

# Designing a Forensic Accounting Model with a Focus on Protecting of Shareholders Rights of Petrochemical Companies: Fuzzy Network Analysis

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## ABSTRACT

Protecting shareholders' rights today is considered a practical competitive function at the level of capital markets, which is based on transparent and coherent actions within the framework of laws and regulations. In other words, the more the level of company operations is based on regulatory and legal procedures, the more level of protection of shareholders' interests can be expected to be observed more uniformly by companies. This study aims to design a forensic accounting model focusing on protecting shareholders' rights of petrochemical companies. The collection tool based on the analytical nature of the research consisted of two parts: evaluation checklist and matrix checklists. In fact, in order to promote the level of innovation in the relationship between forensic processes and quantitative accounting to collect data for the development of the forensic accounting model, through meta-synthesis and Delphi analysis, the components and propositions of forensic accounting were determined in the qualitative section, focusing on the protection of shareholders' rights; then based on the matrix checklist, the most influential research propositions were determined through the analysis of fuzzy networks. The research results in the qualitative part indicate the existence of three components of structural mechanisms; it was the meta-structural and legalization of forensic accounting to protect shareholders' rights, which was approved in the form of 18 statements. Further, the results in the quantitative part concerning the analysis of fuzzy networks were identified. The most effective component of forensic accounting in the protection of shareholders' rights was structural mechanisms, and the most influential statements of forensic accounting in the protection of

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shareholders' rights were three statements of collecting and evaluating information to prove the occurrence of fraudulent acts; the legal process related to litigation was related to the withdrawal of the partner and the anti-money laundering statement and the promotion of information transparency.

## 1. Introduction

The stability of laws and regulations and the rule of law that respect contracts and protect private sector capital can be considered essential factors in ensuring that investors do not invade to protect their capital (Larrain et al., 2018). Investors want high returns and avoid risk. As a result, it can be concluded that secure property owners invest more (Samadi and Mehrpoor, 2013). Therefore, leading research seeks to examine whether the study of legal aspects can improve the protection of the interests of shareholders and stakeholders in general. To answer this question, it should be stated that forensic accounting, through forensic oversight, helps increase the protection of shareholders' rights, as it exposes corporate executives and executives to restrictions on concealing bad news and fraud (Zhang et al., 2018). The rules governing listed companies pay close attention to investors' rights, and these controls make companies require to disclose quality accounting information and provide transparent financial reports to reduce information asymmetry between people inside and outside the organization (Akron and Samdani, 2017). Therefore, this issue increases the awareness of domestic investors to act promptly and thus maintain their investment. Investor protection also increases the cost of expropriation. In such a situation, the significant managers and shareholders work hard to provide poor and costly performance and therefore rent-seeking in their favor. Also, regulators can use external oversight, such as forensic/legal accounting, to identify diversionary resources to punish those within the organization who have sought to conceal bad news. As a result, court accounting increases the level of oversight of shareholder rights (John et al., 2016). Because in this case, due to the existence of oversight, forensic accounting prevents bad news from accumulating within the company, and this issue, while increasing the amount of information transparency, leads to more protection from companies. Forensic accounting is considered a branch of accounting that aims to increase supervision over the financial performance of companies to protect shareholders' interests. Protection includes the level and quality of disclosure, participation in major decisions,

and protection of expropriation or personal transactions by prominent managers and shareholders (Hosseini and Shafizadeh, 2019). Therefore, protecting investors against abuse of managers is the importance of trustworthiness at the level of petrochemical companies because shareholders as principals always have less influence over the power of managers as their representatives (lawyers) (Golmohammadi et al., 2017). In other words, managers can use their power to direct the wealth and interests of the company to their advantage without the participation of other investors. In this case, based on the paradigm of forensic accounting, the presence of incentives such as raising the level of legal capacity can pave the way for a response to further protect the shareholders' rights, even in the context of agency costs. According to the explanations provided, this study aims to design a forensic accounting model focusing on protecting shareholders' rights of petrochemical companies based on fuzzy network analysis.

## 2. Literature review

### 2.1. Forensic accounting

The inherent aim of the forensic accounting profession is to support people, organizations, and governments throughout one of the most challenging times by providing a wide range of services that may maintain their ongoing (Alshurafat et al., 2021). Forensic accounting services are broad; thus, forensic accounting is a multidisciplinary specialization. Forensic accountants' practitioners can work in different organizations, including insurance companies, public institutes, police forces, banks, and government agencies. Although there is an overlap between some services that forensic accounting provides (e.g., fraud detection and cybercrimes detection; litigation services and business valuation), the vast majority of research in the forensic accounting area has classified the services offered by forensic accountants into four main categories, which are litigation services (Rehman and Hashim, 2021).

Forensic accounting is a developed concept of financial law topics that includes money laundering documentation in the accounting of institutions and



businesses. Its knowledge underlies the laws and regulations of the business world to prevent fraud and deal with offenders (James, 2010). This paradigm in accounting is based on collecting and providing financial

information to institutions and investors with a high degree of legal reliability. Dong (2011) presents the dimensions of court accounting in Figure 1.

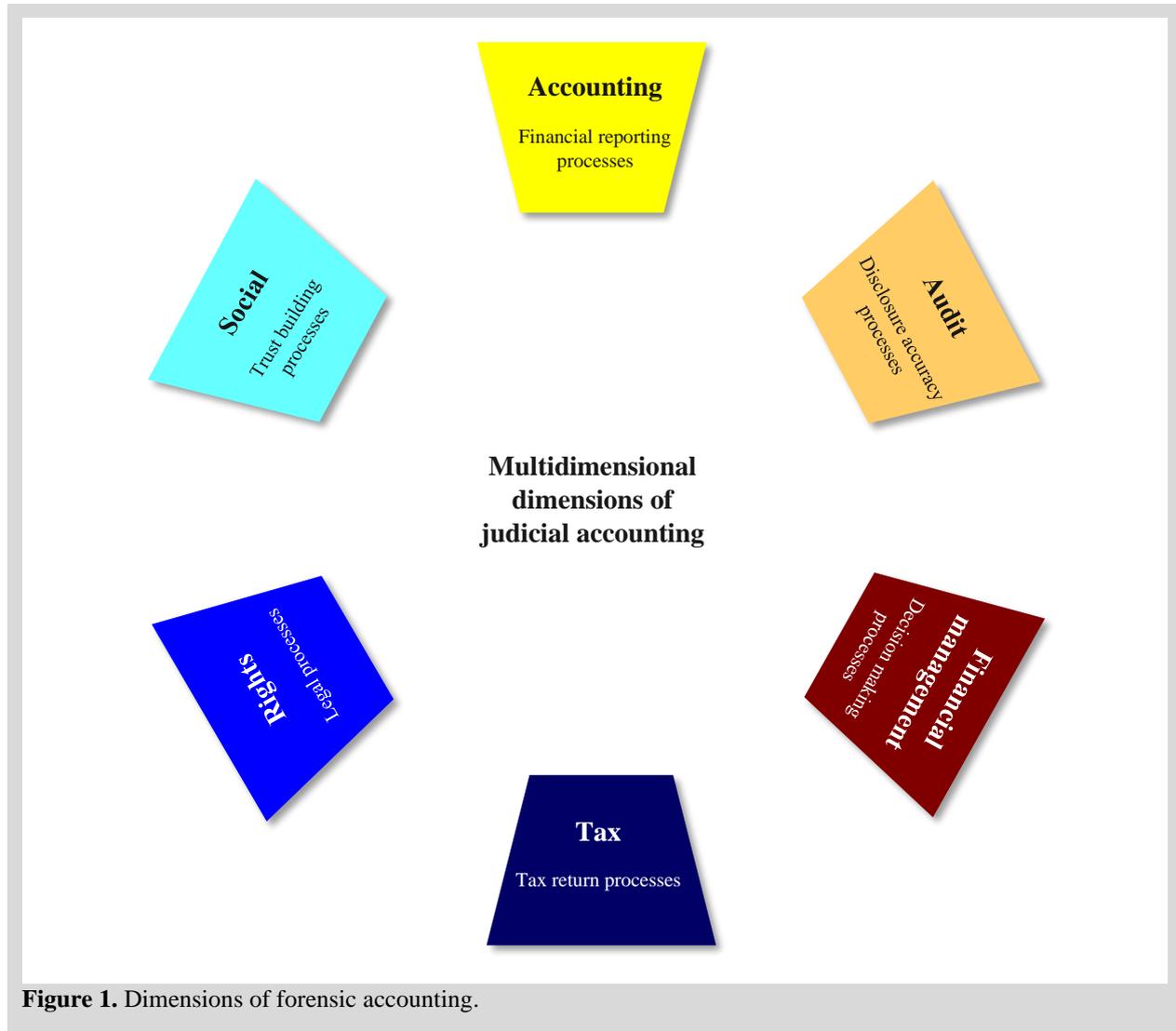


Figure 1. Dimensions of forensic accounting.

The multidimensionality of forensic accounting can help develop financial processes and transparent reporting and reduce information asymmetries based on audit processes, financial management, and tax. Legal can also help raise the level of social trust as a dimension of social accounting function (Wahyuni-TD et al., 2021). Forensic accounting is an implicit approach to the new accounting paradigms and integrates the role of accounting in creating value and transparency for stakeholder decisions (Singleton and Singleton, 2010). In a comprehensive definition of the ACFE (2011), forensic accounting includes the application of principles and explains accounting theories and facts or hypotheses in litigation that cover a wide range of disciplines from accounting to law. It applies accounting skills with an

exploratory mentality to a series of financial issues within the framework of rules and regulations. It applies accounting skills with an exploratory mentality towards a series of financial issues within the framework of laws and regulations based on reliable accounting documents (Fakhari and Osko, 2018). The AICPA (2014) in the definition of forensic accounting refers to the application. Use of specialized accounting skills in matters related to potential or actual civil rights or criminal (legal) lawsuits and generally accepted accounting principles include lost opportunity cost, income, assets or losses, assessment of internal controls, fraud, and any other issues that include accounting expertise and experience in the legal system, but is not

limited to generally accepted accounting principles (Renzhou, 2021).

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## 2.2. Investor protection

Many studies have been conducted on the positive impact of protecting the interests of shareholders on the financial performance of companies. Proper legal protection of shareholders increases their willingness to buy more financial assets such as capital and debt because most of a company's profit flows to them instead of being confiscated by people inside the company (Zivari, Kamran, and Fakhari, 2019). Instead, investor protection and reducing the abuses of people inside the company facilitate the financial investment of companies outside the company and, as a result, the development of financial markets (Ebrahimi et al., 2017). Investor protection is a vital issue, as abuse of minority shareholders by significant shareholders is common in many countries. The extent of abuse can take different forms depending on the weakness of corporate governance. These include selling assets at a lower price to major shareholders or the appointment of relatives and overpayments by order of major shareholders (Altaf and Ahmad Shah, 2018). The Organization for Economic Co-operation and Development (OECD) has defined shareholder rights as a set of seven components (Haidar, 2009):

- The fundamental shareholders rights, the most important of which include the transfer of shares, receiving relevant and vital information about the company on a regular and timely basis, attending and voting in general meetings, appointing and dismissing board members, and sharing in the company's profits.
- The right to participate in decisions concerning fundamental changes in companies, including amendments to the articles of association or other similar governing documents, approval of the issuance of additional shares, and abnormal exchanges involving the transfer of all or most of the assets, leading to the sale (transfer) of the company.
- The right to participate effectively and to vote in the general assembly, the most important of which is to have sufficient and timely information about the time, place, and agenda of the general assembly, facilitate the opportunity for shareholders to ask questions and make requests to the board of directors and to involve shareholders effectively in critical corporate

governance decisions, such as the nomination and election of board members.

- Disclosure of capital structures, allowing certain shareholders to achieve disproportionate control over ownership.
- Efficiency, transparency, and work governing significant transactions (control blocks) of petrochemical companies.
- Facilitate the conditions for exercising the property shareholders' rights, including institutional shareholders.
- Possibility of consulting shareholders on issues related to their fundamental shareholding rights (Jalili and Masoumpur, 2018).

According to the literature review, the research questions are presented in the following order:

1. Identifying the components of forensic accounting with a focus on protecting the rights of stakeholders of petrochemical companies;
2. Identifying forensic accounting statements focusing on protecting the rights of stakeholders in petrochemical companies;
3. Identifying the most effective components of forensic accounting with a focus on protecting the rights of stakeholders of petrochemical companies;
4. Identifying the most effective forensic accounting statements focusing on the protection of the rights of stakeholders of petrochemical companies;

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## 3. Research background

Wang et al. (2021) conducted a study entitled "Corporate Social Responsibility, Protecting Investors' Interests, and Cost of Equity: Evidence for East Asian Companies." In this study, which surveyed 206 petrochemical companies in East Asia between 2010 and 2019, the results showed that improving the level of social responsibility strengthens the protection of investors' rights and includes a reduction in the cost of equity. Kamarudin et al. (2020) conducted a study entitled "Investigating the Impact of Investor Protection and Accounting Quality". In this study, conducted between 2007 and 2016, 42,808 observations from companies in 32 countries were examined. The research hypotheses were tested based on multivariate regression, and the results showed that the protection of investors' rights has a positive and significant effect on accounting quality. Botes and Saadeh (2019) conducted a study entitled "Evidence for the Development of Forensic



Accounting Dimensions”. In this research, which was based on qualitative methodology and content analysis, in the form of systematic analysis of qualitative analysis methods, an attempt was made to determine the multiple nature of court accounting in the form of a coherent framework.

Based on the results obtained, dimensions such as the development of the economic dimension, legal dimension, supervisory and control dimension, tax dimension, and the moral dimension are the most important dimensions that should be considered in the definition of court accounting. Soleimany Amiri and Babaei (2020) conducted a study entitled “Court Accounting Training in Accounting Curriculum in Universities: Perspectives of Academics and Professionals”. This research is a survey conducted by sending a questionnaire to academics and people working in the profession and analyzing the results obtained from the collected data. The research results indicate that most respondents are familiar with the role of court accountants and consider it necessary to use their services in the country’s public sector. Both groups of respondents also expect that the demand for court accounting services will increase in the future, and the benefits of court accounting training in universities and the usefulness of its services in the public sector are considered necessary. Vafaiepour (2020) conducted a study entitled “The Relationship Between Forensic Accounting and the Health of the Economy (Money Laundering)”. In terms of purpose, it is an applied study, and in terms of method, it is a descriptive survey study. For this purpose, a statistical population of 100 judges working on financial issues in legal courts has been considered, which was considered a sample size using the Morgan sampling method of 80 people. SPSS software has been used to investigate the research purpose and analyze the data. The results of testing the hypotheses and analyzing the data indicate a significant and direct relationship between the variables of economic health (money laundering), reducing disruption in the investment process, and increasing the economic foundation with forensic accounting.

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#### 4. Methodology

The basis of separation in any methodological knowledge is the three dimensions of purpose, results, and data type. This research is descriptive/applied research in terms of purpose. To explain the dimensions of the forensic accounting model with a focus on protecting the interests of shareholders, it sought to describe the theoretical approach of research to applied

facts at the petrochemical companies. On the other hand, this research is in the category of developmental research in terms of results because this study analytically seeks to provide a model for forensic accounting in order to develop effectiveness in the protection of shareholders’ rights, a topic that in previous studies has not been addressed much in the field of theoretical framework development. This research also tries to provide a clear and understandable basis of the operational functions of forensic accounting in line with the protection of shareholders’ rights. Finally, it is of mixed type in terms of data type. The research approach of this study is inductive-deductive in terms of data collection logic; in other words, first, through the method of adapting from previous topics and research, the dimensions and components related to forensic accounting are identified based on meta-synthesis analysis and then, based on the method of critical evaluation, the identified criteria are refined. Based on Delphi analysis, the theoretical adequacy of the model dimensions can be examined from the perspective of reliability. In a quantitative part appropriate to the deductive approach of the researcher through the method of fuzzy network analysis while explaining the dimensions of the model at the target community sought to determine the most effective forensic accounting propositions. In this study, meta-synthesis based on the researcher’s insights is done manually with the help of Excel software and Delphi analysis and analysis of variance based on SPSS software and extended analysis of fuzzy networks using MATLAB software.

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#### 5. Statistical society

Due to the analytical nature of the research in both qualitative and quantitative sections, the target population in the qualitative section is 12 academic experts who have a technical and specialized background in theoretical topics of accounting. These individuals were selected through a homogeneous sampling method because the goal was for the people who participated in this section to gain insight into the research subject. Due to the nature of the fuzzy network analysis, which was based on a limited number of participants due to analytical complexities, the target population consisted of 18 official experts in the oil and petrochemical industry.

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#### 6. Research findings

In this section, according to the research methodology, the analyses are presented in two parts,

qualitative and quantitative, to create a more coherent understanding of the research findings.

### 7. Qualitative section analyzes

In this section, two meta-synthesis and Delphi analyses have been used. First, in this section, it is necessary to review the valid scientific databases to

select similar research in 2017 to 2021 in domestic and foreign research. This will help obtain newer research on the research phenomenon. Therefore, to achieve research related to the field of research, in the next step, screening should be done in the first three stages, including title screening, content, and action analysis. Figure 2 is used to perform the second step so as to create a more specific perception.

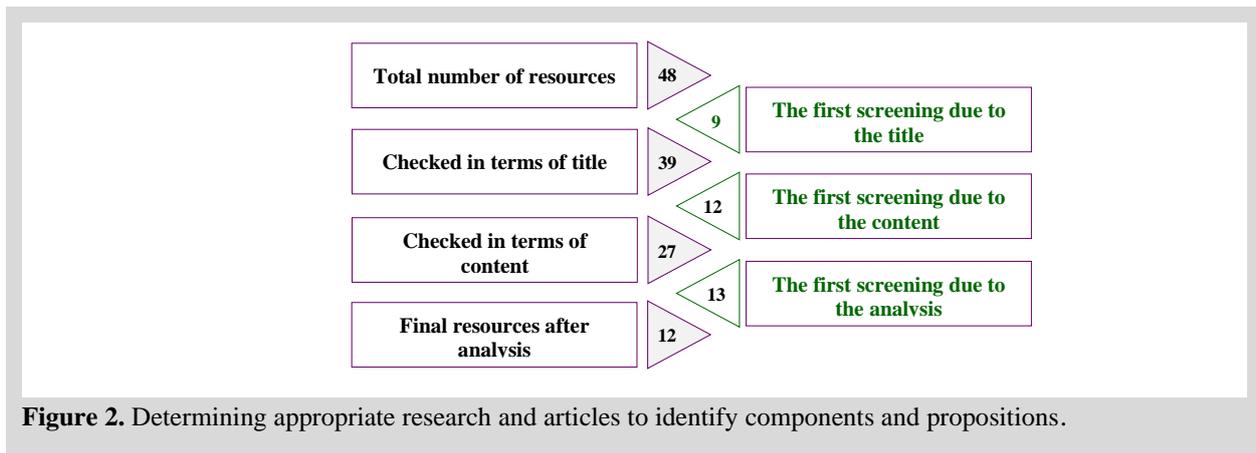


Figure 2. Determining appropriate research and articles to identify components and propositions.

Based on the screening of researches in three aspects of title, content, and analysis, it was determined that 12 researches could be used as an evaluation basis to determine the contents of court accounting statements in order to develop the protection of investors' rights. After this step, the contents of the propositions of each of the mentioned components will be categorized and separated

in the next step. According to this method, the first 12 approved researches are fitted through 10 criteria of critical evaluation method to achieve a more coherent understanding of the nature of research. Table 1 shows how to evaluate this component based on the proposition of 50 points in the form of scores from 1 to 5 based on the 10 criteria described.

Table 1. The critical analysis process to identify research related to forensic accounting.

	Walyuni et al. (2021)	Goh et al. (2021)	Akinbowale et al. (2020)	Nortje and Breidenkamp (2020)	Yang and Lee (2020)	Botes and Saadeh (2019)	Hamdan (2018)	Hegazy et al. (2017)	Kleinman and Anandarajan (2017)	Soleimani-Amiri and Babaei (2020)	Rahmani et al. (2018)	Jafari et al. (2017)
Confirm <input checked="" type="checkbox"/>			<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>				
Delete <input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>						<input checked="" type="checkbox"/>		
Research purpose	2	1	4	2	4	3	3	4	3	3	3	4
The logic of the research method	1	2	3	3	3	3	4	5	4	4	4	3
Research plan	2	2	4	2	4	4	3	4	3	3	3	4
Sampling	3	3	4	3	4	3	3	5	4	2	4	5
Data collecting	3	1	3	3	5	4	3	5	3	3	4	5



	Wahyuni et al. (2021)	Goh et al. (2021)	Akinbowale et al. (2020)	Nortje and Breidenkamp (2020)	Yang and Lee (2020)	Botes and Saadeh (2019)	Hamdan (2018)	Hegazy et al. (2017)	Kleinman and Anandarajan (2017)	Soleimani-Amiri and Babaei (2020)	Rahmani et al. (2018)	Jafari et al. (2017)
<b>Generalization</b>	2	3	4	2	4	4	3	4	3	2	4	5
<b>Ethical</b>	2	2	5	2	5	5	4	3	3	2	3	4
<b>How to statistical analysis</b>	3	2	4	4	5	4	4	3	3	2	4	4
<b>Theoretical capability</b>	3	3	5	3	4	3	3	4	3	2	3	3
<b>Research value</b>	2	2	4	3	4	4	3	4	3	3	3	4
<b>Total</b>	<b>23</b>	<b>21</b>	<b>40</b>	<b>27</b>	<b>42</b>	<b>37</b>	<b>33</b>	<b>41</b>	<b>32</b>	<b>26</b>	<b>35</b>	<b>41</b>

The scores presented based on the fashion index showed that four studies received less than 30 out of 50 scores. Following the guidelines for the adequacy of the scores of this analysis, studies with a score of 30 or higher were approved, were eliminated, and therefore were excluded from the review. Then, the themes or propositions of the research were extracted. Accordingly, the following scoring method was used to determine forensic accounting statements. Based on this

method, all sub-criteria extracted from the text of approved articles were written in the table column. Then, in the row of each table, the names of the approved researchers were given. Based on each researcher's use of the sub-criteria written in the table column, the symbol "☑" was inserted, then the scores of each ☑ were added together in the sub-criteria column, and the scores above the mean of the researches were selected as research components.

**Table 2.** The process of determining the main components of research.

Research status	Researchers	Behavioral mechanisms	Structural mechanisms	Management mechanisms	Meta-structural mechanisms	Social mechanisms	Legal mechanisms
<b>International</b>	Akinbowale et al. (2020)	-	☑	-	☑	-	-
	Yang and Lee (2020)	-	-	☑	-	-	☑
	Botes and Saadeh (2019)	-	-	☑	☑	-	☑
	Hamdan (2018)	☑	☑	-	☑	-	-
	Hegazy et al. (2017)	☑	☑	-	-	☑	☑
	Kleinman and Anandarajan (2017)	-	☑	-	☑	-	☑
<b>Internal</b>	Rahmani et al. (2018)	☑	☑	-	☑	☑	☑
	Jafari et al. (2017)	-	☑	-	☑	-	☑
<b>Total</b>		<b>3</b>	<b>6</b>	<b>2</b>	<b>6</b>	<b>2</b>	<b>6</b>

Based on theoretical and theoretical screening in order to determine the main components of forensic

accounting in order to develop the effectiveness of protection of investors' rights, it was determined: three

main components of structural mechanisms, meta-structural mechanisms, and legal mechanisms were selected as the primary basis for selecting forensic accounting statements in order to develop the effectiveness of protection of investors' rights based on the highest frequency relative to the mean number of studies, as the criteria in this study. In this section, in

order to confirm/delete the research components, using the participation of experts (panel members) based on two scales of mean and agreement coefficient, the components resulting from meta-composition analysis, which are given in Table 3 based on seven-point Likert scale, are examined.

**Table 3.** Delphi analysis process in the first study.

Components	Propositions	Mean	Coefficient of agreement	Confirm	Merge	Delete	Result
				<input checked="" type="checkbox"/>	✖	<input checked="" type="checkbox"/>	
Structural mechanisms	Strengthen the independence of the board to develop the effectiveness of oversight	6	0.80	<input checked="" type="checkbox"/>	-	-	Confirm
	Develop information flow feedback based on information technology effectiveness	5.30	0.65	<input checked="" type="checkbox"/>	-	-	Confirm
	Strengthen internal controls and internal audit dynamics	4.90	0.49	-	✖	-	Merge
	Independence of the Internal Audit Committee	5	0.52				
	Evaluate the performance of the board and disclose their rewards	5.30	0.65	<input checked="" type="checkbox"/>	-	-	Confirm
	Develop bylaws and instructions for the periodic appointment of the CEO	2	0.15	-	-	<input checked="" type="checkbox"/>	Delete
	Strengthen financial reporting structures in the timely reflection of news and information	5.20	0.65	<input checked="" type="checkbox"/>	-	-	Confirm
	Transparency of financial reporting by monitoring the performance of managers	4	0.35	-	-	<input checked="" type="checkbox"/>	Delete
	Specializing in the composition of corporate governance	3	0.20	-	-	<input checked="" type="checkbox"/>	Delete
	Eliminate the dual deficit in the composition of the board	5.20	0.80	<input checked="" type="checkbox"/>	-	-	Confirm
Meta-structural mechanisms of carbon accounting	Combating money laundering and promoting information transparency	5.40	0.70	<input checked="" type="checkbox"/>	-	-	Confirm
	Raising the level of financial awareness through media training	2.50	0.15	-	-	<input checked="" type="checkbox"/>	Delete
	Ways to increase and support organizational whistleblowing to increase transparency	5.10	0.75	<input checked="" type="checkbox"/>	-	-	Confirm
	Study the past trend in identifying ways of tax evasion	5	0.55	<input checked="" type="checkbox"/>	-	-	Confirm



Components	Propositions	Mean	Coefficient of agreement	Confirm	Merge	Delete	Result
				<input checked="" type="checkbox"/>	✖	<input checked="" type="checkbox"/>	
	Development of fair valuation criteria for assets	5.10	0.75	<input checked="" type="checkbox"/>	-	-	Confirm
	Identify ways of embezzlement and control the flow of financial resources	4.89	0.50	-	✖	-	Merge
	Identify the types of fraud strategies and develop possible scenarios	5.02	0.51				
	Removing legal barriers to information transparency	3	0.20	-	-	<input checked="" type="checkbox"/>	Delete
	Awarding a prize; exemptions and benefits to companies to develop financial transparency	2	0.10	-	-	<input checked="" type="checkbox"/>	Delete
	Review the details of the example of determining the criteria for bribery with the aim of fair proportion and balance	4	0.35	-	-	<input checked="" type="checkbox"/>	Delete
	Shorten the path of legal claims to pursue corruption cases	6	0.80	<input checked="" type="checkbox"/>	-	-	Confirm
Legal mechanisms	To guide the legal and administrative decisions to be submitted to the courts	5030	0.65	<input checked="" type="checkbox"/>	-	-	Confirm
	Gather information to support and prove fraudulent acts	4.90	0.49	-	✖	-	Merge
	Evaluate information to relate the findings to the documents provided	5	0.52				
	Collaborate with institutions such as universities and research institutes on the development of companies' realistic financial analysis software	4	0.35	-	-	<input checked="" type="checkbox"/>	Delete
	The legal process related to resolving litigation related to the departure of a partner	5.10	0.75	<input checked="" type="checkbox"/>	-	-	Confirm
	Investigate and evaluate the reasons for the professional negligence of accountants and determine the extent of punishment	5.30	0.85	<input checked="" type="checkbox"/>	-	-	Confirm
	Investigate trademark disputes; patents, and infringements	5.10	0.75	<input checked="" type="checkbox"/>	-	-	Confirm
	Determining the extent of legal damages in bankruptcies and unexpected or natural events	5.20	0.65	<input checked="" type="checkbox"/>	-	-	Confirm

Based on the two criteria of mean and coefficient of agreement in the checklist of seven options, in which the coefficient of the agreement must be within the standard 0.5 to be approved according to the instructions, and the mean is 5 points in that standard out of a total of 29 statements related to forensic accounting to develop the effectiveness of shareholder protection, eight statements with a mean below 5 (according to the Likert scale of seven options) and an agreement coefficient below 0.5

were removed, and six statements were merged in pairs. In the second round of Delphi analysis, based on the results of the two criteria of mean and coefficient of agreement, all statements related to forensic accounting were approved in order to develop the effectiveness of protection of investors' rights, and they reached the so-called theoretical sufficiency, based on which the model can be presented as a quantitative theoretical framework.

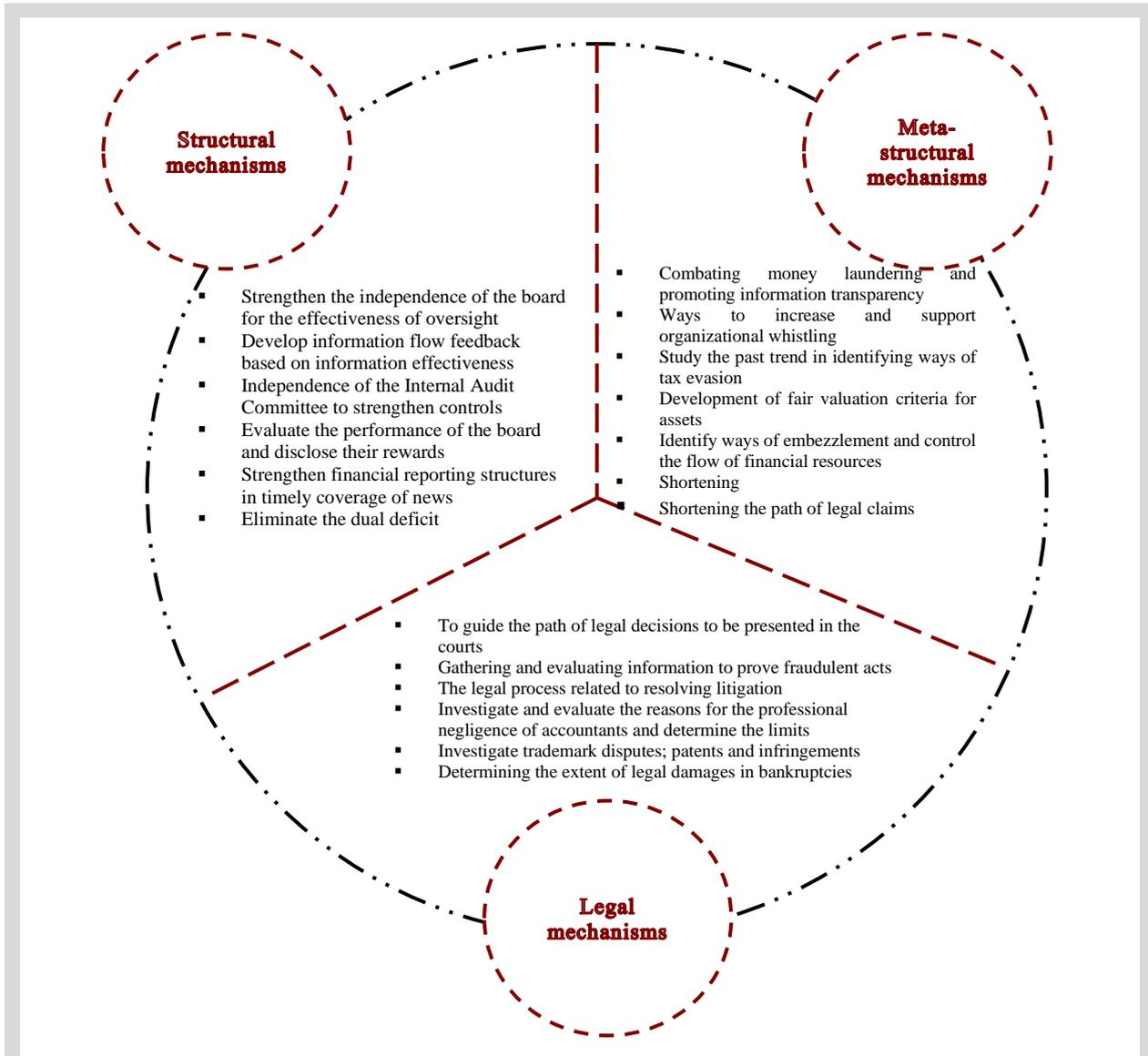


Figure 3. The theoretical framework of the research.

## 8. Quantitative section findings

In this section, fuzzy network analysis is used to identify the ranking of forensic accounting statements to develop the effectiveness of protecting shareholders'

interests. According to this analysis, 18 forensic accounting statements are coded based on Table 4 to develop a more appropriate understanding of the analysis process so as to develop the effectiveness of protecting



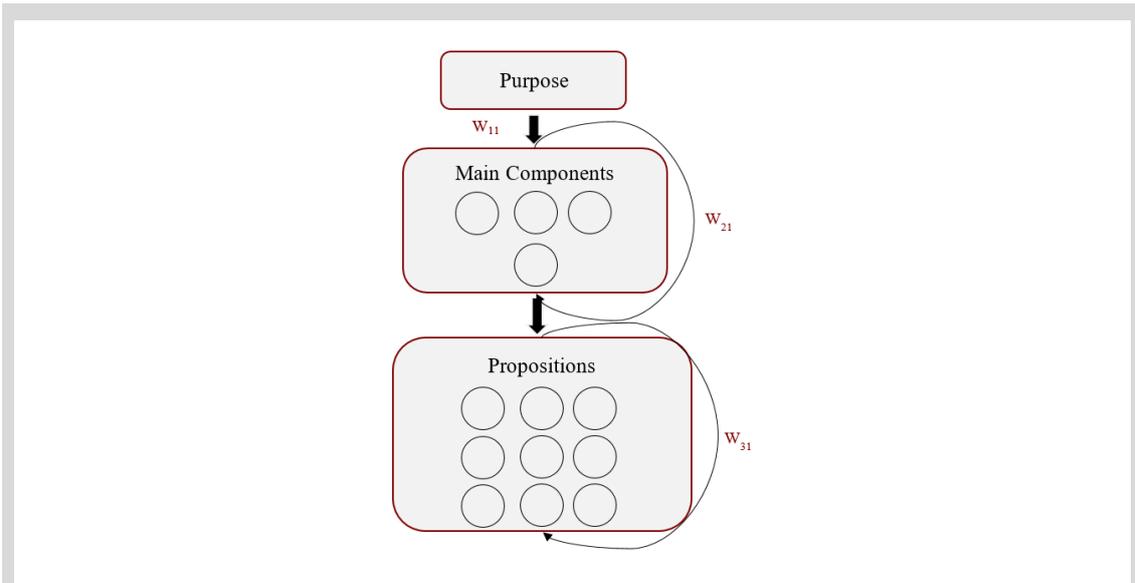
shareholders' interests approved by the Delphi analysis stage.

**Table 4.** The process of coding forensic accounting reports to develop the effectiveness of protecting shareholders' interests.

Components	Propositions	codes
Structural Mechanisms (L)	Strengthen the independence of the board to develop the effectiveness of oversight	L1
	Develop information flow feedback based on information technology effectiveness	L2
	Independence of the Internal Audit Committee to strengthen internal controls	L3
	Evaluate the performance of the board and disclose their rewards	L4
	Strengthen financial reporting structures in the timely reflection of news and information	L5
	Eliminate the dual deficit in the composition of the board	L6
Accounting Meta-Structural Mechanisms (P)	Combat money laundering and promoting information transparency	P1
	Ways to increase and support organizational whistleblowing to increase transparency	P2
	Study the past trend in identifying ways of tax evasion	P3
	Development of fair valuation criteria for assets	P4
	Identify ways to embezzle and control the flow of funds to prevent fraud	P5
	Shorten the path of legal claims to pursue corruption cases	P6
Legal Mechanisms (N)	Guide the legal and administrative decisions to be submitted to the courts	N1
	Collection and evaluation of information in order to link the findings with the evidence provided to prove the occurrence of fraudulent acts	N2
	The legal process related to resolving litigation related to the departure of a partner	N3
	Investigate and evaluate the reasons for the professional negligence of accountants and determine the extent of punishment	N4
	Investigate trademark disputes, patents, and infringements	N5
	Determining the extent of legal damages in bankruptcies and unexpected or natural events	N6

In order to create the general structure of the super-matrix, the relationships and dependencies between the main components with the forensic accounting

statements are created to develop the effectiveness of protecting shareholders' interests based on the description of the following equations.



**Figure 4.** Relationships and dependencies between key components with forensic accounting propositions.

$$W = \begin{matrix} \text{Purpose} & \text{Main} & \text{Criteria} \\ \begin{bmatrix} 0 & 0 & 0 \\ W_{21} & W_{22} & W_{23} \\ 0 & W_{32} & W_{33} \end{bmatrix} \end{matrix}$$

**Figure 5.** The relationships and dependencies of the main components with forensic accounting propositions based on the model.

According to the relationship and dependence description, comparative matrices are formed, and their compatibility level is controlled. At this stage, the comparative matrices of the main criteria, the dependence of the main criteria on each other, the propositions, and their dependence on each other are formed to control the level of compatibility between

them. Based on this, a pairwise comparison between the main components and the propositions is used. To achieve the desired result, group judgment is used for binary comparisons. In this case, the elements of the binary comparison matrix of the criteria will be obtained from the geometric mean of the fuzzy triangular numbers of group ideas.

**Table 5.** Cross-matrix of components and propositions of forensic accounting.

		Components			Propositions																		
Purposes		L	P	N	L11	L12	L13	L14	L15	L16	P21	P22	P23	P24	P25	P26	N31	N32	N33	N34	N35	N36	
Components	L		√	√																			
	P	√		√																			
	N	√	√																				
Propositions	L11	√						√						√					√				
	L12	√						√								√							√
	L13	√					√							√		√							
	L14		√				√															√	
	L15		√								√		√			√							
	L16		√							√		√			√							√	



**Table 7.** Comparison of the second and third components of forensic accounting.

Structural mechanisms of forensic accounting (L)		Meta-structural mechanisms	Legal mechanisms	Special vector (W)	Rank
		P	N		
Meta-structural mechanisms	P	1	(0.96,1.26,1.56)	(0.301)	First
Legal mechanisms	N	(0.64,0.80,1.04)	1	(0.238)	Second

The matrix of Table 7 is specified in the following order:

$$W_{21} = \begin{matrix} L \\ P \\ N \end{matrix} \begin{bmatrix} 0 & 0.348 & 0.531 \\ 0.301 & 0 & 0.320 \\ 0.238 & 0.166 & 0 \end{bmatrix} \quad (2)$$

Based on the control of the compatibility coefficient of each component of the research, the result was determined by the relative importance of the two components of forensic accounting, namely meta-structural mechanisms (P) and legal mechanisms (N), in comparison with the structural mechanisms of forensic accounting (L); meta-structural mechanisms and legal mechanisms are in order of importance respectively. In

other words, by controlling the level of structural mechanisms in forensic accounting, one can first expect to create a meta-structural mechanism in forensic accounting and then a legal mechanism in forensic accounting to develop the effectiveness of protecting investors' rights. In order to understand the interdependencies of each of the research propositions, the reciprocal matrix in the form of a pairwise comparison of each of the research propositions based on  $W_{22}$  should be used. In other words, at this stage, the significance coefficient of each of the statements related to the three-part components of forensic accounting is obtained by binary comparison, and these coefficients will form the columnar elements of the  $W_{22}$  matrix.

**Table 8.** Pair comparison of structural mechanisms of forensic accounting (L).

Purposes	Propositions																		
	L11	L12	L13	L14	L15	L16	P21	P22	P23	P24	P25	P26	N31	N32	N33	N34	N35	N36	
W <sub>22</sub> =	L11	0	0	0	0.644	0	0	0	0	0.466	0	0	0	0.270	0	0	0	0	0
	L12	0	0	0.429	0	0	0	0	0	0	0.458	0.371	0	0	0	0	0	0.311	0
	L13	0	0.583	0	0	0	0	0	0	0.198	0	0.033	0	0	0	0	0	0	0
	L14	0.411	0	0	0	0	0	0	0	0	0	0	0	0	0	0.388	0	0	0
	L15	0	0	0	0	0	0.183	0.482	0	0	0	0.276	0	0	0	0	0	0	0
	L16	0	0	0	0	0.232	0	0.278	0	0	0	0	0	0	0	0.302	0	0	0
	P21	0	0	0	0.232	0.479	0.394	0	0	0	0.542	0	0	0.343	0	0	0	0	0
	P22	0	0	0	0.479	0	0	0	0	0	0	0	0	0	0	0.121	0	0.295	0
	P23	0.344	0	0.280	0	0	0.259	0	0	0	0	0	0	0	0	0	0.305	0	0
	P24	0	0	0	0	0	0	0	0.705	0	0	0	0	0	0	0	0	0	0.317
	P25	0	0.202	0.291	0	0.289	0	0	0	0	0	0	0	0	0	0	0.337	0	0
	P26	0	0	0	0.289	0	0	0	0	0	0	0	0	0.168	0.393	0	0	0.158	0
	N31	0.246	0	0	0	0	0	0.241	0	0	0	0	0.215	0	0	0.189	0	0	0
	N32	0	0	0	0	0	0	0	0	0	0	0	0.470	0	0	0	0	0	0
	N33	0	0	0	0	0	0.164	0	0.093	0	0	0	0	0.218	0	0	0.358	0.235	0
	N34	0	0	0	0.356	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N35	0	0	0	0	0	0	0	0	0.336	0	0.320	0	0	0.462	0	0	0	0.088	
N36	0	0.211	0	0	0	0	0	0.202	0	0	0	0.315	0	0.145	0	0	0	0	

As can be seen in Table 8, the pairwise comparison of each of the statements of the components of forensic accounting has been made, and then it is necessary to

form a super weighted matrix based on the formation of unbalanced hyper-matrix ( $W_{21}$ ;  $W_{22}$ ) whose compatibility is controlled.



**Table 9.** The unbalanced hyper-matrix.

Purposes		Components			Propositions																		
		L	P	N	L11	L12	L13	L14	L15	L16	P21	P22	P23	P24	P25	P26	N31	N32	N33	N34	N35	N36	
Components	L	0.279	0	0.348	0.535	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	P	0.161	0.305	0	0.320	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	N	0.197	0.240	0.166	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Propositions	L11	0	0	0.428	0	0	0	0	0	0	0.644	0	0	0	0	0	0.466	0	0	0	0.270	0	0
	L12	0	0	0.247	0	0	0	0	0	0.429	0	0	0	0	0	0	0	0	0.371	0	0	0	0
	L13	0	0	0.325	0	0	0	0	0.586	0	0	0	0	0	0	0	0.198	0	0.033	0	0	0	0
	L14	0	0	0	0.566	0	0	0	0.411	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	L15	0	0	0	0.175	0	0	0	0	0	0	0	0.183	0	0.482	0	0	0	0.276	0	0	0	0
	L16	0	0	0	0.259	0	0	0	0	0	0	0.232	0	0	0.278	0	0	0.458	0	0	0	0	0
	P21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	P22	0	0	0	0	0.457	0	0	0	0	0	0	0.479	0.394	0	0	0	0	0	0	0	0.343	0
	P23	0	0	0	0	0.235	0	0	0	0	0	0	0	0	0	0	0	0	0.542	0	0	0	0
	P24	0	0	0	0	0.146	0	0	0.344	0	0.280	0	0	0	0	0	0	0	0	0	0	0	0
	P25	0	0	0	0	0.162	0	0	0	0	0	0	0.259	0	0	0.705	0	0	0	0	0	0	0
	P26	0	0	0	0	0	0.227	0	0	0.202	0.291	0	0.289	0	0	0	0	0	0	0	0	0	0
	N31	0	0	0	0	0	0.436	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.168	0.393
	N32	0	0	0	0	0	0.233	0	0.246	0	0	0	0	0	0	0.241	0	0	0	0	0.215	0	0
	N33	0	0	0	0	0	0.104	0	0	0	0	0	0	0	0	0	0	0	0	0	0.470	0	0
	N34	0	0	0	0	0	0	0.575	0	0	0	0.356	0	0.164	0	0	0.093	0	0	0	0	0.218	0
N35	0	0	0	0	0	0	0.178	0	0	0	0	0	0	0	0	0	0.336	0	0.320	0	0	0.462	
N36	0	0	0	0	0	0	0.247	0	0.211	0	0	0	0	0	0	0.202	0	0	0	0.315	0	0.145	

The unbalanced super-matrix must be multiplied by a clustered matrix to convert an unbalanced super-matrix to a rhythmic super-matrix. The cluster matrix reflects the effectiveness of each cluster in achieving the objectives of the study. The cluster matrix is obtained from the binary comparison of clusters within the

primary (unbalanced) super-matrix structure framework. According to the normalization of the limit super-matrix, according to the results of the above table, the propositions are prioritized according to Table 10 in the following order, which shows the vector of ultimate significance (WFANP).

**Table 10.** Prioritization of the most effective forensic accounting statements.

Research Proposals	Proposal codes	The final weight of the propositions	prioritize
Strengthen the independence of the board to develop the effectiveness of oversight	L11	0.083	Sixth
Develop information flow feedback based on information technology effectiveness	L12	0.055	Ninth
Independence of the Internal Audit Committee to strengthen internal controls	L13	0.075	Seventh
Evaluate the performance of the board and disclose their rewards	L14	0.017	Eighteenth
Strengthen financial reporting structures in the timely reflection of news and information	L15	0.039	Thirteenth
Eliminate the dual deficit in the composition of the board	L16	0.062	Eighth
Combat money laundering and promoting information transparency	P21	0.096	Third

Research Proposals	Proposal codes	The final weight of the propositions	prioritize
Ways to increase and support organizational whistleblowing to increase transparency	P22	0.042	
Study the past trend in identifying ways of tax evasion	P23	0.033	Sixteenth
Development of fair valuation criteria for assets	P24	0.037	Fifteenth
Identify ways to embezzle and control the flow of funds to prevent fraud	P25	0.046	Eleventh
Shorten the path of legal claims to pursue corruption cases	P26	0.089	Fifth
To guide the legal and administrative decisions to be submitted to the courts	N31	0.038	Fourteenth
Gathering and evaluating information to prove fraudulent acts	N32	0.104	Second
The legal process related to resolving litigation related to the departure of a partner	N33	0.113	First*
Investigate and evaluate the reasons for the professional negligence of accountants and determine the penalty	N34	0.032	Seventeenth
Investigate trademark disputes; patents, and infringements	N35	0.047	Tenth
Determining the extent of legal damages in bankruptcies and unexpected or natural events	N36	0.095	Fourth

Based on the result of prioritization of each of the forensic accounting propositions, it was determined that the most effective forensic accounting propositions in order to develop the effectiveness of protection of shareholders' interests are three collection propositions and evaluation of information to prove the occurrence of "N33" fraudulent acts and the legal process related to the

settlement of litigation related to the departure of "N32" partner as statements of legal mechanisms of forensic accounting and the P21 anti-money laundering and information transparency proposal as a statement of the meta-structural mechanisms of forensic accounting that play an essential role in protecting the shareholders' rights.

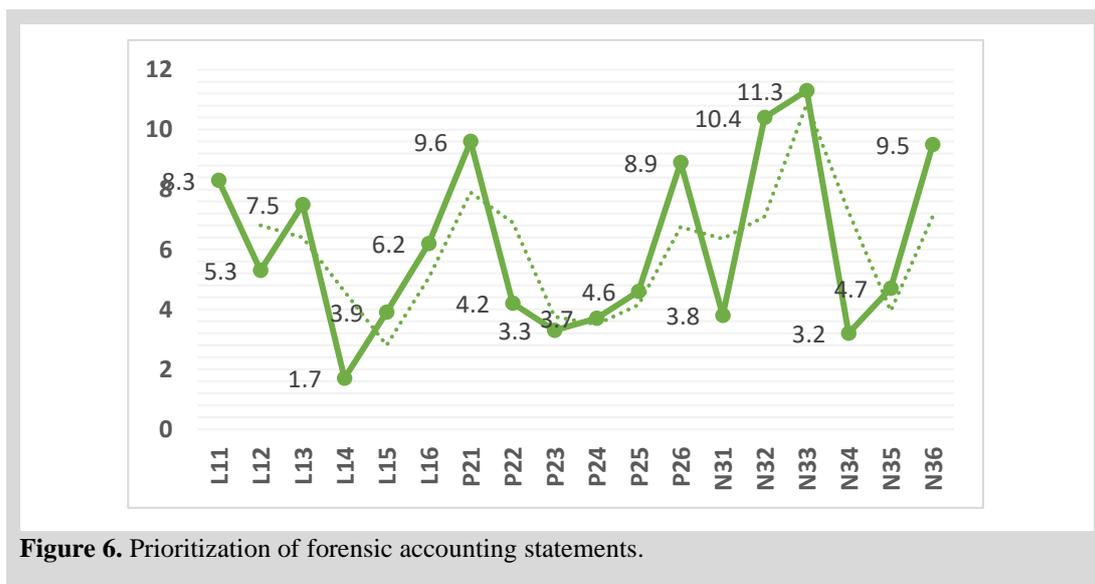


Figure 6. Prioritization of forensic accounting statements.



## 9. Conclusions

This study aimed to design a forensic accounting model focusing on protecting shareholders' rights of petrochemical companies based on fuzzy network analysis. Based on the results obtained, the most effective components of forensic accounting with a focus on protecting the rights of stakeholders of petrochemical companies should be identified, the reason for the importance of structural forensic accounting mechanisms to protect the rights of stakeholders of petrochemical companies. Effective corporate governance oversight can help develop information transparency for external stakeholders; further, because of the sensitivity to the independence of the board of directors and the internal audit committee, we can expect feedback to flow more quickly to stakeholders and these effective oversights. However, meeting the information needs of stakeholders in the form of more robust reporting structures based on the reflection of information facts in due time will prevent excesses and opportunities for managers in awarding shares due to the balance of proportionality in accounting functions, which can further strengthen their confidence in the judiciary in accounting. On the other hand, as the prioritization in this section showed, the structural mechanisms of forensic accounting, without the support of legal mechanisms, practically cannot have the necessary functions. The limits of the law and the binding power of auditors in this area will allow companies to follow the legal oversight of the accounting unit to the legal consequences they feel and to be more diligent in providing evidence and observe any mistakes in the process of compiling and registering accounts through their internal structures. They realize that there can be many legal penalties for the company's accounting unit. The result obtained in this analysis is consistent in terms of component content with research by Akinbowale et al. (2020), Hamdan (2018), Hegazy et al. (2017), Rahmani et al. (2018), and Jafari et al. (2017).

The results also showed that, based on the prioritization of propositions, among the 18 propositions of forensic accounting in order to develop the effectiveness of protection of investors' interests, three propositions of collecting and evaluating information to prove the occurrence of fraudulent acts "N33" and the legal process related to the settlement of litigation related to the withdrawal of partner "N32" as the proposition of the legal mechanisms of forensic accounting and the proposition of combating money laundering and promoting information transparency "P21" as the

proposition of the meta-structural mechanisms of forensic accounting play an essential role in protecting the rights of investors. In the analysis of the result obtained in this section, it should be stated that the statement of collecting and evaluating information to prove the occurrence of fraudulent acts expresses this forensic issue accounting in the form of its legal role by inspecting the documents provided by the accounting unit; it should complete its information in order to identify any fraudulent activity to circumvent the law or violate the public rights of stakeholders benefiting from their actions, and in return, it will stand. In its legal role, forensic accounting will be able to identify any financial violations within the standards with a reason and evidence to respond to them legally. On the other hand, the statement of the legal process related to the settlement of litigation related to the departure of the partner is one of the most critical issues in partnership and drafting inter-company agreements from the perspective of accounting. The scope of financial issues is that forensic accounting, with its arbitrariness and competence, can act based on documents in the form of its legal role to resolve such conflicts and resolve it because the existence of a conflict in a contract can cause financial chaos in an accounting unit at the level of petrochemical companies. Legal accounting in its forensic role can significantly help resolve these issues. Finally, the third influential proposition is combating money laundering and promoting information transparency as the proposition of the meta-structural mechanisms of forensic accounting that play an essential role in protecting the shareholders' rights. In other words, as shareholders continue to invest in petrochemicals and stock exchanges with the support of regulatory agencies and institutions, the warmth of forensic accounting capabilities in the fight against money laundering to promote financial and information transparency will stimulate equity investing. In its influential role in preventing the profiteering of corrupt economists and criminals, forensic accounting investigates the rejection of unhealthy and dirty money in various areas and will not give up until they are convinced that the cash flow is clean. Such perception at the community level of forensic accounting can help develop the community, especially shareholders with petrochemical companies, because investment security is the most crucial criterion for the dynamism of a market.

Based on the obtained results, it is suggested that focusing on structural mechanisms of forensic accounting can lead to the development of adequate protection of shareholders' rights because the corporate

governance combination, based on strict payroll and mandatory supervision, in line with investors' interests, tries to prevent any misconduct. Creating information transparency based on the financial reporting structure can prevent secrecy and the risk of falling stock prices in the future by providing timely news and information. Creating effective legal structures requires the approval of dynamic statutes, considering the criteria for the selection and term of office of the CEO. In order to prevent any wrongdoing in this position and the limits of government authority and oversight, it should be clear and transparent to avoid any legal gap in the accounting unit and financial behavioral practices of managers.

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