.00	0.00	Y
14		D2 Operating Capability		4.55	0.11	Y	4.65	0.10	Y
15		D3 Solvency		4.05	0.17	Y	4.25	0.16	Y
16		D4 Development Capability		4.30	0.15	Y	4.45	0.11	Y
17		D6 Customer Satisfaction		4.90	0.06	Y	4.85	0.07	Y
18		D7 Customer engagement		4.45	0.15	Y	4.70	0.10	Y
19		D8 Customer Contribution		4.15	0.19	Y	4.40	0.13	Y
20		D9 Workforce Satisfaction		4.75	0.11	Y	4.70	0.12	Y
21		D10 Workforce engagement		4.35	0.15	Y	4.45	0.13	Y

22	D11 Workforce Contribution	4.25	0.18	Y	4.65	0.12	Y
23	D12 Supplier/Partner Satisfaction	4.40	0.15	Y	4.55	0.13	Y
24	D13 Supplier/Partner Contribution	4.25	0.16	Y	4.55	0.13	Y
25	D14 Rule maker/Community Satisfaction	4.05	0.21	Y	4.20	0.19	Y
26	D15 Rule maker/Community Contribution	4.20	0.16	Y	4.10	0.15	Y
27	D16 Brand Management	/	/	/	4.60	0.13	Y
28	D17 Customer/Market Development	4.85	0.10	Y	4.90	0.06	Y
29	D18 Customer Relationship Management	4.45	0.18	Y	4.45	0.13	Y
30	D19 Product/Service Production	4.65	0.10	Y	4.60	0.11	Y
31	D20 Product Sales/Service Delivery	4.85	0.07	Y	4.70	0.10	Y
32	D21 Operational Risk Management	4.45	0.13	Y	4.45	0.17	Y
33	D22 Innovation Input	4.80	0.08	Y	4.70	0.12	Y

Annex S: The Screening results of the PESC Indicator system (Continued)

S/N	secondary indicator	tertiary indicator	Level-4 indicator	1st Round			2nd Round		
				arithmetic average	coefficient of variation	Is it consistent?	arithmetic average	coefficient of variation	Is it consistent?
34		D23 Innovation Capability	E1 Workforce Skills	4.30	0.15	Y	4.55	0.13	Y
35			E2 IP Capability	4.30	0.13	Y	4.25	0.15	Y
36		D24 Innovation Activities		4.60	0.11	Y	4.50	0.13	Y
37		D25 Collaborative Innovation		3.80	0.20	Y	4.05	0.17	Y
38		D26 Innovation Output	E3 Product Innovation	4.60	0.13	Y	4.65	0.12	Y
39			E4 Business Process Innovation	4.20	0.16	Y	4.35	0.13	Y
40		D27 Environment	E5 Climate Change	4.10	0.19	Y	4.20	0.18	Y
41			E6 Energy & Resources	4.05	0.18	Y	4.30	0.15	Y
42			E7 Pollutant Emissions	4.45	0.11	Y	4.45	0.15	Y
43			E8 Negative Environmental Events	4.50	0.15	Y	4.40	0.18	Y
44			E9 Environmental Governance Opportunities	3.80	0.18	Y	4.00	0.18	Y
45		D28 Society	E10 Employment	4.35	0.13	Y	4.50	0.13	Y
46			E11 Community Support	4.00	0.21	Y	4.15	0.21	Y
47			E12 Product Liability	4.55	0.13	Y	4.45	0.17	Y
48			E13 Stakeholder Controversies	3.75	0.20	Y	3.90	0.18	Y
49			E14 Social Responsibility	3.90	0.18	Y	3.90	0.16	Y

		Opportunities						
		E15 Governance						
50	D29 Governance	Responsibility	4.20	0.18	Y	4.30	0.15	Y
51		E16 Legal Responsibility	4.40	0.13	Y	4.40	0.17	Y
52		E17 Business Ethics	4.20	0.18	Y	4.30	0.18	Y
53	D30 Workforce Competencies & Capabilities		4.50	0.15	Y	4.50	0.13	Y
54	D31 Workforce Equities & Atmosphere		4.40	0.13	Y	4.25	0.18	Y
55	D32 Workforce Learning & Growth		4.40	0.15	Y	4.30	0.17	Y
56	D33 Digital Technology		4.45	0.11	Y	4.50	0.16	Y
57	D34 Digitization/Intelligence		/	/	/	4.40	0.15	Y
58	D35 Organizational Knowledge		4.45	0.13	Y	4.35	0.18	Y
59	D36 Culture		4.20	0.19	Y	4.25	0.18	Y
60	D37 Leadership		4.60	0.13	Y	4.60	0.13	Y
61	D38 Strategic Synergy		4.60	0.13	Y	4.50	0.13	Y

Annex T: Framework of the PESC Model (Adjusted)

primary indicator	secondary indicator	tertiary indicator	Level-4 indicator
B1. Corporate Value	C1 financial	D1 Profitability	
		D2 Operating Capability	
		D3 Solvency	
		D4 Development Capability	
	C2 sustainability	D5 ESG Rating Results	
B2. Stakeholders	C3 customer	D6 Customer Satisfaction	
		D7 Customer Fit	
		D8 Customer Contribution	
	C4 workforce	D9 Workforce Satisfaction	
		D10 Workforce Fit	
		D11 Workforce Contribution	
	C5 supplier/partner	D12 Supplier/Partner Satisfaction	
		D13 Supplier/Partner Contribution	
	C6 rule maker/community	D14 Rule maker/Community Satisfaction	
		D15 Rule maker/Community Contribution	
B3. Internal Processes	C7 operation	D16 Brand Management	
		D17 Customer/Market Development	
		D18 Customer Relationship Management	
		D19 Product/Service Production	
		D20 Product Sales/Service Delivery	
		D21 Operational Risk Management	
	C8 innovation	D22 Innovation Input	
		D23 Innovation Capability	E1 Workforce Skills
			E2 IP capability

	D24 Innovation Activities	
C8 innovation	D25 Collaborative Innovation	
	D26 Innovation Output	E3 Product Innovation
		E4 Business Process Innovation
C9 ESG	D27 Environment	E5 Climate Change
		E6 Energy & Resources
		E7 Pollutant Emissions
		E8 Negative Environmental Events
		E9 Environmental Governance Opportunities
	D28 Society	E10 Employment
		E11 Community Support

Annex T: Framework of the PESC Model (Adjusted): Continued

primary indicator	secondary indicator	tertiary indicator	Level-4 indicator
B3. Internal Processes	C9 ESG		E12 Product Liability
			E13 Stakeholder Controversies
			E14 Social Responsibility Opportunities
		D29 Governance	E15 Governance Responsibility
			E16 Legal Responsibility
			E17 Business Ethics
B4. Learning and Growth	C10 human capital		
		D30 Workforce Capabilities & Capacity	
		D31 Workforce Equities & Atmosphere	
		D32 Workforce Learning & Growth	
	C11 digital capital	D33 Digital Technology	
		D34 Digitization/Intelligence	
		D35 Organizational Knowledge	
	C12 organizational capital	D36 Culture	
		D37 Leadership	
		D38 Strategic Synergy	

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Annex U: Questionnaire on the Importance of PESC Performance Indicators: Excerpt

Dear Expert,

Thank you very much for your participation in this questionnaire survey. The purpose is to decide the weight of each indicator in the Performance Excellence Evaluation System, which fully matches Chinese manufacturing enterprises, in line with the Criteria for Performance Excellence (GB/T19580:2012). It will take you approximatlye 15 minutes to finish the questionnaire.

Please compare the indicators in pairs to determine their relative importance. The questionnaire is on a scale of 1-9, the meanings and descriptions of the scales are given in the following table:

Rating Scale

Scale	Meaning	Descriptions
1	equally important	two factors are equally important
3	slightly important	In comparison, the former factor is slightly more important than the latter factor.
5	obviously important	In comparison, the former factor is obviously more important than the latter factor.
7	significantly important	In comparison, the former factor is significantly more important than the latter factor.
9	extremely important	In comparison, the former factor is extremely more important than the latter factor.
1/3	slightly unimportant	In comparison, the former factor is slightly less important than the latter factor.
1/5	obviously unimportant	In comparison, the former factor is obviously less important than the latter factor.
1/7	significantly unimportant	In comparison, the former factor is significantly less important than the latter factor.
1/9	extremely unimportant	In comparison, the former factor is extremely less important than the latter factor.

Name: Employer: Occupation: Position:

1) In your opinion, compared with the latter category of indicators in the Performance Excellence Evaluation System (Level 1), the former category of indicators are:

equally important	slightly important	obviously important	significantly important	extremely important	slightly unimportant	obviously unimportant	significantly unimportant	extremely unimportant
1	3	5	7	9	1/3	1/5	1/7	1/9
"Corporate Value"compared with "Stakeholder" ("Corporate Value" level includes the indicators of finance and sustainability ; " Stakeholder" level includes the indicators of customer, workforce, supplier/partner and rulemaker/community):								
○	○	○	○	○	○	○	○	○
"Corporate Value" compared with "Internal Processes" ("Internal Processes" level includes the indicators of Operation,Innovation and ESG) :								
○	○	○	○	○	○	○	○	○
"Corporate Value" compared with "Learning and Growth" ("Learning and Growth "level includes the indicators of Human capital, Information capital and Organizaional capital) :								
○	○	○	○	○	○	○	○	○
"Stakeholder" compared with "Internal Processes" :								
○	○	○	○	○	○	○	○	○
"Stakeholder" compared with "Learning and Growths" :								
○	○	○	○	○	○	○	○	○
"Internal Processes" compared with "Learning and Growth" :								
○	○	○	○	○	○	○	○	○

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Annex V: Business Management Maturity Questionnaire for Advanced Manufacturing Enterprises in the Greater Bay Area: Excerpt

Dear Sir/Madam,

We are honored to invite you on behalf of your enterprise to participate in this questionnaire survey! The targets of this survey are representatives of the enterprises in Advanced Manufacturing Industry in the Guangdong-HongKong-Macao Greater Bay Area in China. The purpose of the survey is to understand the maturity of the performance management system of the enterprises and provide suggestions for enterprises to enhance the maturity level.

To thank you for your active participation, an assessment report on the maturity of your enterprise's performance management system and suggestion for improvement will be provided after the survey is completed.

The RADAR model of EFQM (2018) was incorporated into the maturity evaluation model of ISO 9004 (2000) to form a new scoring system with its scoring criteria and meanings as follows,

a) 0: No formal approach—no systematic approach evident, no results, poor results or unpredictable results;
b) 1: Reactive approach—problem or corrective-based systematic approach; minimum data on improvement results available;
c) 2: Performance Indicators Defined—Define the Results you wanted to achieve;
d) 3: Systematic approach—plan and develop the systematic Approach that will deliver the result, and Deploy the approach
e) 4: Continual improvement emphasized—Assess the impact and Refine to ensure you achieve the desired results;
f) 5: Best-in-class performance—strongly integrated improvement process; best-in-class benchmarked results demonstrated.

Before filling in the form, please put down your basic information, including name, employer, occupation, position and email address. We promise to keep all information in this questionnaire confidential, and assume legal responsibility for the confidentiality of all information in this questionnaire. Thank you for your active participation!

Name: Employer: Department Position: E-Mail address:

No.		Factor Type	Rating on Maturity					
			No formal approach (0)	Reactive approach (1)	Performance Indicators Defined (2)	Systematic approach (3)	Continual improvement emphasized (4)	Best-in-class performance (5)
Q1		**What stage of maturity is your company at, with respect to the processes and results of the following "Financial" type?**						
	Q1-01	Profitability (e.g. Net income per share , Return on Investment, Return on Net Assets, gross profit, Main business income/sales, Earnings before interest and tax, Cash Flow, etc.) , representative indicators of your company among which are (optional):	○	○	○	○	○	○
	Q1-02	Operating capacity (e.g. Working Capital Turnover , Inventory Turnover, Accounts receivable recovery rate, Cost/expense control, Budget Accuracy,etc.) , representative indicators of your company among which are (optional):	○	○	○	○	○	○
	Q1-03	Solvency (e.g. Gearing ratio, etc.) , representative indicators of your company among which are (optional):	○	○	○	○	○	○
	Q1-04	Development capability (e.g. Capital preservation and appreciation rate, profit growth rate, revenue growth rate, etc.) , representative indicators of your company among which are (optional):	○	○	○	○	○	○

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Annex W: Single Hierarchical Arrangement of Individual Expert's Evaluation Indicators

(1) Judgment matrix, weights and consistency test of criterion layer (A)

Table W.1 Judgment matrix and weights of criterion layer A-B (failed)

A	B1	B2	B3	B4	W	Wi	λmax	CR
B1	1	3	7	7	2.103	52.565%	4.719	0.269
B2	0.33	1	7	7	1.219	30.479%		
B3	0.14	0.14	1	7	0.504	12.597%		
B4	0.14	0.14	0.14	1	0.174	4.359%		

Note: CR＞0.1, the consistency test of judgment matrix fails and needs to be adjusted. The "maximum directional improvement" method is used for adjustment, and the adjustment results are shown in Table W-2, which passes the consistency test.

Table W.2 Judgment matrix and weights of criterion layer A-B (adjusted)

A	B1	B2	B3	B4	W	Wi	λmax	CR
B1	1	3	7	7	2.197	54.926%	4.132	0.05
B2	0.33	1	7	7	1.314	32.840%		
B3	0.14	0.14	1	1	0.245	6.117%		
B4	0.14	0.14	1	1	0.245	6.117%		

(2) Judgment matrix, weights and consistency test of indicator layer (B)

Table W.3 Judgment matrix and weights of indicator layer B1-C

B1	C1	C2	W	Wi	λmax	CR
C1	1	9	1.801	90.045%	1.995	null
C2	0.11	1	0.199	9.955%		

Table W.4 Judgment matrix and weights of indicator layer B2-C (failed)

B 2	C3	C4	C5	C6	W	Wi	λmax	CR
C3	1	5	9	9	2.3	57.512%	5.169	0.438
C4	0.2	1	9	9	1.094	27.350%		
C5	0.11	0.11	1	9	0.469	11.723%		
C6	0.11	0.11	0.11	1	0.137	3.416%		

Note: CR＞0.1, the consistency test of judgment matrix fails and needs to be adjusted. The "minimum change" method is used for adjustment, and the adjustment results are shown in Table W-5, which passes the consistency test.

Table W.5 Judgment matrix and weights of indicator layer B2-C (adjusted)

B2	C3	C4	C5	C6	W	Wi	λmax	CR
C3	1	5	9	9	2.5	62.510%	4.229	0.086
C4	0.2	1	7	7	1.078	26.946%		
C5	0.11	0.14	1	1	0.211	5.272%		
C6	0.11	0.14	1	1	0.211	5.272%		

Table W.6 Judgment matrix and weights of indicator layer B3-C

B3	C7	C8	C9	W	Wi	λmax	CR
C7	1	1	5	1.364	45.455%		
C8	1	1	5	1.364	45.455%	3	0
C9	0.2	0.2	1	0.273	9.091%		

Table W.7 Judgment matrix and weights of indicator layer B4-C

B4	C10	C11	C12	W	Wi	λmax	CR
C10	1	7	7	2.337	77.894%		
C11	0.14	1	1	0.332	11.053%	2.987	-0.013
C12	0.14	1	1	0.332	11.053%		

Annex X: Evaluation Results (Weights) and Averages of 20 Experts

Judgment matrix code	Indicator code	Expert code																				Average value
		001	003	005	006	007	008	009	010	011	013	014	016	017	018	019	020	021	022	023	024	
A	B1	30.64%	52.33%	25.10%	8.33%	54.93%	23.98%	39.93%	67.19%	27.74%	39.41%	43.58%	44.82%	48.47%	29.10%	24.17%	22.38%	63.61%	12.50%	49.53%	38.92%	37.333%
	B2	24.39%	31.28%	55.60%	8.33%	32.84%	17.69%	35.76%	8.92%	27.74%	43.16%	7.90%	10.19%	16.12%	38.48%	24.17%	48.51%	19.11%	62.50%	32.86%	38.92%	29.223%
	B3	30.64%	8.19%	9.65%	41.67%	6.12%	17.69%	16.02%	14.72%	7.40%	10.81%	4.93%	10.19%	12.97%	22.80%	32.51%	16.13%	11.17%	12.50%	8.80%	15.29%	15.509%
	B4	14.33%	8.19%	9.65%	41.67%	6.12%	40.65%	8.29%	9.17%	37.12%	6.63%	43.58%	34.82%	22.44%	9.63%	19.14%	12.99%	6.12%	12.50%	8.80%	6.86%	17.934%
B1	C1	87.61%	87.61%	75.00%	50.00%	90.05%	50.00%	75.09%	87.50%	75.09%	83.33%	24.91%	50.00%	75.09%	50.00%	90.05%	83.33%	50.00%	90.05%	50.00%	83.33%	70.402%
	C2	12.39%	12.39%	25.00%	50.00%	9.96%	50.00%	24.91%	12.50%	24.91%	16.67%	75.09%	50.00%	24.91%	50.00%	9.96%	16.67%	50.00%	9.96%	50.00%	16.67%	29.598%
B2	C3	47.23%	39.56%	50.00%	37.50%	62.51%	29.95%	39.93%	62.09%	46.61%	17.90%	31.21%	38.22%	48.51%	44.41%	69.12%	53.92%	66.30%	23.67%	32.06%	59.39%	45.004%
	C4	35.28%	39.56%	16.67%	37.50%	26.95%	50.00%	35.76%	20.75%	6.60%	38.78%	41.00%	43.22%	16.13%	44.41%	9.61%	9.30%	15.66%	6.06%	32.06%	21.88%	27.357%
	C5	11.69%	9.16%	16.67%	12.50%	5.27%	9.51%	16.02%	9.07%	8.52%	30.45%	24.35%	9.93%	22.38%	5.26%	10.12%	28.20%	5.45%	30.29%	28.49%	9.36%	15.135%
	C6	5.80%	11.73%	16.67%	12.50%	5.27%	10.54%	8.29%	8.10%	38.27%	12.87%	3.44%	8.64%	12.99%	5.92%	11.16%	8.58%	12.59%	39.99%	7.39%	9.36%	12.505%
B3	C7	43.55%	74.61%	42.86%	42.86%	45.46%	60.08%	33.33%	72.42%	71.43%	74.85%	47.39%	42.90%	42.90%	33.33%	64.43%	45.46%	33.33%	77.89%	43.55%	33.33%	51.298%
	C8	48.68%	11.95%	42.86%	14.29%	45.46%	19.96%	33.33%	19.33%	14.29%	18.05%	47.39%	14.20%	42.90%	33.33%	28.24%	45.46%	33.33%	11.05%	48.68%	33.33%	30.305%
	C9	7.78%	13.44%	14.29%	42.86%	9.09%	19.96%	33.33%	8.25%	14.29%	7.10%	5.23%	42.90%	14.20%	33.33%	7.33%	9.09%	33.33%	11.05%	7.78%	33.33%	18.398%
B4	C10	19.96%	74.61%	42.86%	33.33%	77.89%	63.40%	42.90%	22.98%	48.68%	47.98%	47.39%	33.33%	42.84%	47.39%	19.96%	14.20%	71.43%	81.87%	51.10%	71.43%	47.775%
	C11	19.96%	11.95%	14.29%	33.33%	11.05%	10.60%	14.20%	7.63%	7.78%	11.46%	5.23%	33.33%	14.18%	5.23%	19.96%	42.90%	14.29%	9.07%	9.93%	14.29%	15.533%
	C12	60.08%	13.44%	42.86%	33.33%	11.05%	26.00%	42.90%	69.39%	43.55%	40.57%	47.39%	33.33%	42.98%	47.39%	60.08%	42.90%	14.29%	9.07%	38.97%	14.29%	36.692%
C1	D1	41.88%	56.64%	30.00%	34.82%	67.34%	40.14%	36.53%	40.67%	69.12%	32.51%	24.17%	40.74%	47.41%	24.17%	12.17%	50.18%	30.45%	70.11%	44.02%	47.41%	42.023%
	D2	21.71%	28.00%	30.00%	44.82%	21.18%	17.02%	17.11%	31.30%	10.12%	19.14%	24.17%	24.51%	28.26%	24.17%	12.17%	26.28%	12.87%	9.97%	40.45%	28.26%	23.575%
	D3	8.09%	9.87%	10.00%	10.19%	5.74%	5.48%	9.83%	6.88%	9.61%	24.17%	32.51%	7.20%	12.17%	19.14%	47.41%	15.87%	38.78%	9.97%	8.09%	12.17%	15.157%
	D4	28.33%	5.49%	30.00%	10.19%	5.74%	37.36%	36.53%	21.15%	11.16%	24.17%	19.14%	27.55%	12.17%	32.51%	28.26%	7.67%	17.90%	9.97%	7.45%	12.17%	19.245%
C2	D5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	100.000%
C3	D6	14.20%	74.61%	42.86%	10.62%	33.33%	19.96%	60.08%	71.43%	26.69%	42.90%	51.10%	33.33%	60.08%	14.20%	14.20%	60.08%	33.33%	47.39%	51.10%	14.20%	38.784%
	D7	42.90%	11.95%	14.29%	26.05%	33.33%	60.08%	19.96%	14.29%	6.36%	42.90%	9.93%	33.33%	19.96%	42.90%	42.90%	19.96%	33.33%	5.23%	38.97%	42.90%	28.076%
	D8	42.90%	13.44%	42.86%	63.34%	33.33%	19.96%	19.96%	14.29%	66.96%	14.20%	38.97%	33.33%	19.96%	42.90%	42.90%	19.96%	33.33%	47.39%	9.93%	42.90%	33.140%

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Annex X: Evaluation Results (Weights) and Averages of 20 Experts (Continued)

Judgment matrix code	Indicator code	Expert code																				Average value
		001	003	005	006	007	008	009	010	011	013	014	016	017	018	019	020	021	022	023	024	
C4	D9	15.79%	74.61%	33.33%	10.62%	33.33%	23.03%	60.08%	60.00%	9.67%	23.03%	81.87%	60.08%	60.08%	46.71%	14.20%	47.98%	19.96%	77.89%	42.90%	14.20%	40.468%
	D10	65.60%	13.44%	33.33%	26.05%	33.33%	7.65%	19.96%	20.00%	10.47%	7.65%	9.07%	19.96%	19.96%	46.71%	42.90%	11.46%	60.08%	11.05%	42.90%	42.90%	27.223%
	D11	18.62%	11.95%	33.33%	63.34%	33.33%	69.32%	19.96%	20.00%	79.87%	69.32%	9.07%	19.96%	19.96%	6.58%	42.90%	40.57%	19.96%	11.05%	14.20%	42.90%	32.309%
C5	D12	50.00%	83.33%	50.00%	25.00%	50.00%	75.09%	75.09%	25.00%	16.67%	50.00%	50.00%	50.00%	75.09%	50.00%	75.09%	83.33%	50.00%	90.05%	50.00%	24.91%	54.933%
	D13	50.00%	16.67%	50.00%	75.00%	50.00%	24.91%	24.91%	75.00%	83.33%	50.00%	50.00%	50.00%	24.91%	50.00%	24.91%	16.67%	50.00%	9.96%	50.00%	75.09%	45.067%
C6	D14	50.00%	50.00%	50.00%	25.00%	50.00%	75.09%	75.09%	50.00%	16.67%	83.33%	50.00%	24.81%	50.00%	50.00%	75.09%	25.00%	50.00%	12.39%	75.09%	50.00%	49.379%
	D15	50.00%	50.00%	50.00%	75.00%	50.00%	24.91%	24.91%	50.00%	83.33%	16.67%	50.00%	75.19%	50.00%	50.00%	24.91%	75.00%	50.00%	87.61%	24.91%	50.00%	50.621%
C7	D16	6.26%	50.00%	8.41%	4.28%	8.24%	9.91%	29.45%	8.44%	3.19%	7.84%	29.96%	11.25%	11.87%	3.60%	9.78%	10.77%	25.00%	23.19%	19.08%	15.23%	14.788%
	D17	19.26%	10.00%	21.91%	8.35%	21.93%	11.19%	14.30%	25.44%	24.98%	15.70%	34.51%	11.25%	26.61%	20.63%	25.46%	10.77%	35.85%	4.72%	15.76%	15.23%	18.692%
	D18	13.50%	10.00%	10.79%	11.90%	21.93%	11.19%	14.86%	12.92%	10.75%	11.21%	4.88%	16.04%	26.64%	15.94%	15.54%	9.26%	22.32%	2.52%	11.20%	15.23%	13.430%
	D19	38.07%	10.00%	25.24%	25.16%	21.93%	25.49%	17.76%	26.28%	23.81%	26.02%	4.88%	22.71%	14.67%	17.29%	15.54%	35.92%	5.42%	23.19%	24.67%	30.23%	21.713%
	D20	15.34%	10.00%	25.24%	25.16%	21.93%	5.88%	17.76%	18.48%	15.27%	21.02%	4.88%	16.04%	14.67%	23.03%	15.37%	27.99%	5.42%	23.19%	10.72%	11.93%	16.465%
	D21	7.57%	10.00%	8.41%	25.16%	4.05%	36.34%	5.87%	8.44%	22.02%	18.22%	20.87%	22.71%	5.54%	19.51%	18.32%	5.29%	6.00%	23.19%	18.57%	12.16%	14.912%
C8	D22	45.08%	19.06%	14.29%	42.86%	20.00%	14.78%	35.59%	28.26%	8.61%	43.51%	23.91%	27.87%	40.65%	31.45%	26.72%	15.24%	24.95%	17.12%	24.67%	13.05%	25.883%
	D23	11.22%	22.70%	14.29%	14.29%	20.00%	19.26%	35.59%	28.26%	36.80%	6.28%	23.91%	18.98%	26.85%	31.45%	40.41%	27.37%	30.09%	36.95%	24.67%	19.20%	24.428%
	D24	9.52%	10.19%	14.29%	14.29%	20.00%	14.78%	15.83%	12.05%	5.62%	6.28%	20.05%	15.18%	10.83%	3.47%	18.21%	27.37%	9.08%	4.73%	15.86%	46.76%	14.719%
	D25	8.26%	19.04%	14.29%	14.29%	20.00%	14.78%	9.28%	12.05%	9.39%	14.46%	2.81%	18.98%	10.83%	3.66%	5.25%	7.46%	5.79%	4.73%	15.86%	9.21%	11.020%
	D26	25.91%	29.02%	42.86%	14.29%	20.00%	36.40%	3.71%	19.37%	39.59%	29.47%	29.32%	18.98%	10.83%	29.97%	9.42%	22.56%	30.09%	36.47%	18.95%	11.79%	23.950%
C9	D27	60.08%	19.96%	33.33%	10.62%	19.96%	63.40%	63.40%	19.96%	9.09%	26.00%	77.89%	33.33%	14.20%	33.33%	33.33%	26.00%	33.33%	23.03%	33.33%	47.98%	34.078%
	D28	19.96%	19.96%	33.33%	26.05%	19.96%	10.60%	26.00%	19.96%	45.46%	63.40%	11.05%	33.33%	42.90%	33.33%	33.33%	63.40%	33.33%	7.65%	33.33%	11.46%	29.390%
	D29	19.96%	60.08%	33.33%	63.34%	60.08%	26.00%	10.60%	60.08%	45.46%	10.60%	11.05%	33.33%	42.90%	33.33%	33.33%	10.60%	33.33%	69.32%	33.33%	40.57%	36.532%
C10	D30	47.98%	47.98%	33.33%	9.09%	60.08%	19.96%	60.08%	42.90%	16.77%	47.98%	51.10%	33.33%	33.33%	23.03%	33.33%	65.60%	47.98%	22.98%	33.33%	47.98%	38.906%
	D31	11.46%	11.46%	33.33%	45.46%	19.96%	19.96%	19.96%	42.90%	9.38%	11.46%	38.97%	33.33%	33.33%	7.65%	33.33%	15.79%	11.46%	7.63%	33.33%	11.46%	22.580%
	D32	40.57%	40.57%	33.33%	45.46%	19.96%	60.08%	19.96%	14.20%	73.85%	40.57%	9.93%	33.33%	33.33%	69.32%	33.33%	18.62%	40.57%	69.39%	33.33%	40.57%	38.514%

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Annex X: Evaluation Results (Weights) and Averages of 20 Experts (Continued)

Judgment matrix code	Indicator code	Expert code																				Average value
		001	003	005	006	007	008	009	010	011	013	014	016	017	018	019	020	021	022	023	024	
C11	D33	33.33%	42.90%	14.29%	9.09%	33.33%	18.05%	42.90%	47.98%	7.78%	33.33%	11.46%	33.33%	42.90%	6.58%	42.90%	19.33%	33.33%	14.20%	19.96%	33.33%	27.015%
	D34	33.33%	14.20%	42.86%	45.46%	33.33%	7.10%	14.20%	11.46%	43.55%	33.33%	47.98%	33.33%	14.20%	46.71%	14.20%	72.42%	33.33%	42.90%	19.96%	33.33%	31.859%
	D35	33.33%	42.90%	42.86%	45.46%	33.33%	74.85%	42.90%	40.57%	48.68%	33.33%	40.57%	33.33%	42.90%	46.71%	42.90%	8.25%	33.33%	42.90%	60.08%	33.33%	41.125%
C12	D36	63.40%	33.33%	20.00%	9.09%	33.33%	26.69%	33.33%	19.96%	10.47%	19.96%	81.87%	33.33%	26.00%	51.10%	33.33%	10.60%	45.46%	23.03%	33.33%	33.33%	32.047%
	D37	26.00%	33.33%	20.00%	45.46%	33.33%	6.36%	33.33%	60.08%	79.87%	60.08%	9.07%	33.33%	63.40%	38.97%	33.33%	63.40%	45.46%	69.32%	33.33%	33.33%	41.039%
	D38	10.60%	33.33%	60.00%	45.46%	33.33%	66.96%	33.33%	19.96%	9.67%	19.96%	9.07%	33.33%	10.60%	9.93%	33.33%	26.00%	9.09%	7.65%	33.33%	33.33%	26.914%
D23	E1	83.33%	50.00%	50.00%	50.00%	75.09%	75.09%	83.33%	75.09%	16.67%	24.91%	50.00%	50.00%	50.00%	90.05%	24.81%	75.09%	12.28%	87.61%	50.00%	24.91%	54.914%
	E2	16.67%	50.00%	50.00%	50.00%	24.91%	24.91%	16.67%	24.91%	83.33%	75.09%	50.00%	50.00%	50.00%	9.96%	75.19%	24.91%	87.72%	12.39%	50.00%	75.09%	45.086%
D26	E3	75.09%	50.00%	50.00%	50.00%	75.09%	50.00%	83.33%	50.00%	87.61%	50.00%	90.05%	83.33%	75.09%	50.00%	50.00%	50.00%	16.67%	24.91%	75.09%	50.00%	59.314%
	E4	24.91%	50.00%	50.00%	50.00%	24.91%	50.00%	16.67%	50.00%	12.39%	50.00%	9.96%	16.67%	24.91%	50.00%	50.00%	50.00%	83.33%	75.09%	24.91%	50.00%	40.687%
D27	E5	9.18%	7.07%	11.11%	4.76%	20.00%	4.95%	27.34%	14.75%	3.37%	11.21%	5.52%	6.47%	16.30%	3.90%	7.29%	46.81%	7.63%	4.97%	16.38%	8.08%	11.855%
	E6	9.18%	21.38%	11.11%	23.81%	20.00%	23.51%	34.41%	33.38%	25.78%	33.75%	21.31%	31.05%	13.94%	30.33%	5.94%	27.75%	25.82%	13.94%	25.19%	32.10%	23.183%
	E7	12.06%	19.01%	33.33%	23.81%	20.00%	27.38%	20.55%	27.67%	27.16%	27.43%	40.52%	21.45%	19.65%	30.33%	9.64%	3.81%	23.58%	23.46%	19.48%	29.29%	22.980%
	E8	47.40%	28.44%	33.33%	23.81%	20.00%	31.25%	12.57%	14.72%	32.96%	18.51%	5.05%	16.92%	36.17%	31.93%	45.26%	10.15%	19.40%	32.03%	19.48%	20.61%	25.000%
	E9	22.19%	24.10%	11.11%	23.81%	20.00%	12.90%	5.14%	9.48%	10.73%	9.09%	27.61%	24.11%	13.94%	3.53%	31.86%	11.47%	23.58%	25.60%	19.48%	9.92%	16.982%
D28	E10	39.66%	17.85%	26.56%	44.18%	36.40%	17.70%	31.15%	38.21%	13.51%	23.01%	31.92%	18.95%	25.60%	18.98%	32.40%	8.98%	21.26%	6.35%	30.61%	45.03%	26.416%
	E11	13.19%	7.38%	8.85%	6.31%	14.78%	5.67%	31.15%	12.88%	6.60%	15.72%	3.78%	15.86%	17.69%	18.98%	20.85%	16.33%	16.52%	31.00%	19.18%	12.21%	14.747%
	E12	27.13%	27.13%	22.12%	16.50%	19.26%	58.44%	19.55%	30.77%	36.49%	23.01%	28.74%	24.67%	39.39%	27.87%	31.49%	52.09%	24.96%	29.46%	19.18%	18.36%	28.830%
	E13	9.53%	33.45%	33.62%	16.50%	14.78%	9.09%	11.23%	9.24%	38.59%	28.73%	30.44%	15.86%	8.67%	18.98%	7.63%	17.79%	18.64%	29.46%	15.52%	12.21%	18.998%
	E14	10.48%	14.19%	8.85%	16.50%	14.78%	9.09%	6.92%	8.90%	4.81%	9.53%	5.12%	24.67%	8.67%	15.18%	7.63%	4.81%	18.64%	3.72%	15.52%	12.21%	11.009%
D29	E15	42.90%	60.08%	14.29%	71.43%	42.90%	26.69%	33.33%	60.08%	11.46%	33.33%	12.88%	47.98%	33.33%	5.88%	42.90%	45.46%	9.09%	23.03%	33.33%	18.62%	33.449%
	E16	42.90%	19.96%	42.86%	14.29%	42.90%	6.36%	33.33%	19.96%	40.57%	33.33%	76.53%	11.46%	33.33%	49.02%	42.90%	45.46%	45.46%	69.32%	33.33%	65.60%	38.442%
	E17	14.20%	19.96%	42.86%	14.29%	14.20%	66.96%	33.33%	19.96%	47.98%	33.33%	10.59%	40.57%	33.33%	45.10%	14.20%	9.09%	45.46%	7.65%	33.33%	15.79%	28.109%

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Annex Y: Weights and Ranking of PESC Indicators (AHP-based)

Criterion Layer	primary indicator	weight	secondary indicator	weight	tertiary indicator	weight	Level-4 indicator	weight	Syntheti c weight	Single Ranking	Total Ranking
PESC Index System	B1. Corporate Value	37.333%	C1 finance	70.402%	D1 Profitability	42.023%			11.045%	1	2
					D2 Operating Capability	23.575%			6.196%	2	3
					D3 Solvency	15.157%			3.984%	4	7
					D4 Development Capability	19.245%			5.058%	3	5
			C2 sustainability	29.598%	D5 ESG Rating Results	100.000%			11.050%	1	1
	B2. Stakeholders	29.223%	C3 customer	45.004%	D6 Customer Satisfaction	38.784%			5.101%	1	4
					D7 Customer Fit	28.076%			3.692%	3	8
					D8 Customer Contribution	33.140%			4.358%	2	6
			C4 workforce	27.357%	D9 Workforce Satisfaction	40.468%			3.235%	1	11
					D10 Workforce Fit	27.223%			2.176%	3	15
					D11 Workforce Contribution	32.309%			2.583%	2	13
			C5 supplier/partner	15.135%	D12 Supplier/Partner Satisfaction	54.933%			2.430%	1	14
					D13 Supplier/Partner Contribution	45.067%			1.993%	2	17
			C6 rule maker/community	12.505%	D14 Rule maker/Community Satisfaction	49.379%			1.804%	2	20
					D15 Rule maker/Community Contribution	50.621%			1.850%	1	19
			C7 operation	51.298%	D16 Brand Management	14.788%			1.177%	5	27
					D17 Customer/Market Development	18.692%			1.487%	2	23
					D18 Customer Relationship Management	13.430%			1.068%	6	29
					D19 Product/Service Production	21.713%			1.727%	1	22
					D20 Product Sales/Service Delivery	16.465%			1.310%	3	24
					D21 Operational Risk Management	14.912%			1.186%	4	26
			C8 innovation	30.305%	D22 Innovation Input	25.883%			1.217%	1	25
					D23 Innovation Capability	24.428%	E1 Workforce Skills	54.914%	0.630%	4	34
							E2 IP Capability	45.086%	0.518%	5	35
					D24 Innovation Activities	14.719%			0.692%	2	32
					D25 Collaborative Innovation	11.020%			0.518%	6	36

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Annex Y: Weights and Ranking of PESC Indicators (AHP-based) (Continued)

Criterion Layer	primary indicator	weight	secondary indicator	weight	tertiary indicator	weight	Level-4 indicator	weight	Synthetic weight	Single Ranking	Total Ranking
PESC Index System	B3. Internal Processes	15.509%	C8 innovation	30.305%	D26 Innovation Output	23.950%	E3 Product Innovation	59.314%	0.668%	3	33
							E4 Business Process Innovation	40.687%	0.458%	7	37
			C9 ESG	18.398%	D27 Environment	34.078%	E5 Climate Change	11.855%	0.115%	5	48
							E6 Energy & Resources	23.183%	0.225%	2	43
							E7 Pollutant Emissions	22.980%	0.223%	3	44
							E8 Negative Environmental Events	25.000%	0.243%	1	41
							E9 Environmental Governance Opportunities	16.982%	0.165%	4	46
					D28 Society	29.390%	E10 Employment	26.416%	0.222%	2	45
							E11 Community Support	14.747%	0.124%	4	49
							E12 Product Liability	28.830%	0.242%	1	42
							E13 Stakeholder Controversies	18.998%	0.159%	3	47
							E14 Social Responsibility Opportunities	11.009%	0.092%	5	50
					D29 Governance	36.532%	E15 Governance Responsibility	33.449%	0.349%	2	39
							E16 Legal Responsibility	38.442%	0.401%	1	38
							E17 Business Ethics	28.109%	0.293%	3	40
	B4. Learning and Growth	17.934%	C10 human capital	47.775%	D30 Workforce Capabilities & Capacity	38.906%			3.333%	1	9
					D31 Workforce Climate & Equity	22.580%			1.935%	3	18
					D32 Workforce Learning & Growth	38.514%			3.300%	2	10
			C11 digital capital	15.533%	D33 Digitalte Thnology	27.015%			0.753%	3	31
					D34 Digitization/Intelligence	31.859%			0.887%	2	30
					D35 Organizational Knowledge	41.125%			1.146%	1	28
			C12 organizational capital	36.692%	D36 Culture	32.047%			2.109%	2	16
					D37 Leadership	41.039%			2.700%	1	12
					D38 Strategic Synerty	26.914%			1.771%	3	21

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Annex Z: Weights and Ranking of PESC Indicators (Based on AHP-EM)

Criterion Layer	primary indicator (B)	weight (AHP-EVM)	secondary indicator (C)	weight (AHP-EVM)	tertiary indicator(D)				Level-4 indicator(E)				Ranking	
					Terms	weight (AHP)	weight (EVM)	weight (AHP-EVM)	Terms	weight (AHP)	weight (EVM)	weight (AHP-EVM)	Single Ranking	Total Ranking
PESC Index System	B1. Corporate Value	0.2153	C1 finance	0.1509	D1 Profitability	0.11045	0.01618	0.0575					1	2
					D2 Operating Capability	0.06196	0.01419	0.0351					2	3
					D3 Solvency	0.03984	0.01897	0.0281					4	7
					D4 Development capability	0.05058	0.01429	0.0302					3	5
			C2 sustainability	0.0644	D5 ESG Rating Results	0.11050	0.02845	0.0644					1	1
	B2. Stakeholders	0.2284	C3 customer	0.0856	D6 Customer Satisfication	0.05101	0.01163	0.0289					2	6
					D7 Customer Fit	0.03692	0.02609	0.0308					1	4
					D8 Customer Contribution	0.04358	0.01205	0.0259					3	8
			C4 workforce	0.0605	D9 Workforce Satisfaction	0.03235	0.01447	0.0223					1	15
					D10 Workforce Engagement	0.02176	0.01558	0.0183					3	24
					D11 Workforce Contribution	0.02583	0.01533	0.0199					2	21
			C5 supplier/partner	0.0346	D12 Supplier/Partner Satisfaction	0.02430	0.01426	0.0187					1	23
					D13 Supplier/Partner Contribution	0.01993	0.01278	0.0159					2	30
			C6 rulemaker/community	0.0477	D14 Rulemaker/Community Satisfaction	0.01804	0.02999	0.0248					1	9
					D15 Rulemaker/Community Contribution	0.01850	0.02632	0.0229					2	12
			C7 operation	0.1104	D16 Brand Management	0.01177	0.02071	0.0168					4	27
					D17 Customer/Market Development	0.01487	0.01724	0.0162					5	29
					D18 Customer Relationship Management	0.01068	0.01373	0.0124					6	44
					D19 Product/Service Production	0.01727	0.02552	0.0219					2	16
					D20 Product Sales/Service Delivery	0.01310	0.02666	0.0207					3	19
					D21 Operational Risk Management	0.01186	0.03051	0.0223					1	14
					D22 Innovation Input	0.01217	0.01712	0.0150					4	33
			C8 innovation	0.1063	D23 Innovation Capability			0.0293	E1 Workforce Skills	0.00630	0.01980	0.0139	1	36
									E2 IP Capability	0.00518	0.02346	0.0154		31
					D24 Innovation Activities	0.00692	0.01951	0.0140					5	35
					D25 Collaborative Innovation	0.00518	0.02977	0.0190					3	22

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Annex Z: Weights and Ranking of PESC Indicators (Based on AHP-EM) (Continued)

Criterion Layer	primary indicator (B)	weight (AHP-EVM)	secondary indicator (C)	weight (AHP-EVM)	tertiary indicator(D) Terms	weight (AHP)	weight (EVM)	weight (AHP-EVM)	Level-4 indicator(E) Terms	weight (AHP)	weight (EVM)	weight (AHP-EVM)	Ranking Single Ranking	Total Ranking
PESC Index System	B3. Internal Processes	0.3734	C8 innovation	0.1063	D26 Innovation Output			0.0291	E3 Product Innovation	0.00668	0.01920	0.0137	2	37
									E4 Business Process Innovation	0.00458	0.02375	0.0154		32
			C9 ESG	0.1567	D27 Environment			0.0659	E5 Climate Change	0.00115	0.02401	0.0140	1	34
									E6 Energy & Resources	0.00225	0.02050	0.0125	5	43
									E7 Pollutant Emissions	0.00223	0.02127	0.0129	3	40
									E8 Negative Environmental Events	0.00243	0.02247	0.0137	2	38
									E9 Environmental Governance Opportunities	0.00165	0.02152	0.0128	4	42
									E10 Employment	0.00222	0.01490	0.0093	5	50
									E11 Community Support	0.00124	0.02203	0.0129	2	41
					D28 Society			0.0578	E12 Product Liability	0.00242	0.01596	0.0100	4	49
									E13 Stakeholder Controversies	0.00159	0.02229	0.0132	1	39
									E14 Social Responsibility Opportunities	0.00092	0.02108	0.0122	3	45
									E15 Governance Responsibility	0.00349	0.01756	0.0114	1	46
					D29 Governance			0.0331	E16 Legal Responsibility	0.00401	0.01648	0.0110	2	47
									E17 Business Ethics	0.00293	0.01683	0.0107	3	48
	B4. Learning and Growth	0.1829	C10 human capital	0.0634	D30 Workforce Capabilities & Capacity	0.03333	0.01573	0.0234					1	10
					D31 Workforce Equities & Atmosphere	0.01935	0.01454	0.0166					3	28
					D32 Workforce Learning & Growth	0.03300	0.01568	0.0233					2	11
			C11 digital capital	0.0608	D33 Digital Technology	0.00753	0.03455	0.0227					1	13
					D34 Digitization/Intelligence	0.00887	0.03060	0.0211					2	17
					D35 Organizational Knowledge	0.01146	0.02135	0.0170					3	26
			C12 organizational capital	0.0587	D36 Culture	0.02109	0.02105	0.0211					1	18
					D37 Leadership	0.02700	0.01450	0.0200					2	20
					D38 Strategic Synergy	0.01771	0.01753	0.0176					3	25

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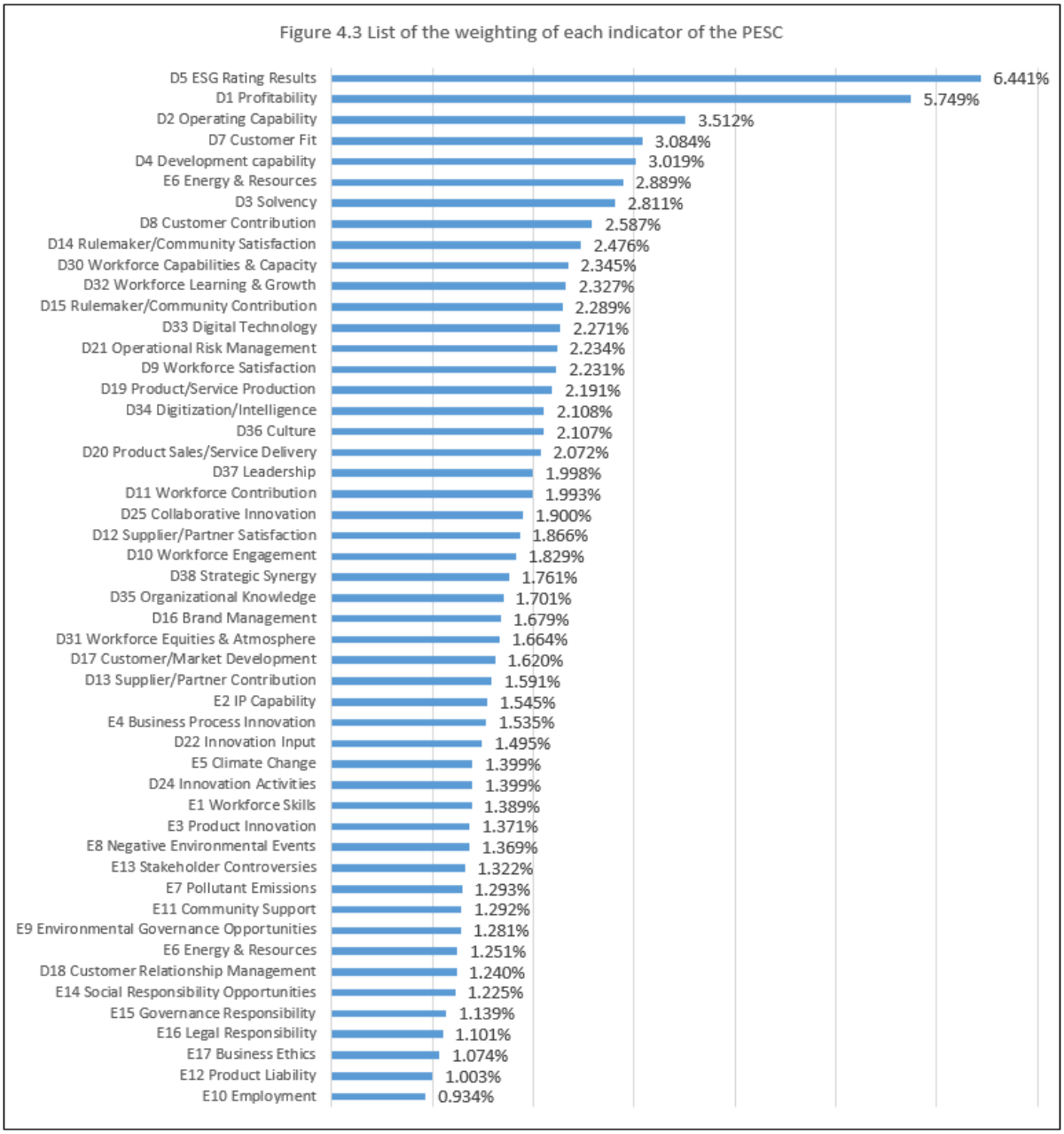
Annex AA: Ranking of PESC Indicator Weights



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Annex AB: Distribution of Sample Enterprises

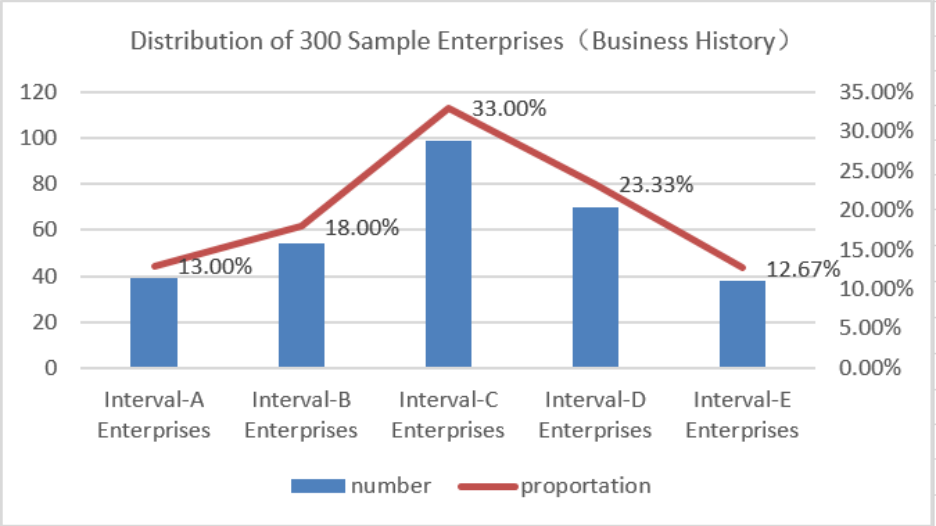

Figure AB.1: Distribution of sample enterprises (business history)

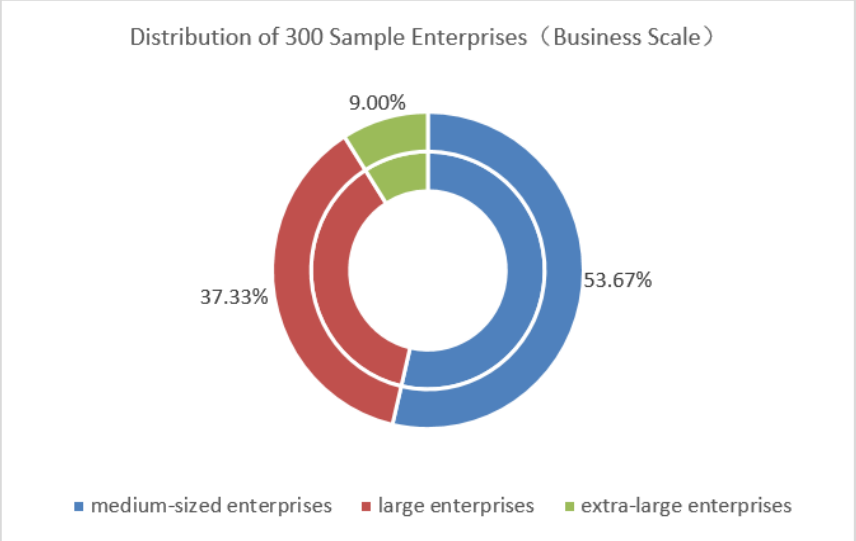

Figure AB.2: Distribution of sample enterprises (business scale)

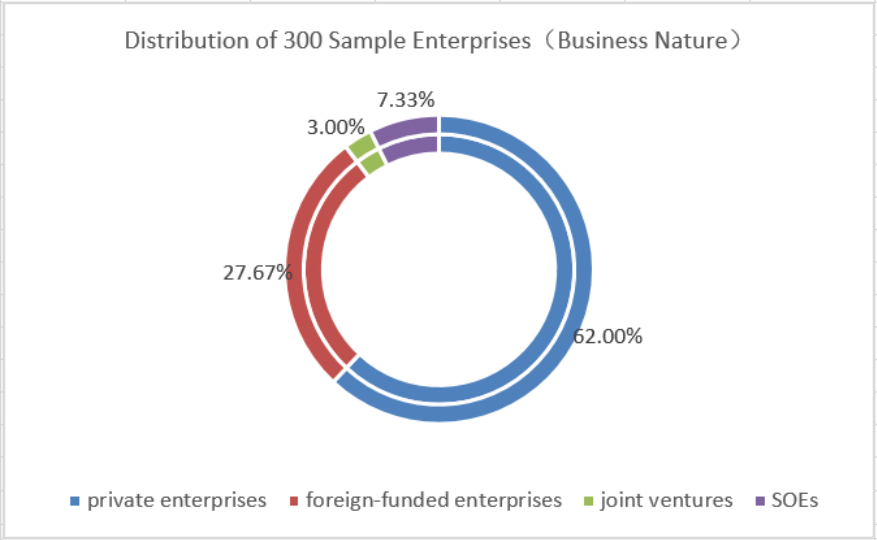

Figure AB.3: Distribution of sample enterprises (business nature)

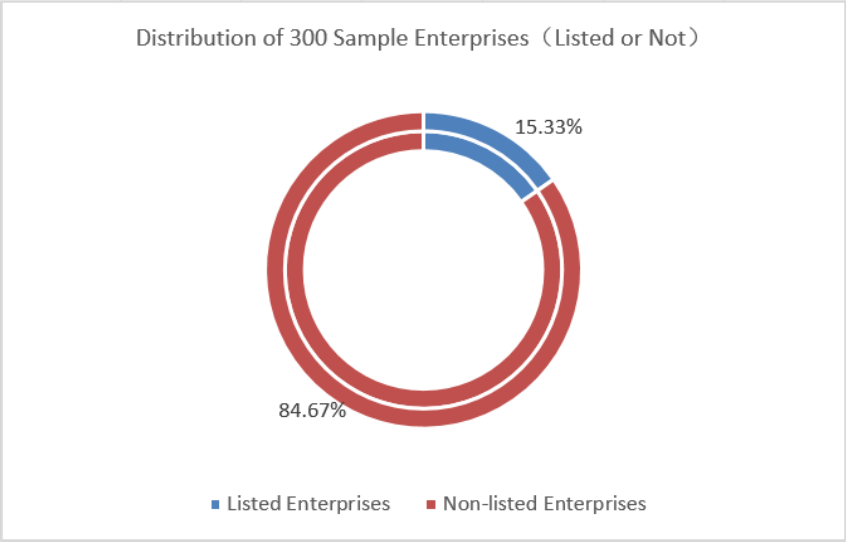

Figure AB.4: Distribution of sample enterprises (listed or not)

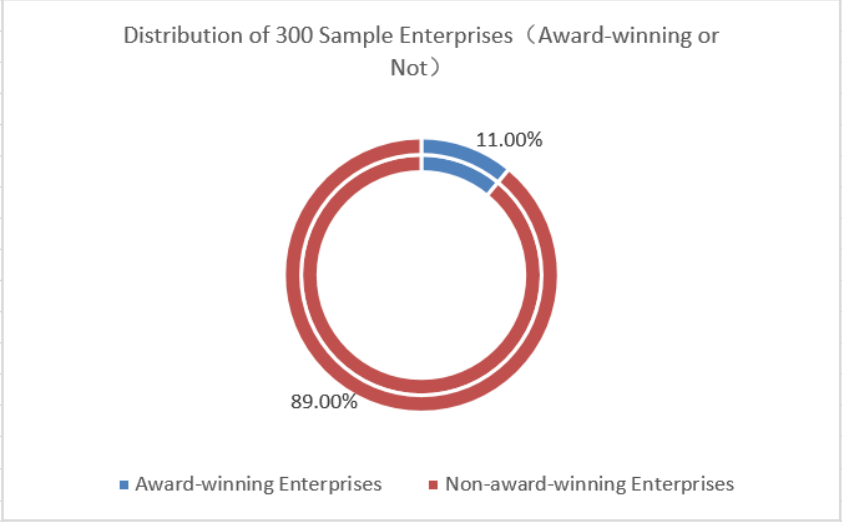

Figure AB.5: Distribution of sample enterprises (award-winning or not)

Annex AC: Corporate Management Maturity of Sample Enterprises

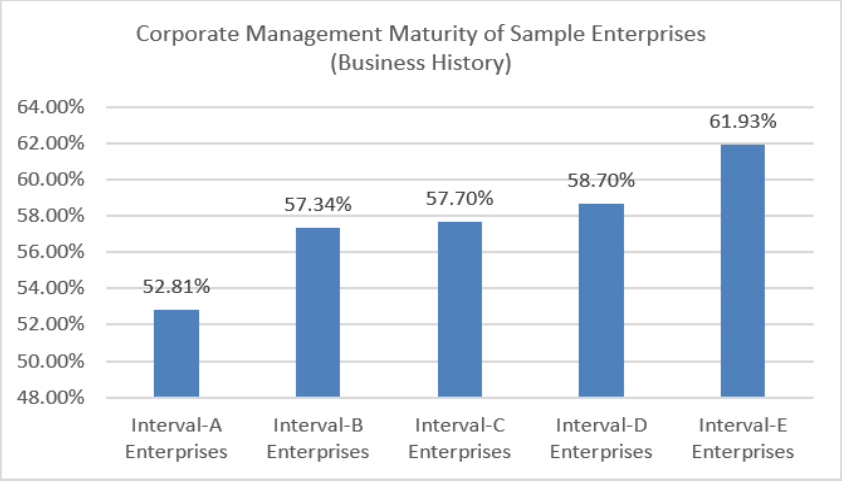

Figure AC.1: Corporate management maturity (business history)

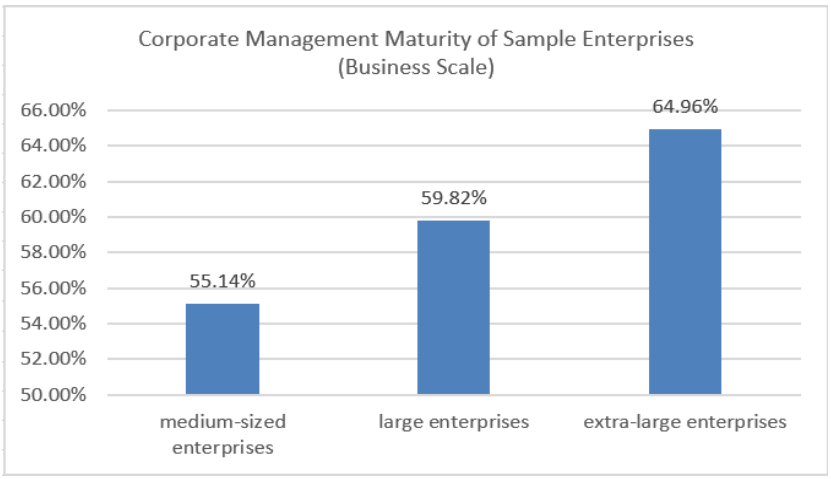

Figure AC.2: Corporate management maturity (business scale)

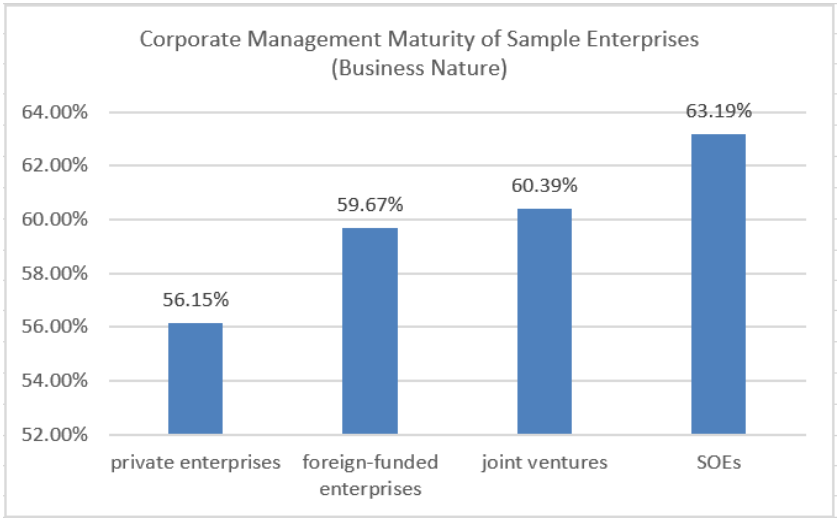

Figure AC.3: Corporate management maturity (business nature)

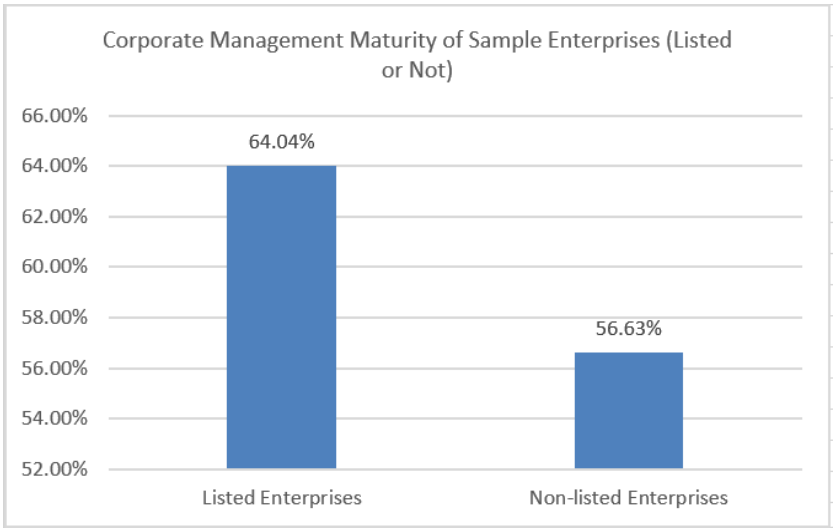

Figure AC.4: Corporate management maturity (listed or not)

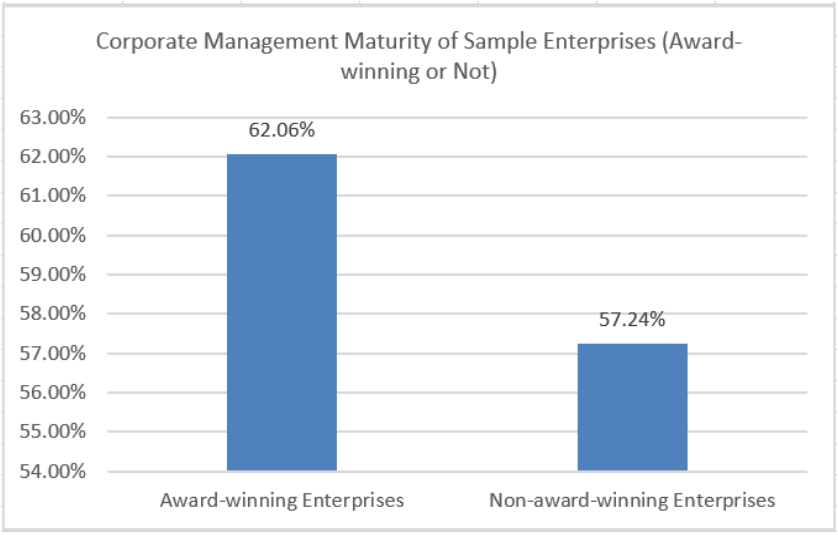

Figure AC.5: Corporate management maturity (award-winning or not)

Annex AD: Room for Improvement on Top 20

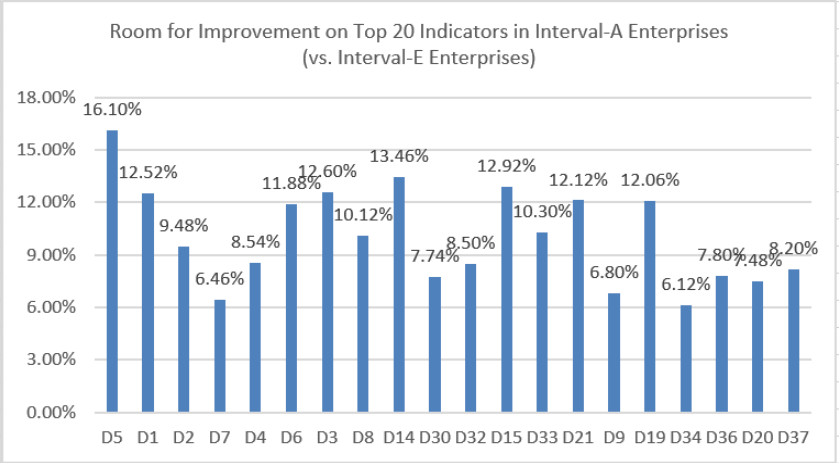

Figure AD.1: Room for improvement on top 20 indicators in interval-a enterprises (vs. interval-e enterprises)

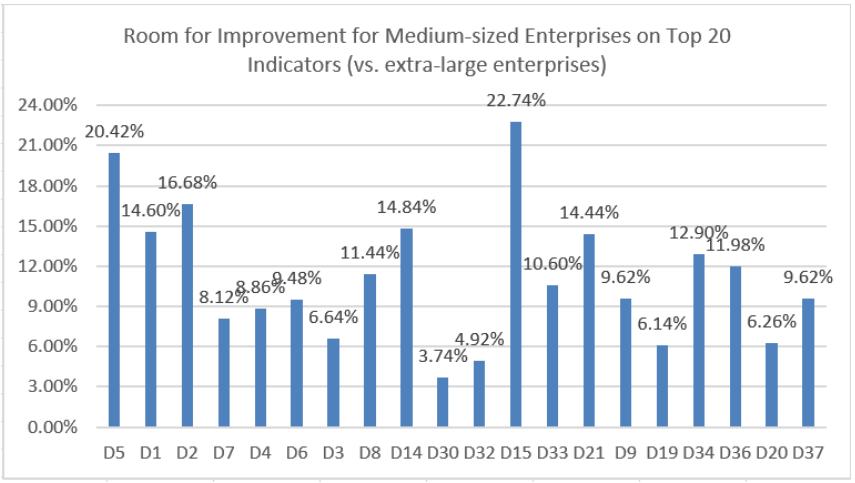

Figure AD.2: Room for improvement for medium-sized enterprises on top 20 indicators (vs. extra-large enterprises)

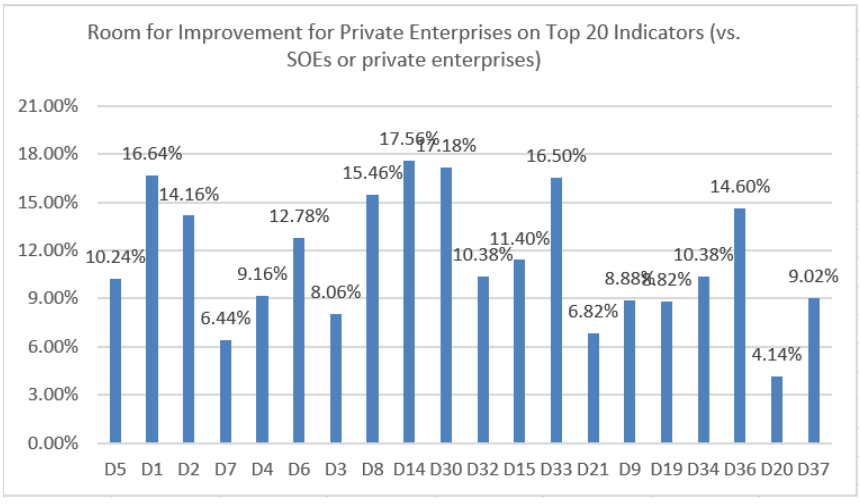

Figure AD.3: Room for improvement for private enterprises on top 20 indicators (vs. benchmark enterprises)

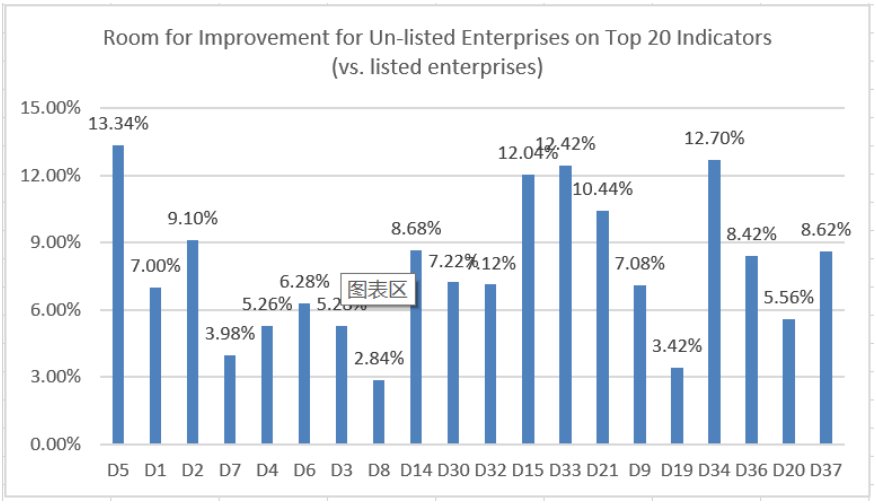

Figure AD.4: Room for improvement for un-listed enterprises on top 20 indicators (vs. listed enterprises)

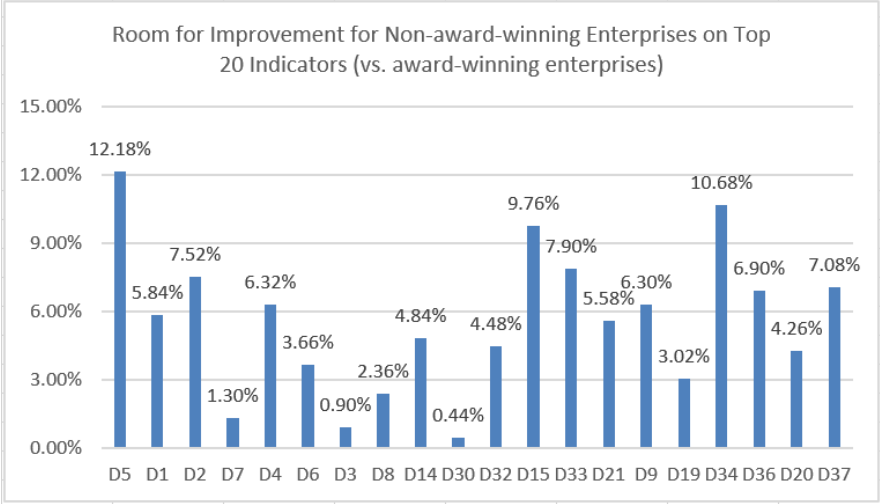

Figure AD.5: Room for improvement for non-award-winning enterprises on top 20 indicators (vs. award-winning enterprises)