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Financial Accounting Standards, Operating Performance, and Enterprise Value of Photovoltaic Companies Under the Context of Carbon Neutrality

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Abstract: In the context of the global transition to carbon neutrality, photovoltaic power generation has become an important driver of clean energy expansion. In response to the practical problems of inconsistent accounting standards in the photovoltaic industry and the fragmentation of related research dimensions, this paper examines the actual effects of financial accounting standardization on the operational costs, financial risks, financing efficiency, and market value of photovoltaic enterprises. Using 72-panel observation data on 12 A-share photovoltaic-listed companies from 2021 to 2026 as the research sample, a regression analysis was conducted using the two-way fixed-effects model. Based on the annual report text, the four standardized levels of cost accounting, risk control, green financing, and carbon asset disclosure were measured using a 1-5 Likert scale, and all continuous variables were subjected to 1% bilateral truncation. The regression results show that the coefficient of cost accounting standardization is -0.103, and the coefficient of financial risk control improvement is -0.138. Both are significantly reducing enterprise operational costs and asset-liability risks at the 1% statistical level. The coefficient of green financing diversification is 0.076, and the coefficient of carbon asset standardized disclosure is 0.105. Both are significantly improving enterprise financing efficiency and Tobin's Q valuation at the 1% statistical level. All research hypotheses are supported by the data. Based on the empirical findings, this paper proposes practical recommendations for cost allocation, risk warning, green financing, and carbon asset accounting. The related quantitative conclusions can provide an empirical basis for financial management in photovoltaic enterprises and for the formulation of industry accounting norms.

Keywords: Photovoltaic Enterprises, Financial Accounting Standardization, Financial Risk Management, Carbon Asset Accounting, Enterprise Value

1. Introduction

The global transition toward carbon neutrality has intensified the strategic importance of renewable energy industries, particularly photovoltaic power generation. Driven by international climate governance commitments, national dual-carbon roadmaps, and accelerated investment in clean-energy infrastructure, photovoltaic power has become a central pillar of the global energy transformation because of its low-carbon characteristics, scalability, and technological maturity (ElSayed et al., 2026). According to the International Energy Agency Photovoltaic Power Systems Program, newly installed global photovoltaic capacity reached approximately 698 GW in 2025, representing continued expansion in the sector, while cumulative installed photovoltaic capacity exceeded 3 TW by the beginning of 2026. In addition, solar photovoltaic installed capacity is expected to surpass coal-fired installed capacity by 2027, indicating a structural shift in the global power system. From the perspective of capital allocation, global clean-energy investment is projected to reach USD 665 billion in 2026, with photovoltaic projects representing a substantial proportion of renewable-energy investment. This trend demonstrates that photovoltaic enterprises are increasingly positioned at the intersection of energy transition, capital-market valuation, and financial governance (Qamar et al., 2026; Kunaifi, Alnuzipura, & Raghoebarsing, 2025; Sabry, Bıyıkoğlu, & Camdali, 2026; Belghouthi, Mensi, & Al Yahyaee, 2026).

Nevertheless, the rapid expansion of the photovoltaic industry has also created complex financial and accounting challenges. Unlike traditional manufacturing or conventional thermal-power enterprises, photovoltaic companies are commonly characterized by heavy fixed-asset investment, long project recovery cycles, high dependence on external financing, and strong sensitivity to policy incentives, raw-material price volatility, subsidy adjustments, and carbon-market mechanisms (Tudoroiu & Tudoroiu, 2026). These characteristics require accounting systems that can accurately capture life-cycle project costs, differentiated asset depreciation, subsidy-related revenue recognition, carbon asset measurement, and risk exposure across different stages of project development and operation. However, existing accounting practices in the photovoltaic sector remain inconsistent, particularly in relation to the allocation of shared infrastructure costs, treatment of carbon-emission reduction benefits, disclosure of green financing information, and establishment of dynamic financial-risk warning mechanisms (Bhardwaj et al., 2025; Takase et al., 2026).

In the context of China's A-share photovoltaic listed companies, these issues are especially significant. Large-scale photovoltaic projects often involve shared supporting facilities, includi-

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-ng public racks, inverters, transformers, access roads, and operation and maintenance

buildings. When such costs are allocated using simple average methods, the resulting accounting information may fail to reflect the actual resource consumption of different power-generation units. Similarly, when enterprises do not establish independent carbon asset accounts, the economic value of emission reductions may be absorbed into general business income or expenses, thereby weakening the transparency of carbon-related financial information. Furthermore, many photovoltaic operators continue to rely on static annual financial indicators for risk evaluation, rather than adopting dynamic systems that incorporate equipment depreciation, silicon-material price fluctuations, subsidy-policy changes, and carbon-market uncertainty. These limitations reduce the comparability, reliability, and decision-usefulness of financial information for investors, creditors, regulators, and enterprise managers (China Appraisal Society [CAS], 2022; IFRS Foundation, 2023a, 2023b).

Financial accounting standardization is therefore not only a technical accounting issue but also a governance mechanism that may influence enterprise performance and market value. More standardized cost accounting can improve the matching between resource consumption and project-level cost allocation, thereby supporting more accurate operating-cost control. A more complete financial-risk control system can strengthen debt monitoring, impairment recognition, cash-flow management, and early warning mechanisms. Diversified green financing channels can improve access to long-term capital and reduce excessive dependence on short-term borrowing. In addition, standardized carbon asset accounting and disclosure can reduce information asymmetry and signal the low-carbon competitiveness of photovoltaic enterprises to capital-market participants. These mechanisms suggest that accounting standardization may be closely associated with operating performance, financing efficiency, financial-risk exposure, and enterprise valuation (Imhof, Seavey, & Smith, 2017; Black, Godwin, & Harris, 2025) (add 2 to 3 citations here).

Although prior studies have examined photovoltaic finance, cost control, green financing, financial risk, and carbon accounting, the existing literature remains fragmented. First, studies on photovoltaic cost management have mainly focused on upstream manufacturing costs, silicon-material prices, component production, or the static cost estimation of single power-station projects. Limited attention has been paid to the allocation of shared infrastructure costs in large-scale photovoltaic bases or to the construction of a full life-cycle accounting framework covering project construction, operation, maintenance, and disposal (Onyekach, 2025). Second, research on photovoltaic financial risk has primarily relied on static indicators such as asset-liability ratio, liquidity ratio, and year-end financial position, while paying insufficient attention to dynamic risk mechanisms that integrate asset depreciation, raw-material price cycles, policy uncertainty, and equipment impairment (Barker & Mayer, 2025). Third, the green-financing literature has largely emphasized policy interpretation, green credit, and financing support, but has not sufficiently examined how diversified financing channels, including green bonds, carbon funds, and asset securitization, may influence financing efficiency in photovoltaic enterprises (Shen, Lyu, & Zhu, 2022). Fourth, studies on carbon accounting in the renewable-energy sector have often focused on carbon-emission reduction measurement, while giving limited attention to the recognition, measurement, fair-value adjustment, and continuous disclosure of carbon assets within enterprise financial reporting systems (Dsouza, Krishnamoorthy, Kayani, Nawaz, & Hasan, 2025; Deshayes & Brown, 2026).

To address these gaps, this study develops an integrated framework linking financial accounting standardization with operating performance, financial risk, financing efficiency, and enterprise value in photovoltaic listed companies. Unlike prior research that examines cost accounting, risk control, green financing, or carbon asset disclosure as separate research streams, this study integrates these four dimensions into a unified empirical model. Specifically, it examines whether the standardization of life-cycle cost accounting, the completeness of financial-risk control, the diversification of green financing, and the quality of carbon asset accounting and disclosure are associated with key enterprise outcomes. By using balanced panel data from Chinese A-share photovoltaic listed companies, the study provides empirical evidence on the financial and market consequences of accounting standardization in the renewable-energy sector.

Accordingly, this study is guided by four research questions. First, to what extent is life-cycle cost accounting standardization associated with the operating cost ratio of photovoltaic listed enterprises? Second, how does the completeness of financial-risk control relate to the financial risk level of photovoltaic enterprises, as reflected by the asset-liability ratio? Third, does diversification in green financing channels improve the financing efficiency of photovoltaic enterprises? Fourth, do standardized carbon asset accounting and disclosure contribute to higher enterprise market value, as measured by Tobin's Q? These questions are developed around the logic of cost, risk, financing, and carbon assets, thereby forming a coherent empirical pathway from industry-specific accounting challenges to enterprise-level financial and market outcomes.

This study contributes to the literature in three ways. First, it extends photovoltaic financial accounting research by moving beyond single-dimensional analysis and developing an integrated framework that connects cost accounting, financial-risk control, green financing, and carbon asset disclosure. Second, it contributes to renewable-energy finance research by examining how accounting standardization is associated with financing efficiency and enterprise valuation in a capital-intensive low-carbon industry. Third, it offers practical implications for photovoltaic enterprises, investors, creditors, and regulators by identifying accounting mechanisms that may improve financial transparency, risk management, capital access, and market recognition. In doing so, the study provides a basis for strengthening photovoltaic accounting standards and improving the quality of financial disclosure under the broader context of carbon neutrality.

2. Literature Review and Hypothesis Development

2.1. Financial Accounting Standardization in Photovoltaic Enterprises

The rapid expansion of the photovoltaic industry has increased the need for accounting systems that can reflect the economic substance of renewable-energy operations. Photovoltaic enterprises differ from conventional manufacturing and power-generation firms because their business models involve high initial capital expenditure, long asset recovery periods, complex depreciation structures, policy-dependent income streams, carbon-related benefits, and considerable exposure to external financing conditions. These characteristics require accounting practices that are capable of capturing project-level costs, asset impairment risks, subsidy-related revenue, financing structures, and carbon asset values with sufficient accuracy and comparability (Tudoroiu & Tudoroiu, 2026; Zhang & Wei, 2026).

Financial accounting standardization refers to the use of consistent, transparent, and comparable accounting rules for recognizing, measuring, allocating, and disclosing financial information. In the photovoltaic sector, standardization is particularly important because the economic performance of firms depends not only on electricity sales but also on construction costs, shared infrastructure, depreciation schedules, green financing arrangements, subsidy policies, and carbon-market participation. When accounting practices are inconsistent, financial statements may not accurately reflect the true cost structure, financial risk, financing capacity, or market value of photovoltaic enterprises. Consequently, investors, creditors, regulators, and enterprise managers may face difficulties in assessing firm performance and long-term value (Mueller & Mueller, 2024; Bhardwaj et al., 2025; Bai et al., 2026).

Table 1: Distinctive financial accounting characteristics of photovoltaic enterprises

# no	Classification of accounting characteristics	Detailed explanation of the content
1	Differential depreciation of fixed assets	The service life of photovoltaic modules is 25 years. The lifespan of floating supports and underwater corrosive auxiliary equipment is only 15-20 years. Uniform straight-line depreciation will overestimate the book value of the assets and lay the foundation for asset impairment risks.
2	The costs of public sharing are complex.	The shared facilities such as inverters, public roads, and operation and maintenance workshops for large-scale photovoltaic bases cannot be simply averaged to match the costs with the power generation of each unit. This leads to inaccurate project cost accounting.
3	The difficulties in double-income accounting	Operating income is divided into regular electricity sales revenue, various types of policy subsidies, and asset subsidies that need to be deferred for amortization. Revenue subsidies need to match the current costs. Mixed accounting will cause significant fluctuations in annual profits.
4	Carbon asset specific attributes	Photovoltaic power generation generates tradable carbon quotas, which are considered as independent intangible assets. Most enterprises do not have a separate account for carbon assets, and the value of carbon reduction cannot be fully reflected in the financial reports.
5	Long-term heavy reliance on financing	The payback period for large-scale photovoltaic power stations is 8 to 12 years. The projects are highly dependent on external financing. Incomplete risk control will continuously push up the debt-to-asset ratio. Changes in raw material prices and subsidy policies are likely to trigger capital chain risks.

Source: by the author

Existing studies have examined several aspects of photovoltaic finance and accounting, including project bankability, photovoltaic system cost estimation, financial-risk mitigation, green financing, and carbon-market participation (Jadidi et al., 2025; Ramiah et al., 2026; Wu, 2025). Nevertheless, these studies often treat cost control, risk management, financing, and carbon accounting as separate research domains. Such fragmentation limits the ability of the literature to explain how standardized accounting practices may influence enterprise-level outcomes through multiple financial channels. Therefore, a more integrated approach is required to examine whether accounting standardization is associated with operating cost control, financial-risk reduction, financing efficiency, and market valuation in photovoltaic listed companies.

2.2. Life-Cycle Cost Accounting Standardization and Operating Cost Ratio

Cost accounting is a central issue in photovoltaic enterprises because photovoltaic projects involve substantial expenditures during construction, operation, maintenance, and disposal. Unlike traditional firms, photovoltaic companies must account for equipment procurement, installation, grid connection, anti-corrosion treatment, land use, maintenance, inverter replacement, and decommissioning costs across a long project life cycle. In large-scale photovoltaic bases, shared supporting facilities such as racks, transformers, public roads, inverters, and operation and maintenance buildings further complicate cost allocation. If these shared costs are allocated using simple average methods, the resulting cost information may not match the actual resource consumption of different power-generation units (Ramiah et al., 2026).

The accounting matching principle suggests that costs should be recognized and allocated in accordance with the revenues and economic benefits they generate. From this perspective, life-cycle cost accounting can improve the accuracy of cost recognition by linking project expenditures to different stages of photovoltaic asset use. Standardized cost allocation can also reduce arbitrary classification between capitalized expenditures and current operating expenses. When enterprises adopt more systematic cost accounting rules, they are more likely to identify high-cost links, control unnecessary operating expenditures, and improve internal cost-management decisions (Ahmad, 2025, Ahmad et al., 2025)

In photovoltaic enterprises, standardized cost accounting may reduce the operating cost ratio through several mechanisms. First, it enables more accurate allocation of shared infrastructure costs to different project units. Second, it strengthens the distinction between construction expenditure, maintenance expenditure, and disposal-related expenditure. Third, it improves managerial visibility over cost drivers across the full project life cycle. Fourth, it allows enterprises to compare cost performance across projects and periods. Accordingly, firms with a higher degree of life-cycle cost accounting standardization are expected to have lower operating cost ratios.

H1: *The higher the standardization degree of full life-cycle cost accounting in photovoltaic enterprises, the lower the operating cost ratio of the enterprise.*

2.3. Financial Risk Control and Financial Risk Level

Photovoltaic enterprises are exposed to significant financial risk because of their heavy reliance on fixed assets, long repayment cycles, policy uncertainty, and dependence on external financing. Project development requires substantial capital before stable cash flows are generated, while revenue may be affected by electricity prices, subsidy adjustments, carbon-market fluctuations, equipment degradation, and raw-material price cycles. These conditions increase the importance of financial-risk identification, debt monitoring, asset impairment assessment, and cash-flow control (Jadidi et al., 2025; Yin et al., 2024).

Financial risk control refers to the ability of an enterprise to identify, evaluate, monitor, and respond to risks that may affect solvency, liquidity, asset value, and capital structure. In photovoltaic firms, a complete risk-control system should include both quantitative financial indicators and industry-specific non-financial indicators. Quantitative indicators include asset-liability ratio, current ratio, interest coverage ratio, and operating cash flow. Industry-specific indicators include silicon-material price volatility, subsidy-policy changes, carbon-price movements, technological replacement, equipment wear, and differentiated depreciation requirements. When risk control is limited to static year-end financial indicators, enterprises may fail to detect early signs of liquidity pressure, debt mismatch, or asset impairment (Yin et al., 2026; Zhang & Wei, 2026).

Asset impairment theory provides a useful explanation for the relationship between risk control and financial risk. Photovoltaic assets may lose value due to technological obsolescence, equipment corrosion, lower-than-expected power generation, or changes in market and policy conditions. If enterprises do not conduct timely impairment tests or apply appropriate depreciation policies, asset values may be overstated, while leverage and solvency risk may be underestimated. A more complete financial-risk control system can improve the recognition of asset deterioration, strengthen debt structure management, and support earlier intervention when risk indicators deteriorate. Therefore, enterprises with stronger financial-risk control mechanisms are expected to show lower financial risk levels.

H2: *The more complete the financial risk identification, assessment, and disposal mechanism of photovoltaic enterprises, the lower their financial risk level.*

2.4. Green Financing Diversification and Financing Efficiency

Green financing plays an increasingly important role in supporting renewable-energy investment. Because photovoltaic projects require large-scale upfront capital and have long payback periods, access to suitable financing channels is essential for sustainable enterprise growth. Traditional short-term bank loans may not match the cash-flow cycle of photovoltaic projects, creating repayment pressure and increasing liquidity risk. In contrast, green credit, green bonds, carbon funds, policy funds, and asset securitization can provide more flexible financing arrangements that better correspond to the long-term nature of photovoltaic investment (Fofana et al., 2025; Ramiah et al., 2026; Takase et al., 2026).

The pecking order theory of financing suggests that firms select financing sources according to information asymmetry, financing cost, and access constraints. In renewable-energy industries, transparent accounting information and credible carbon disclosure may reduce information asymmetry between enterprises and external capital providers. When photovoltaic firms disclose standardized cost data, risk-control information, project cash flows, and carbon-related financial information, banks and investors may have greater confidence in the firm’s repayment capacity and long-term value. This can improve access to green credit, lower financing barriers, and increase the ability to obtain funds through green bonds or carbon-oriented investment vehicles.

Diversification of green financing channels may improve financing efficiency in several ways. First, it reduces dependence on a single source of capital and lowers the risk of financing constraints. Second, it allows firms to match financing maturity with project recovery periods. Third, it can reduce capital costs when green financial instruments offer preferential rates or policy support. Fourth, it signals environmental credibility and strengthens investor confidence. Accordingly, photovoltaic enterprises with more diversified green financing channels are expected to obtain financing more efficiently and expand the scale of green debt financing relative to total assets.

H3: *The higher the degree of diversification of green financing channels, the higher the financing efficiency of photovoltaic enterprises.*

2.5. Carbon Asset Accounting Disclosure and Enterprise Market Value

Carbon asset accounting has become an important issue for renewable-energy enterprises because carbon-emission reduction benefits may generate measurable economic value. Photovoltaic power generation can contribute to emission reduction and may create tradable carbon-related benefits under carbon-market mechanisms. However, if these benefits are not separately recognized, measured, and disclosed, the financial statements of photovoltaic enterprises may fail to reflect the full economic value of low-carbon operations. This may reduce the usefulness of accounting information for investors and limit the valuation premium associated with carbon-neutral development (Wu, 2025; Liu et al., 2026).

Carbon information signaling theory suggests that firms can reduce information asymmetry and influence investor expectations by disclosing credible carbon-related information. In capital markets, investors increasingly consider environmental performance, carbon exposure, climate risk, and low-carbon transition capacity when evaluating firm value. When photovoltaic enterprises provide standardized disclosure on carbon asset recognition, measurement methods, fair-value adjustments, carbon-trading income, and annual emission reductions, they send a signal of stronger environmental governance and low-carbon competitiveness. This can increase investor confidence and improve market valuation.

The relationship between carbon asset disclosure and enterprise value is particularly relevant for photovoltaic listed companies. These firms operate in an industry directly connected to carbon neutrality, and their market value may be influenced by expectations regarding carbon-market participation, policy support, ESG performance, and future growth opportunities. Standardized carbon asset accounting can make the financial value of emission reductions more visible, while transparent disclosure can enhance the credibility of the firm’s low-carbon strategy. Therefore, photovoltaic enterprises with more complete carbon asset accounting and disclosure systems are expected to have higher market valuation, as reflected in Tobin’s Q.

H4: *The more standardized the carbon asset accounting and disclosure system is, the higher the market value of photovoltaic listed enterprises.*

2.6. Integrated Research Framework

Drawing on the accounting matching principle, asset impairment theory, pecking order theory, and carbon information signaling theory, this study develops an integrated framework linking financial accounting standardization with enterprise outcomes in the photovoltaic sector. The framework is based on four connected mechanisms. First, life-cycle cost accounting standardization is expected to improve cost allocation and reduce the operating cost ratio. Second, financial-risk control completeness is expected to strengthen debt monitoring, asset impairment recognition, and cash-flow management, thereby reducing financial risk. Third, green financing diversification is expected to improve financing efficiency by expanding access to suitable low-carbon capital. Fourth, carbon asset accounting and disclosure standardization are expected to enhance enterprise market value by reducing information asymmetry and signaling low-carbon competitiveness.

These four mechanisms reflect the specific accounting and financial conditions of photovoltaic enterprises. Because photovoltaic firms operate in a capital-intensive, policy-sensitive, and carbon-related industry, their performance cannot be fully explained through traditional cost or profitability indicators alone. Instead, cost management, risk control, financing access, and carbon asset disclosure should be examined together. This integrated perspective provides the basis for empirically testing how different dimensions of accounting standardization are associated with operating performance, financial risk, financing efficiency, and enterprise value.

2.7. Research Framework

This study develops an integrated research framework to examine the association between financial accounting standardization and enterprise-level financial outcomes among photovoltaic-listed companies. The framework is developed within the context of carbon neutrality, where photovoltaic enterprises face distinctive accounting and financial challenges related to life-cycle cost allocation, financial-risk control, green financing, and carbon asset disclosure.

The framework consists of four core explanatory variables and four corresponding dependent variables. First, the degree of standardization in cost accounting is expected to be negatively associated with the operating cost ratio. This relationship is based on the view that standardized full life-cycle cost accounting can improve cost allocation, distinguish capitalized and operating expenditures, and support more accurate cost control. Second, the completeness of the financial-risk control system is expected to be negatively associated with financial risk level. A more complete risk-control system may strengthen debt monitoring, depreciation management, impairment testing, and early warning mechanisms, thereby reducing asset-liability risk.

Third, the diversification level of green financing is expected to be positively associated with financing efficiency. Photovoltaic enterprises that use multiple green financing channels, such as green credit, green bonds, and carbon-related financing, may improve their ability to obtain financial resources and reduce dependence on a single source of capital. Fourth, the improvement degree of carbon asset accounting and disclosure is expected to be positively associated with enterprise market value. Standardized carbon asset recognition, measurement, and disclosure may enhance the visibility of low-carbon value creation and improve investor recognition, as reflected in Tobin's Q. The framework also includes four control variables: enterprise size, years since listing, enterprise growth potential, and operating cash flow level. These variables are included because firm scale, listing experience, revenue growth, and cash-flow strength may influence operating cost, financial risk, financing efficiency, and market value. Therefore, the research framework links accounting standardization with enterprise outcomes while controlling for key firm-level characteristics.

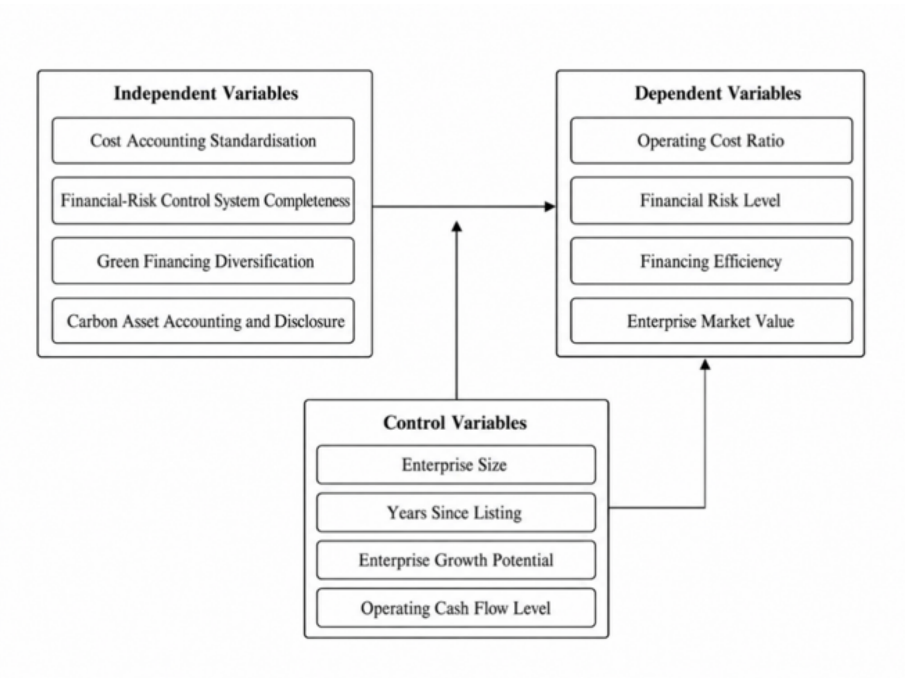

Figure 1: Research framework

3. Research Methodology

3.1. Research Design

This study adopts a quantitative panel-data research design to examine the relationship between financial accounting standardization and enterprise-level financial outcomes in the photovoltaic industry. A panel-data approach is suitable for this study because it allows the analysis to capture both cross-sectional differences among firms and time-based changes across the study period. The study focuses on four dimensions of financial accounting standardization: cost accounting standardization, completeness of financial risk control, green financing diversification, and carbon asset accounting and disclosure. These dimensions are examined in relation to four financial outcomes: operating cost ratio, financial risk level, financing efficiency, and enterprise market value.

3.2. Sample Selection and Data Sources

The study uses a balanced panel dataset of 12 A-share photovoltaic listed companies in China from 2021 to 2026, generating 72 firm-year observations. The selected companies cover major areas of the photovoltaic value chain, including silicon manufacturing, centralized photovoltaic operations, and distributed photovoltaic businesses. The original financial indicators were obtained from the Wind database. The four core explanatory variables were measured through textual disclosure in company annual reports and ESG reports using a 1–5 Likert scale. A higher score indicates a greater degree of accounting standardization, financial risk control completeness, green financing diversification, or carbon asset accounting disclosure. To reduce the influence of extreme values, all continuous variables were winsorized at the 1% level on both tails.

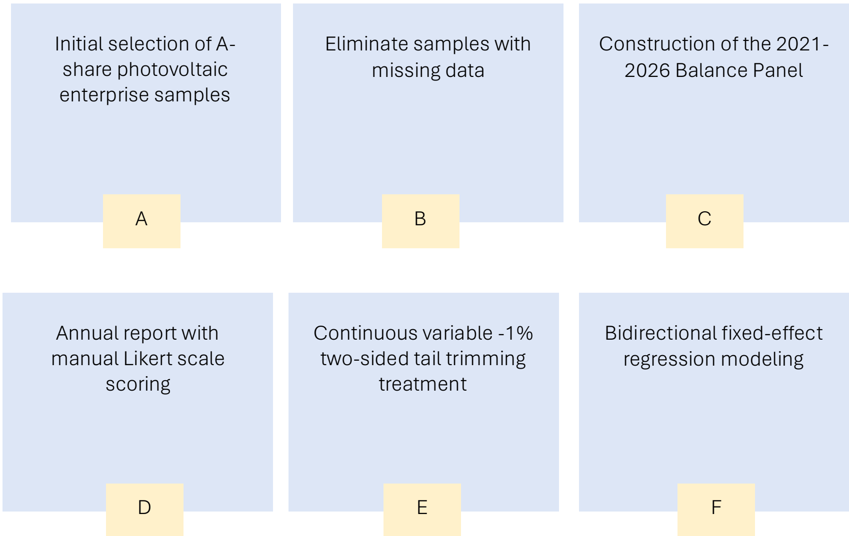

Figure 2: Sample selection, data preprocessing, and empirical modeling process

3.3. Variable Definition and Measurement

To ensure consistency in empirical testing, the variables are divided into three categories: dependent variables, core explanatory variables, and control variables. The dependent variables represent the four financial outcomes examined in the study. The core explanatory variables capture the four dimensions of financial accounting standardization, while the control variables account for firm-level characteristics that may influence the dependent variables.

Table 2: Definition and Calculation of Empirical Variables

Variable type	Variable name	Measurement standard	Corresponding hypothesis
Dependent variable	Operating cost ratio	Total operating costs of the enterprise in the current year / total assets of the enterprise at the end of the year	H1
Dependent variable	Financial risk level	Total liabilities of the enterprise at the end of the year / total assets at the end of the year, namely asset-liability ratio	H2
Dependent variable	Financing efficiency level	Green debt financing scale of the enterprise in the current year / total assets at the end of the year	H3
Dependent variable	Enterprise market value	Total market value of the enterprise at the end of the year / replacement cost of total assets, namely Tobin's Q	H4
Core explanatory variable	Standardisation degree of cost accounting	Scored using a 1–5 Likert scale based on cost accounting policies disclosed in annual reports. A higher score indicates a more standardised full life-cycle cost accounting and allocation system.	H1
Core explanatory variable	Completeness of the financial-risk control system	Scored using a 1–5 Likert scale based on risk management policies disclosed in annual reports. A higher score indicates a more complete risk identification, assessment, and disposal mechanism.	H2
Core explanatory variable	Diversification level of green financing	Scored using a 1–5 Likert scale based on the financing structure disclosed in annual reports. A higher score indicates more diversified financing channels, such as green credit and green bonds.	H3
Core explanatory variable	Improvement degree of carbon asset accounting and disclosure	Scored using a 1–5 Likert scale based on carbon accounting information disclosed in annual reports and ESG reports. A higher score indicates a more	H4

Variable type	Variable name	Measurement standard	Corresponding hypothesis
		standardised carbon asset confirmation, measurement, and disclosure system.	
Control variable	Enterprise size	Natural logarithm of total assets at the end of the year	—
Control variable	Years since listing	Number of consecutive years that the enterprise has been listed as of the end of the current year	—
Control variable	Enterprise growth potential	Year-on-year growth rate of operating revenue	—
Control variable	Operating cash flow level	Net cash flow generated from operating activities in the current year / total assets at the end of the year	—

Source: by the author

The operating cost ratio is used to measure the cost burden of photovoltaic enterprises relative to their asset scale. Financial risk level is measured by the asset-liability ratio, reflecting the degree of leverage and debt pressure. Financing efficiency is measured by the proportion of green debt financing to total assets, while enterprise market value is measured using Tobin's Q. The four core explanatory variables are based on accounting and disclosure practices, allowing the study to examine whether different dimensions of accounting standardization are associated with enterprise financial outcomes.

3.4. Empirical Model

To test the four hypotheses, this study applies a two-way fixed-effects regression model. The model controls for both individual firm effects and year effects. Firm fixed effects help control for unobserved firm-specific characteristics, while year fixed effects help control for time-related external influences affecting all firms in the same year. The empirical analysis estimates four separate models. The first model examines the relationship between cost accounting standardization and operating cost ratio. The second model examines the relationship between financial-risk control completeness and financial risk level. The third model examines the relationship between green financing diversification and financing efficiency. The fourth model examines the relationship between carbon asset accounting and disclosure and Tobin's Q. The control variables included in each model are enterprise size, years since listing, enterprise growth potential, and operating cash flow level. These variables are included because firm scale, listing experience, growth capacity, and cash-flow strength may influence cost control, financial risk, financing capacity, and enterprise value.

4. Data Analysis and Interpretation

4.1. Baseline Regression Results

A two-way fixed-effects regression model was used to test the four hypotheses. The regression results are presented in Table 3. Each model corresponds to one hypothesis and one dependent variable: operating cost ratio, financial risk level, financing efficiency, and Tobin's Q.

Table 3: Baseline Regression Results

Variable	Operating cost ratio H1	Financial risk H2	Financing efficiency H3	Tobin's Q H4
Standardisation degree of cost accounting	-0.103***	—	—	—
Completeness of the financial-risk control system	—	-0.138***	—	—
Diversification level of green financing	—	—	0.076***	—
Improvement degree of carbon asset accounting and disclosure	—	—	—	0.105***
Enterprise size	-0.029**	-0.043**	0.024*	0.041**
Years since listing	-0.004*	-0.007**	0.003	0.006*
Enterprise growth potential	-0.062**	-0.081***	0.047**	0.084***
Operating cash flow level	-0.131***	-0.109**	0.084***	0.115***
Individual/year fixed effects	Controlled	Controlled	Controlled	Controlled
R^2	0.807	0.831	0.774	0.816
F-statistic	36.87***	42.51***	31.26***	38.74***
Observations	72	72	72	72

*Source: by the author. Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Cells marked "—" indicate that the variable was not included in the corresponding model.*

The results show that all four core explanatory variables are statistically significant and have the expected signs. The R^2 values range from 0.774 to 0.831, indicating that the models explain a substantial proportion of the variation in the dependent variables. The F-statistics of all four models are significant at the 1% level, showing that the regression models have statistical explanatory power.

4.2. Interpretation of Hypothesis Testing Results

The first hypothesis examines the relationship between cost accounting standardization and operating cost ratio. The coefficient of cost accounting standardization is -0.103 and is significant at the 1% level. This negative coefficient indicates that a one-unit increase in cost accounting standardization is associated with a 0.103-unit decrease in the operating cost ratio, holding other variables constant. This finding supports H1. It suggests that photovoltaic enterprises with more standardized full life-cycle cost accounting and public cost allocation systems tend to have lower operating cost ratios. Standardized cost accounting may help firms allocate shared infrastructure costs more accurately, distinguish capitalized expenditure from operating expenditure, and identify high-cost operational activities more effectively. The second hypothesis examines the relationship between financial-risk control completeness and financial risk level. The coefficient of financial-risk control completeness is -

0.138 and is significant at the 1% level. This result indicates that a one-unit increase in financial-risk control completeness is associated with a 0.138-unit decrease in the asset-liability ratio, after controlling for firm characteristics and fixed effects. Therefore, H2 is supported. This finding suggests that photovoltaic enterprises with more complete risk identification, assessment, depreciation management, impairment testing, and debt-monitoring mechanisms tend to have lower leverage-related risk.

The third hypothesis examines the relationship between green financing diversification and financing efficiency. The coefficient of green financing diversification is 0.076 and is significant at the 1% level. This positive coefficient indicates that a one-unit increase in the diversification level of green financing is associated with a 0.076-unit increase in green debt financing relative to total assets. Therefore, H3 is supported. This finding suggests that enterprises using more diversified green financing channels, such as green credit, green bonds, and carbon-related financing, are more likely to improve their financing efficiency. The fourth hypothesis examines the relationship between carbon asset accounting and disclosure and enterprise market value. The coefficient of carbon asset accounting and disclosure is 0.105 and is significant at the 1% level. This result indicates that a one-unit increase in the improvement degree of carbon asset accounting and disclosure is associated with a 0.105-unit increase in Tobin's Q, holding other variables constant. Therefore, H4 is supported. This finding suggests that standardized carbon asset confirmation, measurement, and disclosure may enhance the visibility of low-carbon value creation and improve investor recognition of photovoltaic enterprises.

4.3. Interpretation of Control Variables

Enterprise size is negatively associated with operating cost ratio and financial risk level, with coefficients of -0.029 and -0.043, respectively. Both coefficients are significant at the 5% level. This indicates that larger photovoltaic enterprises tend to have lower operating cost ratios and lower asset-liability risk. Enterprise size is also positively associated with financing efficiency and Tobin's Q, with coefficients of 0.024 and 0.041, respectively. These findings suggest that larger firms may benefit from economies of scale, stronger financing capacity, and higher capital-market recognition. Years since listing is negatively associated with the operating cost ratio and financial risk level. The coefficient is -0.004 for operating cost ratio and significant at the 10% level, while the coefficient is -0.007 for financial risk and significant at the 5% level. This suggests that firms with longer listing histories may have more mature governance systems and stronger financial-management experience. The coefficient for financing efficiency is 0.003, but it is not statistically significant. The coefficient for Tobin's Q is 0.006 and significant at the 10% level, indicating a weak positive association between listing experience and enterprise market value.

Enterprise growth potential is significantly related to all four dependent variables. It is negatively associated with operating cost ratio, with a coefficient of -0.062 at the 5% level, and negatively associated with financial risk, with a coefficient of -0.081 at the 1% level. These results indicate that firms with stronger revenue growth tend to have lower cost pressure and lower leverage-related risk. Enterprise growth potential is also positively associated with financing efficiency, with a coefficient of 0.047 at the 5% level, and positively associated with Tobin's Q, with a coefficient of 0.084 at the 1% level. These findings suggest that growth-oriented photovoltaic enterprises are more likely to attract financing support and receive higher market valuation. Operating cash flow level is significant across all four models. It is negatively associated with operating cost ratio, with a coefficient of -0.131 at the 1% level, and negatively associated with financial risk, with a coefficient of -0.109 at the 5% level. This indicates that stronger operating cash flow is associated with lower cost burden and lower asset-liability risk. Operating cash flow is positively associated with financing efficiency, with a coefficient of 0.084 at the 1% level, and positively associated with Tobin's Q, with a coefficient of 0.115 at the 1% level. These results suggest that cash-flow strength is an important financial foundation for cost control, debt management, financing access, and enterprise value.

4.4. Findings from the Empirical Analysis

The empirical analysis supports all four hypotheses. First, cost accounting standardization is significantly and negatively associated with the operating cost ratio, indicating that full life-cycle cost accounting may improve cost-control performance in photovoltaic enterprises. Second, the completeness of the financial-risk control system is significantly and negatively associated with financial risk, suggesting that dynamic risk identification, depreciation management, impairment testing, and debt monitoring may help reduce asset-liability pressure. Third, green financing diversification is significantly and positively associated with financing efficiency, showing that enterprises with more diversified green financing channels are better positioned to obtain green financial resources. Fourth, carbon asset accounting and disclosure are significantly and positively associated with Tobin's Q, indicating that standardized carbon-related accounting information may strengthen market recognition of photovoltaic enterprises. These results show that financial accounting standardization is closely associated with the financial performance and market value of photovoltaic enterprises. Cost accounting, risk control, green financing, and carbon asset disclosure should therefore be treated as interconnected components of financial governance rather than isolated accounting practices. Since the analysis is based on observational panel data, the results should be interpreted as statistical associations rather than definitive causal effects.

5. Discussion

5.1. Interpretation of the Main Findings

The empirical findings provide evidence that financial accounting standardization is significantly associated with operating cost control, financial-risk reduction, financing efficiency, and enterprise market value in photovoltaic listed companies. These results support the argument that accounting practices in the photovoltaic industry should not be treated merely as compliance-oriented reporting activities. Rather, they may operate as important financial governance mechanisms that influence how enterprises allocate costs, manage risks, access capital, and communicate low-carbon value to the capital market. The finding that life-cycle cost accounting standardization is negatively associated with the operating cost ratio supports the view that more systematic cost recognition and allocation can improve cost-management quality. Photovoltaic enterprises operate through long project cycles involving construction, operation, maintenance, and disposal. During these stages, shared facilities such as inverters, transformers, racks, public roads, and operation and maintenance buildings create cost-allocation difficulties. When firms adopt standardized life-cycle cost accounting, they are better positioned to distinguish construction-related capital expenditure from operating expenditure and to allocate shared costs according to resource consumption. This finding is consistent with the accounting matching principle, which emphasizes that costs should be recognized in relation to the economic benefits they generate (Ramiah et al., 2026). It also extends photovoltaic cost-management literature by showing that cost accounting standardization is not only a technical accounting issue but also a mechanism associated with improved operating cost outcomes.

The negative relationship between financial-risk control completeness and financial risk level indicates that photovoltaic enterprises with stronger risk identification, assessment, and disposal mechanisms tend to have lower asset-liability ratios. This result is theoretically consistent with asset impairment theory and financial-risk management literature. Photovoltaic firms are exposed to equipment depreciation, technological replacement, subsidy-policy adjustment, silicon-material price volatility, and carbon-market uncertainty. When these risks are not monitored dynamically, asset values may be overstated, debt pressure may accumulate, and liquidity risk may increase. A more complete financial-risk control system can improve depreciation policy, impairment testing, debt monitoring, and cash-flow warning capacity. This finding supports prior arguments that risk-mitigation mechanisms are particularly important for capital-intensive photovoltaic projects with long repayment periods (Jadidi et al., 2025; Yin et al., 2024).

The positive association between green financing diversification and financing efficiency suggests that photovoltaic enterprises with broader access to green credit, green bonds, carbon-oriented funds, and asset securitization may obtain stronger financing support relative to their asset scale. This finding is consistent with the pecking order theory of financing, which suggests that firms face different financing costs and constraints depending on information asymmetry and external capital-market conditions. In the photovoltaic sector, transparent accounting information and credible green-financing disclosure can reduce uncertainty for banks, bondholders, and institutional investors. Consequently, diversified green financing may help firms reduce dependence on short-term debt, improve maturity matching, and support long-term project investment (Ramiah et al., 2026). At the same time, this result should be interpreted carefully because the current measurement of financing efficiency is based on green debt financing relative to total assets. Future research should further examine whether diversified green financing reduces financing cost, improves debt maturity structure, or enhances capital-use efficiency.

The positive relationship between carbon asset accounting and disclosure and Tobin’s Q indicates that capital-market participants may value transparent carbon-related accounting information. Photovoltaic enterprises operate in a sector directly connected to carbon neutrality, which means that their carbon-reduction capacity, carbon asset recognition, and carbon-market participation may influence investor expectations. Standardized carbon asset accounting can make emission-reduction benefits more visible, while regular disclosure in annual reports and ESG reports can reduce information asymmetry. This finding is consistent with carbon information signaling theory, which suggests that credible disclosure of carbon-related information can strengthen investor confidence and improve market valuation (Wu, 2025; Liu et al., 2026).

5.2. Relationship with Previous Literature

The findings contribute to several streams of literature. First, they extend research on photovoltaic cost management by shifting attention from production-cost estimation and single-project cost analysis to enterprise-level accounting standardization. Previous studies have mainly examined photovoltaic project costs, technology costs, or system bankability (Ramiah et al., 2026; Qamar et al., 2026). The present study adds to this literature by showing that standardized life-cycle cost accounting is associated with lower operating cost ratios at the firm level. Second, the findings contribute to photovoltaic financial-risk research by incorporating accounting-based risk-control mechanisms. Earlier studies have examined risk mitigation in photovoltaic project finance and renewable-energy investment risk (Jadidi et al., 2025). However, less attention has been paid to how internal accounting systems, depreciation rules, impairment recognition, and risk-warning mechanisms relate to leverage risk. By linking financial-risk control completeness with the asset-liability ratio, this study provides evidence that accounting-based risk governance may be relevant for financial stability in photovoltaic enterprises.

Third, the study contributes to green-finance literature by examining green financing diversification within photovoltaic listed companies. Prior research has discussed the role of green credit, renewable-energy investment, project bankability, and policy support in financing clean-energy projects (Ramiah et al., 2026). This study adds an enterprise-level perspective by showing that the diversification of green financing channels is positively associated with green financing intensity. This suggests that photovoltaic firms may benefit from combining bank loans, green bonds, carbon funds, and asset-backed financing rather than relying on a single financing source. Fourth, the study contributes to carbon accounting and ESG disclosure literature by connecting carbon asset accounting and disclosure with enterprise market value. Prior studies have examined carbon markets, carbon asset financing, and carbon-related financial performance (Bhardwaj et al., 2025; Liu et al., 2026; Wu, 2025). The present findings suggest that carbon asset disclosure may have market-value relevance in photovoltaic enterprises. This is important because the value of photovoltaic firms is increasingly shaped not only by traditional financial indicators but also by their capacity to demonstrate low-carbon competitiveness and carbon-related financial transparency.

5.3. Theoretical Implications

The study offers several theoretical implications. First, it extends the accounting matching principle to the photovoltaic industry by showing that life-cycle cost accounting standardization is relevant in contexts where project costs occur across construction, operation, maintenance, and disposal stages. This implication is important because photovoltaic firms face cost-allocation issues that differ from those of conventional manufacturing firms. The findings suggest that accounting matching should be applied not only to revenue and expense recognition but also to the allocation of shared infrastructure costs across long-term renewable-energy projects. Second, the study enriches asset impairment theory by connecting financial-risk control completeness with leverage-related financial risk. In photovoltaic enterprises, asset impairment is closely linked to equipment degradation, technological change, policy shifts, and market volatility. The findings indicate that firms with stronger accounting-based risk-control systems may be better able to identify and manage these risks. This supports the idea that asset impairment practices should be integrated into broader financial-risk warning systems rather than treated as isolated year-end accounting adjustments.

Third, the study applies pecking order theory to the green-financing context. Traditional financing theory emphasizes information asymmetry and financing hierarchy, while the photovoltaic industry introduces additional factors such as carbon neutrality, green certification, ESG disclosure, and policy-supported capital. The findings suggest that diversified green financing may improve financing access when enterprises provide standardized financial and carbon-related information. This extends financing theory by showing that green-financing capacity may depend on both capital-market conditions and accounting-information quality. Fourth, the study supports carbon information signaling theory by showing that standardized carbon asset accounting and disclosure are associated with higher Tobin's Q. This indicates that carbon-related accounting information may have valuation relevance for investors in renewable-energy industries. As capital markets increasingly evaluate firms through climate-risk and low-carbon-transition lenses, carbon asset disclosure may become an important signal of long-term competitiveness, environmental governance, and future growth potential.

5.4. Practical Implications

The findings have practical implications for photovoltaic enterprises, investors, creditors, and regulators. For photovoltaic enterprises, the results suggest that accounting standardization should be treated as part of strategic financial management. Firms should establish life-cycle cost accounting systems that distinguish construction, operation, maintenance, and disposal costs, while also developing allocation rules for shared infrastructure. Such systems can improve cost visibility and support more accurate project-level decision-making. For financial-risk management, photovoltaic firms should move beyond static year-end indicators and develop dynamic risk-warning systems. These systems should integrate financial indicators, equipment depreciation, impairment tests, raw-material price movements, subsidy-policy changes, and carbon-market conditions. By doing so, enterprises may detect risk signals earlier and reduce the likelihood of excessive leverage, liquidity pressure, or asset-value distortion.

For financing management, the findings indicate that photovoltaic enterprises should diversify green financing channels. Reliance on short-term bank loans may create maturity mismatch because photovoltaic projects often require long recovery periods. Firms should therefore combine green credit, green bonds, asset securitization, carbon funds, and policy-based financing where appropriate. Transparent disclosure of project cash flows, carbon assets, and risk-control mechanisms can also improve credibility with banks, institutional investors, and bond markets. For carbon asset management, photovoltaic enterprises should establish independent carbon asset accounting and disclosure systems. Carbon emission reductions, carbon-trading income, carbon asset fair value, and carbon-related risks should be disclosed clearly in annual reports and ESG reports. This practice can improve the transparency of low-carbon value creation and may strengthen investor recognition of the enterprise's carbon-neutrality contribution. For regulators and industry associations, the findings suggest the need for more unified accounting guidance for photovoltaic enterprises. Specific standards are needed for shared cost allocation, differentiated depreciation of photovoltaic equipment, subsidy-related revenue recognition, green financing disclosure, and carbon asset measurement. More consistent accounting rules would improve financial-statement comparability and reduce information asymmetry across the photovoltaic industry.

5.5. Limitations of the Findings

Although the empirical findings are meaningful, several limitations should be acknowledged. First, the sample is limited to Chinese A-share photovoltaic listed companies. As a result, the findings may not be directly generalizable to non-listed photovoltaic firms, small and medium-sized operators, or photovoltaic enterprises in other institutional environments. Future studies should expand the sample to include overseas firms, privately held enterprises, and project-level photovoltaic operators. Second, the core explanatory variables are measured through manual scoring of annual reports and ESG reports. Although this approach allows the study to capture qualitative differences in accounting standardization, it may introduce subjectivity. Future research should develop a more detailed coding framework, use multiple coders, report inter-rater reliability, and combine text-based scoring with quantitative indicators. Third, the analysis is based on observational panel data. Although two-way fixed effects control for firm-specific and year-specific unobserved heterogeneity, the model may not fully eliminate endogeneity, reverse causality, or omitted-variable bias. For example, firms with stronger financial performance may have more resources to improve accounting disclosure, rather than accounting standardization directly leading to better financial outcomes. Future research should consider lagged explanatory variables, instrumental-variable models, dynamic panel methods, or quasi-natural experimental designs. Fourth, the measurement of financing efficiency requires further refinement. In the current design, financing efficiency is measured as green debt financing relative to total assets. While this indicator captures the scale of green financing, it does not directly measure financing cost, financing speed, debt maturity matching, or capital-use efficiency. Future studies should adopt more comprehensive indicators to capture the economic meaning of financing efficiency. Fifth, the inclusion of 2026 observations requires careful clarification. If full-year 2026 annual-report data are not available, the authors should explain whether the data are based on interim reports, annualized values, or projections. Without this clarification, the reliability of the panel dataset may be questioned.

6. Conclusion

In the context of global carbon neutrality and energy transition, photovoltaic enterprises face distinctive accounting and financial-management challenges related to asset intensity, cost allocation, financing dependence, subsidy treatment, and carbon asset disclosure. Based on balanced panel data from 12 A-share photovoltaic listed companies from 2021 to 2026, this study examined the relationship between financial accounting standardization and enterprise financial outcomes. The findings indicate that standardized full life-cycle cost accounting is negatively associated with the operating cost ratio, while a more complete financial-risk control system is negatively associated with asset-liability risk. The results also show that diversified green financing channels are positively associated with financing efficiency, and that standardized carbon asset accounting and disclosure are positively associated with Tobin's Q. These findings suggest that accounting standardization may play an important role in improving cost control, risk management, financing capacity, and market valuation in photovoltaic enterprises. This study contributes to the literature by developing an integrated financial accounting framework that links cost accounting, financial-risk control, green financing, and carbon asset disclosure. Practically, the findings provide useful guidance for photovoltaic enterprises seeking to improve financial transparency and for regulators aiming to develop more consistent industry-specific accounting standards. However, the study is limited to Chinese A-share photovoltaic listed companies, and the scoring of accounting standardization relies on annual-report text analysis. Future research may expand the sample, improve the measurement of accounting standardization, and apply more robust methods to examine the long-term effects of photovoltaic accounting practices.

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