DATA FUSION METHODOLOGY FOR AUTOMATING MANAGERIAL ACCOUNTING TO ENHANCE FINANCIAL MANAGEMENT OF ENERGY SECTOR COMPANIES IN UZBEKISTAN

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Abstract: The research focuses on justifying the prospects for enhancing the financial management of energy sector companies through the application of data fusion methodology for automating managerial accounting. The research also develops scientific and methodological recommendations for this purpose in the Republic of Uzbekistan. The research is conducted based on international experience in 2022 using statistics from the UN, UNDP RBAS, MBRF, and the World Bank. Econometric models are constructed using regression analysis, systemically explaining the cause-and-effect relationships of financial management in companies in the energy sector. As a result, the author concludes that the inflow of investments into the energy sector is determined by such parameters of managerial accounting as the speed of managerial accounting, timeliness of data provision for financial management, and the comprehensiveness of managerial accounting and depth of financial information disclosure within it, the broad opportunities for optimization of which are revealed by the automation of managerial accounting based on advanced ICT. By unveiling the "black box" of financial management of companies in the energy sector in the Republic of Uzbekistan, uncertainty is reduced, and predictability of investment decision-making is increased, deepening the scientific understanding of the logic of making these decisions – thereby determining the theoretical significance and scientific novelty of the research results. The identified prospect of enhancing the financial management of energy sector companies in the Republic of Uzbekistan holds practical significance because it can be used as a roadmap for investment development of this industry in the Republic of Uzbekistan. The developed data fusion methodology for automating managerial accounting holds managerial significance because it will make it possible to improve the practice of financial management of energy sector companies in Uzbekistan and increase their investment attractiveness.

Keywords: Data fusion methodology; Automation of management; Managerial accounting; Financial management; Energy sector companies; Energy sector of Uzbekistan; Investment decision-making.

1. Introduction

The energy sector holds significant importance for contemporary economic systems, particularly in dynamically developing countries like the Republic of Uzbekistan. First, the energy sector provides a substantial number of jobs, significantly contributes to GDP formation, replenishes the national budget through tax revenues, and accelerates the pace of economic growth.

Second, for many economic systems, the energy sector serves as an area of international production specialization, which is most common among dynamically developing countries. Third, rapid and widespread digitalization is leading to growing demand for energy resources in the economy. Consequently, the significance of the energy sector in the infrastructure provision of economic systems increases further with the development of the digital economy.

For these reasons, private investment in the development of the energy sector generates a multiplier effect on economic development. The financial management of energy companies plays a crucial role in attracting private investment into the development of the energy sector. The most apparent, universally recognized, and widely described condition for attracting private investment in the energy sector is their profitability.

The problem lies in the insufficient elaboration of issues related to investment decision-making in the financial management of energy sector companies. Since investment decisions are usually made at the stage of planning investment and innovation projects, venture investors do not yet know what the return on investment will be.

As a result, the process of making investment decisions in the financial management of energy sector companies is theoretically a "black box" and practically a high-risk process. This determines the relevance of a more detailed study of issues related to the financial management of energy sector companies and scientific elaboration of the cause-and-effect relationships of this managerial process.

The novelty of this research lies in proposing an innovative method for improving the financial management of energy sector companies – through the application of data fusion methodology for automating managerial accounting by these companies. The research aims to justify the prospects for improving the financial management of energy sector companies through the application of data fusion methodology for automating managerial accounting, as well as in the development of scientific and methodological recommendations for this purpose in the Republic of Uzbekistan.

2. Literature Review

This research relies on the theory of financial management, according to which investment decision-making falls within the realm of financial management of companies [5; 17]. International experience in investment decision-making in the energy sector has been thoroughly studied in existing literature [4]. The practice of financial management, including investment decision-making, in companies within the energy sector of the Republic of Uzbekistan is also documented in several published works [3; 11].

To attract private investment into the energy sector, Uzbekistan implements a practice of tightening requirements for financial managers: their workload and responsibility are increasing; there is a strengthening of control over their activities [4]. The methodology of managerial accounting in energy sector companies involves the fragmentation of managerial accounting areas when they are autonomously automated if such automation is carried out [2]. However, the process of making investment decisions in the financial management system of energy sector companies in the Republic of Uzbekistan remains a "black box," as illustrated in Fig. 1.
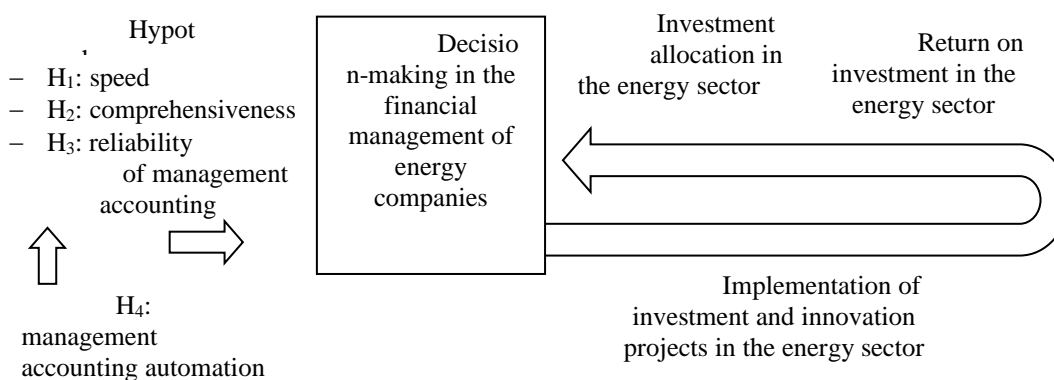
Hypot
- H_1: speed
- H_2: comprehensiveness
- H_3: reliability
      of management accounting

Decision-making in the financial management of energy companies

Investment allocation in the energy sector

Return on investment in the energy sector

Implementation of investment and innovation projects in the energy sector

H_4: management accounting automation

Figure 1: "Black box" of financial management of energy sector companies in the Republic of Uzbekistan
Source: Developed by the author.

As is shown in Fig. 1, the process of making investment decisions in the financial management of energy sector companies involves the allocation of investments into innovative projects within this sector. The return on investments resulting from implementing these projects determines the making of future decisions. Nevertheless, uncertainty remains regarding how information on investment returns enters the financial management system and what conditions this information must meet to rationalize investment decisions. This constitutes a gap in the literature and raises the following two research questions:

RQ_1: What parameters of managerial accounting determine the influx of investments into the energy sector? Based on a review of existing literature, this research puts forward the following three hypotheses:

- H_1: The speed of managerial accounting and timeliness of data provision for financial management determine the influx of investments into the energy sector [10];

- H_2: The comprehensiveness of managerial accounting and depth of financial information disclosure within it determine the influx of investments into the energy sector [1];

- H_3: The reliability and accuracy of managerial accounting data determine the influx of investments into the energy sector [9].

RQ_2: What impact does the automation of managerial accounting have on its parameters significant for attracting investments into the energy sector? Drawing on several works [7; 8], the author proposes the following hypothesis H_4: Automation of managerial accounting using advanced information and communication technologies (ICT) enhances the speed, comprehensiveness, and reliability of managerial accounting.

To test the hypotheses put forward in this research, the author examined international experience and conducted economic-mathematical modeling to analyze the impact of the speed, comprehensiveness, and reliability of managerial accounting on the influx of investments into the energy sector, as well as their dependence on the application of ICT.

3. Materials and Methods

In this research, the author applied the method of regression analysis. Using this method, the author determined the regression relationship of the indicator "Investment in energy with private participation, billion current US dollars" (InvEnerg), calculated by the World Bank [15], based on the following factors related to managerial accounting:

- "Time spent dealing with the requirements of government regulations, % of senior management time" (T), calculated by the World Bank [16];

- "Depth of credit information index, score 0-8 (0=low to 8=high)" (D), calculated by the World Bank [14];

- "Statistical Performance Index, score 0-100 (worst 0-100 best)" (S), calculated by UN [12].

Second, the author determined the regression relationship of the indicators T, D, and S (individually) to "ICT usage, score 0-100" (AMT), calculated by UNDP, RBAS, and MBRF [13]. The research period is 2023. The research sample includes all 38 countries worldwide for which necessary statistics on the listed indicators are available. The statistical data used in the research are presented in Tables 1–3.

The research model has the following form:

$$InvEnerg = a_{InvEnerg} + b_T * T + b_D * D + b_S * S; \quad T = a_T + b_{AMT(T)} * AMT;$$
$$D = a_D + b_{AMT(D)} * AMT; \quad S = a_S + b_{AMT(S)} * AMT \qquad 1)$$

The reliability of the results of regression analysis is assessed using the Fisher's F-test and the Student's t-test. In the research model (1), positive values of the regression coefficients b_T, b_D, and b_S indicate a positive influence of the speed, comprehensiveness, and reliability of managerial accounting, respectively, on the influx of private investments into the energy sector and serve as confirmations of hypotheses H_1, H_2, and H_3.

Table 1: Statistical basis of the research

Country name	ICT usage, score 0–100	Investment in energy with private participation (bln. current US$)	Time spent dealing with the requirements of government regulations (% of senior management time)	Depth of credit information index (0=low to 8=high)	Statistical Performance Index (worst 0-100 best)
Albania	41.94	0.12	2.30	6.00	83.42
Argentina	48.60	0.52	20.50	8.00	71.77
Armenia	40.42	0.04	1.80	8.00	82.79
Azerbaijan	29.20	0.55	2.70	8.00	73.49
Bangladesh	26.71	0.61	13.30	4.00	69.75
Benin	27.30	0.02	5.70	0.00	62.57
Botswana	22.06	0.01	10.20	7.00	61.19
Brazil	49.01	6.13	14.20	8.00	80.53
Bulgaria	47.13	0.11	10.50	5.00	83.88
Burkina Faso	22.86	0.05	22.20	0.00	64.83
China	61.58	0.56	0.90	8.00	59.60
Colombia	37.35	0.77	19.50	7.00	85.90
Dominican Republic	36.45	0.31	7.10	8.00	72.42
Egypt, Arab Rep.	29.51	1.68	0.40	8.00	79.60
El Salvador	23.24	0.03	11.20	7.00	73.76
India	43.93	2.59	12.60	7.00	78.20
Kenya	31.54	0.07	8.60	8.00	62.31
Lao PDR	22.93	0.96	0.80	6.00	60.40
Lesotho	20.45	0.01	2.70	6.00	57.46
Madagascar	23.78	0.03	3.30	6.00	53.75
Malaysia	56.85	0.05	5.20	8.00	76.62
Morocco	33.97	0.17	15.20	7.00	72.26
Mozambique	15.00	0.13	6.50	4.00	56.69
Nepal	23.81	0.86	1.40	5.00	61.99
Pakistan	26.47	0.10	3.50	7.00	71.13
Peru	44.65	0.87	11.80	8.00	73.27
Philippines	40.57	0.25	5.40	7.00	83.38
Senegal	28.59	0.16	3.00	7.00	72.21
Serbia	50.04	0.02	10.00	7.00	80.84
South Africa	41.09	1.84	9.70	7.00	82.38
Thailand	51.43	0.79	4.80	7.00	82.51
Togo	26.30	0.08	10.30	8.00	66.68

Tunisia	34.66	0.10	0.10	7.00	75.13
Turkiye	48.96	0.50	5.90	8.00	87.71
Uganda	19.31	0.02	6.50	7.00	70.74
Uzbekistan	31.65	1.95	4.90	7.00	70.57
Viet Nam	36.84	2.49	1.70	8.00	73.17
Zimbabwe	19.78	0.04	3.20	7.00	70.21

Source: Compiled by the author based on research materials.

Similarly, positive values of the regression coefficients $b_{AMT(T)}$, $b_{AMT(D)}$, and $b_{AMT(S)}$ indicate a positive influence of automation of managerial accounting based on ICT on the speed, comprehensiveness, and reliability of managerial accounting, respectively, and serve as confirmation of hypothesis H_4. Based on the research model (1), using the simplex method, the author determined a value of AMT at which the speed, comprehensiveness, and reliability of managerial accounting in the Republic of Uzbekistan are maximized. As a result, the achievable expected change in the volume of private investments in the energy sector in the Republic of Uzbekistan is determined.

4. Results

To determine the role of speed, comprehensiveness, and reliability of managerial accounting in the influx of investments into the energy sector, the author conducted a regression analysis of the dependence of InvEnerg on T, D, and S. It was found that the connection between InvEnerg and T is statistically insignificant because the Student's t-test was not passed. This indicates that the speed of managerial accounting in energy companies does not influence the influx of private investments into the energy sector. Consequently, hypothesis H_1 is refuted. The results of the regression analysis for the selected explanatory variables (D and S) are presented in Table 2.

Table 2: Regression analysis of the dependence of InvEnerg on D and S

Regression statistics	
Multiple R	0.2915
R^2	0.0850
Normalized R^2	0.0327
Standard error	1.1284
Observations	38

Variance analysis

	df	SS	MS	F	*Significance F*
Regression	2	4.1396	2.0698	1.6254	0.2113
Residual	35	44.5684	1.2734		
Total	37	48.7080			

	Coefficients	Standard error	t-statistic	P-value	Lower 95%	Upper 95%
Y-intercept	-1.7633	1.4999	-1.1756	0.2477	-4.8083	1.2817
D	0.0926	0.1038	0.8922	0.3784	-0.1181	0.3033
S	0.0253	0.0220	1.1505	0.2578	-0.0193	0.0698

Source: Calculated and compiled by the author.

The results obtained in Table 2 indicate that the volume of private investments in the energy sector is by 29.15% determined by managerial accounting factors. The regression equation takes the following form:

$$InvEnerg = -1.7633 + 0.0926*D + 0.0253*S \qquad (2)$$

According to equation (2), with an increase in the comprehensiveness of managerial accounting and depth of financial information disclosure by 1 point, the volume of investments in the energy sector increases by 0.0926 billion dollars (the Student's t-test for the explanatory variable D passed at the significance level of 0.40). With an increase in the reliability and accuracy of managerial accounting data by 1 point, the volume of investments in the energy sector increases by 0.0253 billion dollars (the Student's t-test for the explanatory variable S passed at the significance level of 0.30).

The Fisher's F-test for equation (2) passed at the significance level of 0.25, confirming its validity. Since the regression coefficients $b_{AMT(D)}$ and $b_{AMT(S)}$ in equation (2) are positive and equal to 0.0926 and 0.0253, this indicates a positive influence of the comprehensiveness and reliability of managerial accounting on the influx of private investments in the energy sector, thus proving hypotheses H_2 and H_3. Regression analysis of the dependence of D on AMT is conducted in Table 3.

Table 3: Regression analysis of the dependence of D on AMT

Regression statistics	
Multiple R	0.4012
R^2	0.1610
Normalized R^2	0.1377
Standard error	1.7743
Observations	38

Variance analysis

	df	SS	MS	F	Significance F
Regression	1	21.7465	21.7465	6.9077	0.0125
Residual	36	113.3325	3.1481		
Total	37	135.0789			

	Coefficients	Standard error	t-statistic	P-value	Lower 95%	Upper 95%
Y-intercept	4.3379	0.9095	4.7698	$3*10^{-5}$	2.4934	6.1823
AMT	0.0655	0.0249	2.6283	0.0125	0.0150	0.1160

Source: Calculated and compiled by the author.

The results obtained in Table 3 indicate that the comprehensiveness of managerial accounting and the depth of financial information disclosure are determined by the automation of managerial accounting using advanced ICT by 40.12%. The regression equation takes the following form:

$$D=4.3379+0.0655*AMT \qquad (3)$$

According to equation (3), with an increase in the degree of automation of managerial accounting using advanced ICT by 1 point, the comprehensiveness of managerial accounting and the depth of financial information disclosure increase by 0.0655 points (the Student's t-test for the explanatory variable AMT passed at the significance level of 0.05). The Fisher's F-test for equation (3) passed at the significance level of 0.05, confirming its validity. Regression analysis of the dependence of S on AMT is conducted in Table 4.

Table 4: Regression analysis of the dependence of S on AMT

Regression statistics	
Multiple R	0.5839
R²	0.3410
Normalized R²	0.3227
Standard error	7.4350
Observations	38

Variance analysis					
	df	SS	MS	F	Significance F
Regression	1	1029.6930	1029.6930	18.6271	0.0001
Residual	36	1990.0541	55.2793		
Total	37	3019.7471			

	Coefficients	Standard error	t-statistic	P-value	Lower 95%	Upper 95%
Y-intercept	56.6372	3.8110	14.8617	0.0000	48.9082	64.3662
AMT	0.4505	0.1044	4.3159	0.0001	0.2388	0.6622

Source: Calculated and compiled by the author.

The results obtained in Table 4 indicate that the reliability and accuracy of managerial accounting data are determined by 58.39% through the automation of managerial accounting using advanced ICT. The regression equation takes the following form:

$$S=56.6372+0.4505*AMT \qquad (4)$$

According to equation (4), with an increase in the degree of automation of managerial accounting using advanced ICT by 1 point, the reliability and accuracy of managerial accounting data increase by 0.4505 points (the Student's t-test for the

explanatory variable AMT passed at the significance level of 0.01). The Fisher's F-test for equation (4) passed at the significance level of 0.01, confirming its validity.

Since the regression coefficients $b_{AMT(D)}$ and $b_{AMT(S)}$ in equations (3) and (4) took positive values (namely, 0.0655 and 0.4505), this indicates the positive influence of automation of managerial accounting based on ICT on the comprehensiveness and reliability of managerial accounting data, thereby proving hypothesis H_4.

Based on regression equations (2)-(4), the simplex method determined such a value of AMT at which the comprehensiveness and reliability of managerial accounting are maximized in the Republic of Uzbekistan. The author also determined the expected change in the volume of private investments in the energy sector in the Republic of Uzbekistan due to these measures. The prospect for improving the financial management of energy companies in the Republic of Uzbekistan is shown in Fig. 2.
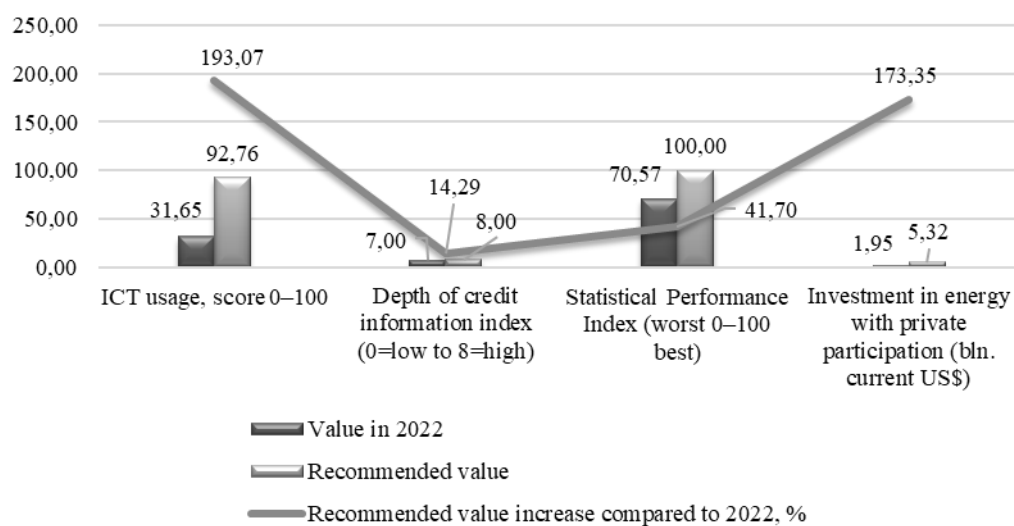

Figure 2: Perspective of improving financial management of energy sector companies in the Republic of Uzbekistan

Source: Calculated and compiled by the author.

As depicted in Fig. 2, the enhancement of financial management in the energy sector companies in the Republic of Uzbekistan offers the prospect of increasing investment in this sector by 173.35% – from $1.95 billion in 2022 to $5.32 billion at comparable prices. To realize this prospect in practice, the following are required:

–Maximization (an increase of 14.29% from 7.00 points in 2022 to 8.00 points) of the comprehensiveness of managerial accounting in energy companies in the Republic of Uzbekistan and the depth of disclosure of financial information therein;

–Maximization (an increase of 41.70% from 70.57 points in 2022 to 100.00 points) of the reliability and accuracy of managerial accounting data in energy companies in the Republic of Uzbekistan.

To enhance the financial management of energy sector companies, it is recommended to increase the degree of automation of managerial accounting based on advanced ICT by 193.07% from 31.65 points in 2022 to 92.76 points. To implement these recommendations in practice within the activities of energy sector companies in Uzbekistan, a data fusion

methodology for automating managerial accounting in their financial management system has been developed (Fig. 3).
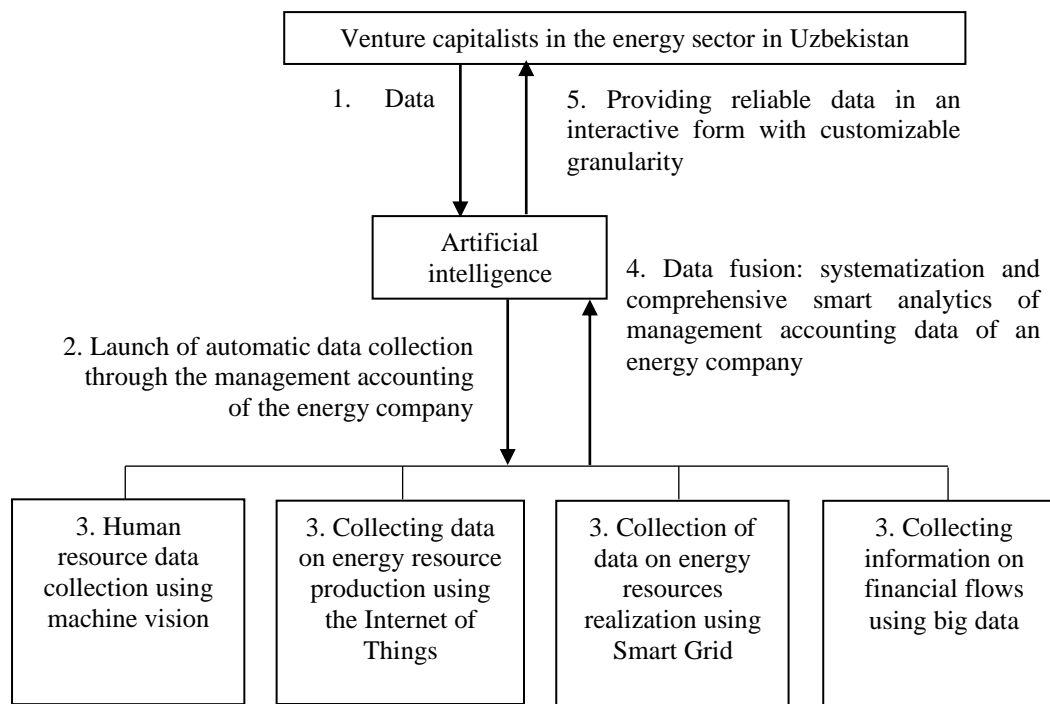

Figure 3: Data fusion methodology for automation of management accounting in the financial management system of energy companies in Uzbekistan

Source: Compiled by the author.

As illustrated in Figure 3, the developed data fusion methodology for automating managerial accounting in the financial management system of energy sector companies in Uzbekistan involves the following sequence of stages. In the first stage, venture investors in the energy sector in Uzbekistan request data. In the second stage, artificial intelligence initiates automatic data collection through the managerial accounting of the energy company.

In the third stage, automated data collection is carried out in each area of the economic activity of the energy company. Data collection about human resources is done through machine vision, energy resource production through the Internet of Things, energy resource sales through Smart Grid, and financial flows through big data.

In the fourth stage, artificial intelligence performs data fusion: systematization and comprehensive smart data analytics of the managerial accounting data of the energy company. In the fifth stage, reliable data in an interactive format with customizable details are provided to venture investors in the energy sector in Uzbekistan.

The features and advantages of the developed data fusion methodology for automating managerial accounting in the financial management system of energy sector

companies in Uzbekistan compared to the existing methodology of managerial accounting applied in Uzbekistan are as follows:

–The transition from a single-stage to a five-stage process of managerial accounting. This makes managerial accounting more targeted and directly aimed at providing information for investment and innovation projects in the energy sector, fully satisfying the current needs of decision-makers in this industry;

The systemic nature of managerial accounting data is due to their logical coherence with artificial intelligence. Thanks to the consistency of the data, gaps in the information provision of investment and innovation projects in the energy sector are overcome, as well as discrepancies in data from different sources.

5. Discussion

This research contributes to the literature pertaining to the theory of financial management [5; 17], by elucidating the black box of financial management in energy sector companies in the Republic of Uzbekistan. The research has expounded the following:

(1) How information regarding investment returns enters the financial management system – through managerial accounting;

(2) The conditions this information must meet to rationalize investment decisions – the detail and reliability of managerial accounting data.

Existing conceptions of financial management in energy sector companies in the Republic of Uzbekistan are juxtaposed with new scientific findings presented in this research (Table 5).

Table 5: Vision of the financial management of energy sector companies in the Republic of Uzbekistan: existing literature and this research

Areas of comparison	Existing literature	This research
The main conditions for attracting private investment in the energy sector	Promptness of management accounting and timeliness of providing data for financial management [10]	Refuted
	Detail of management accounting and depth of financial information disclosure in it [1]	Confirmed
	Reliability and reliability of management accounting data [9]	Confirmed
A way of meeting the conditions for attracting private investment in the	Tightening of requirements for financial managers: growth of their workload and responsibility, strengthening of control over	Automation of management accounting by energy companies

energy sector	their activities [4]	
Methodology of management accounting of companies in the energy industry	Methodology of fragmentation of management accounting areas at their separate automation in case of its realization [2]	Data fusion methodology of management accounting automation

Source: Developed by the author.

According to Table 5, unlike Salahodjaev et al. [10], this research refutes the existing assumption regarding the significance of managerial accounting speed in making investment decisions and substantiates that the swiftness of managerial accounting and timely provision of data for financial management does not determine the influx of investments into the energy sector (hypothesis H_1 is refuted).

Furthermore, the key conditions for attracting private investments into the energy sector have been clarified, including the detail of managerial accounting and the depth of financial information disclosure therein (in confirmation of Ahmad et al. [1], hypothesis H_2 is confirmed) and the reliability and accuracy of managerial accounting data (in confirmation of Kozimjonov [9], hypothesis H_3 is confirmed).

In contrast to Gulnora [4], the proposal for compliance with the conditions for attracting private investments into the energy sector does not involve tightening requirements for financial managers (increasing their workload and responsibility, intensifying control over their activities) but rather the automation of managerial accounting by energy companies (confirming hypothesis H_4).

In contrast to Alrawashedh [2], the methodology for managerial accounting in energy sector companies proposes abandoning the fragmentation of managerial accounting areas during their separate automation in favor of the data fusion methodology for automating managerial accounting. For this purpose, the author provided original scientific and methodological recommendations.

6. Conclusion

Thus, based on international experience, the author developed econometric models, systemically explaining the cause-and-effect relationships of financial management in energy sector companies in

2022. The author established that the swiftness of managerial accounting is not crucial for attracting investments into the energy sector.

The main conclusion of this research is that the influx of investments into the energy sector is determined by managerial accounting parameters such as the speed of managerial accounting, timeliness of providing data for financial management, and the detail and depth of financial information disclosure therein, with ample opportunities for optimization offered by the automation of managerial accounting based on advanced ICT.

The theoretical significance of research results lies in reducing uncertainty and increasing predictability in investment decision-making in the energy sector of the Republic of Uzbekistan by uncovering the "black box" of financial management in energy

sector companies and deepening the scientific understanding of the logic behind making these decisions.

The practical significance of this research is expressed in that the identified perspective for improving the financial management of energy sector companies in the Republic of Uzbekistan can be used as a roadmap for the investment development of this sector in the Republic of Uzbekistan.

The managerial significance is associated with the fact that the developed data fusion methodology for automating managerial accounting will enhance the practice of financial management in energy sector companies in Uzbekistan and increase their investment attractiveness.

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