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Assessing Feasibility of an Effective Regulatory Framework for Iran's Petrochemical Industry

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Highlights

- The important optimal regulatory factors that should be emphasized by the regulatory in the Iranian petrochemical industry were mentioned and ranked in the order of ratio, accountability, financial independence, legal independence, and political independence.
- The most important challenges are the weakness of laws to attract foreign and domestic investors, the lack of trust, and the lack of integration in this industry from the upstream sector to the downstream sector.
- The Competition Council and the Securities and Exchange High Council as regulators of the physical and financial markets are considered; however, the overall structure of these councils must first be dramatically reformed so that they can effectively regulate.

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Abstract

In recent years, the completion of the value chain and increased exportation of petrochemical products have been utilized to offset oil and gas export losses. As a result, this may have created various challenges and complexities within the oil and gas industry. This study aims to identify key challenges confronting Iran's petrochemical industry, with a particular focus on regulatory issues. It seeks to distinguish and prioritize the most critical regulatory factors necessary for establishing an effective regulatory framework in the petrochemical sector. To this end, data were collected through several interviews and questionnaire with Iran's petrochemical experts. Using the collected data, we utilized the Delphi method to help identify the most critical challenges. The impact and significance of each challenge were determined through statistical analysis. The research findings indicate that the most important challenges are the weakness of laws to attract foreign and domestic investors, the lack of trust, and the lack of integration in this industry from upstream to downstream sector. Further, based on the research results, it is essential for Iran's petrochemical industry to have two regulatory agencies. The Competition Council and the Securities and Exchange High Council as regulators of the physical and financial markets are considered; however, the overall structure of these councils must first be dramatically reformed so that they can regulate effectively. The important effective regulating factors which should be emphasized by the regulator in Iran's petrochemical industry are indicated and ranked as allocation, responsiveness, financial independence, legal independence, and political independence.

Keywords: Challenges, Delphi method, Effective regulatory framework, Features, Petrochemical industry

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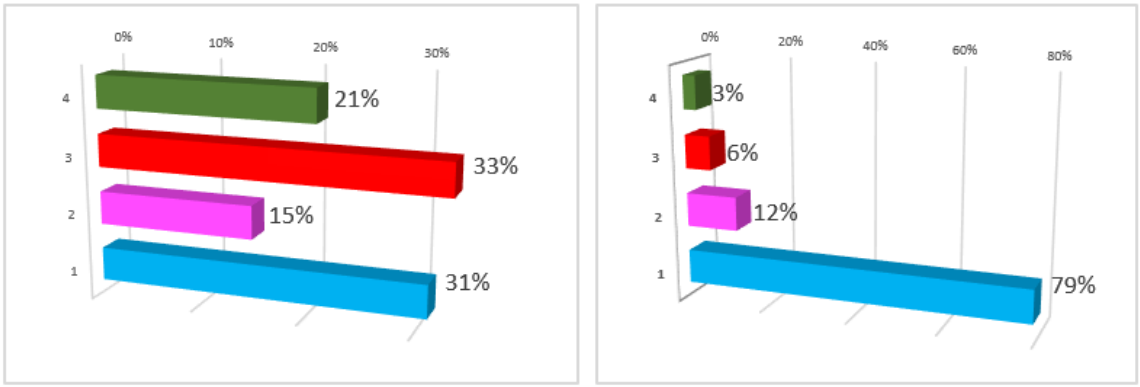
1. Introduction

One of the main issues in economics is the role of government in a country's development. Generally, state intervention in the economy is carried out by various institutions, one of which is the regulator. Apart from the regulator, there are other institutions, such as the policy-makers and facilitators. The regulator's task is to regulate the provisions to achieve the policies or strategies, whereas, the facilitator is trying to increase the efficiency of the industry. Providing these needs, especially in developing countries, calls for government intervention with the lack of necessary infrastructure. The Iranian petrochemical industry faces significant challenges, including inadequate legal frameworks that deter investment, a lack of trust in the sector, and poor integration between upstream and downstream operations. The Ministry of Petroleum lacks political and financial independence, and decision-making is complicated by multiple entities. Issues such as undefined processes for project proceeds, low involvement of specialized organizations, and transparency concerns regarding health and safety standards further exacerbate the situation. Additionally, there are inconsistencies in product supply and pricing, government restrictions on investment, and a lack of structured planning for exports. These factors collectively highlight the inefficiencies within the industry's regulatory and operational framework.

The issue of the present study is identifying the most important challenges of Iran's petrochemical industry and distinguishing the most important regulating factors for effective results. After the extraction of challenges and regulatory indicators of the petrochemical industry in Iran, the effective features of the regulator in this industry and its structure are suggested. This issue is very important because one of the key obstacles to economic development is the issues generated in the petrochemical industry, as investigated in this study.

The energy sector, especially the petrochemical industry, has certain characteristics that could cause the market to fail. This causes the energy sector to be less visible than other economic sectors within the framework of the market forces. The reason is that this sector's projects are highly capital-intensive and require a long time to be built. Therefore, entering or leaving this industry is much more demanding, and the result is that there are serious barriers to creating an effective energy competition. Therefore, the energy sector, especially the petrochemical industry, should be controlled in competitive and uncompetitive sectors through regulatory instruments. In this section, the characteristics of the petrochemical industry are mentioned; they do not make the market competitive and force us to utilize regulators in this industry.

The monopoly petrochemical products market is the other related discussion in the field of petrochemical industry's regulation. According to the information gathered from Iran's Securities and Exchange Organization (n.d.), the monopoly situation in Iran's petrochemical products market is shown in Figure 1. According to part (a) which shows the monopoly in the market for petrochemical products based on the weight of these products, 31% of the total petrochemical products weight are produced by only one producer, 15% by two producers, 33% by three producers and 21% by four producers. According to Figure 1, none of the petrochemical products has more than four producers. Most of the products are produced only by one petrochemical plant. This kind of monopoly could be a hazard to the market of the product in the incident of a problem in these plants such as fire and problem in supplying feedstock. On the other hand, part (b) shows the monopoly on this market; based on the suppliers' particular product number, 79% of the products are produced by one petrochemical plant, 12% by two plants, 6% by three plants, and 3% by four petrochemical plants.



a) Monopoly based on the weight of products b) Monopoly based on the number of supplies

Figure 1

Monopoly on Iran's petrochemical products market (Iran stock exchange)

Regarding the above-mentioned cases and the existence of a monopoly in this industry which does not make the market competitive, a regulator should be established in the petrochemical industry. It is worth mentioning that the regulator can act on the feedstock market, petrochemical products, or both. Regarding the suggestions, it is clear that regulating the petrochemical sector has far more complexity than other sectors.

The objectives of the manuscript are to identify and rank the key challenges facing Iran's petrochemical industry, particularly those related to regulatory issues. Utilizing the Delphi method, the study seeks to gather expert opinions and conduct statistical analyses so as to assess the significance of the identified challenges. It aims to distinguish and prioritize the most critical regulatory factors necessary for establishing an effective regulatory framework in the petrochemical sector. Ultimately, the manuscript intends to provide actionable policy recommendations to enhance the regulatory framework and effectively address the challenges within the petrochemical sector.

The remainder of this paper is structured as follows: Section 2 describes the relevant literature and theoretical background. Section 3 presents data and theoretical and empirical methodologies, and Section 4 provides empirical results, discussions, and policy recommendations. Section 5 finally concludes the paper.

2. Literature review and theoretical background

The term regulation is utilized as a part of a wide range of ideas inside legislative issues or sociology, situations, and fields (Selznick, 1985). Moreover, it has encountered an expanding notoriety in recent years. In the middle of financial emergencies, the expression "regulation" appears to resonate through the world more loudly than any other time. Another reason is the regulation's development as a scholarly industry. Therefore, to colonize these recently vital fields of intrigue, bringing about competition among scholars and experts seems to be essential (Black, 2001).

Regulation can be defined as requesting any cognizant action, which means controlling demonstration, coordinating, or supervising per a run, standard, or framework. Further, it is a definition for state activity expected to impact or conduct control. It includes all types of state market supervision as well as contract and criminal law (Prosser, 1997; Veggeland, 2009). Although, practically speaking, competition law can collaborate and even clash with social regulation (MacAvoy, 1992), competition implementation is once in a while sent to cure the kinds of market failure that fall inside the social regulation domain (Kingston, 2010a; Stewart, 2000).

Moreover, there are a few monetary contentions supporting the regulation (MacAvoy, 1992). The most well-known depend on revising for market failure or value-based contemplations. On account of social regulation, an essential method of reasoning is that individual organizations may not consider the full social cost of their activities without government intercession. On account of financial regulation, for enhancing generation proficiency the essential monetary basis needs to be done with the potential regulations. While it is conceivable to give some financial bases to regulation for an extensive variety of monetary actions, such methods of reasoning are regularly not convincing. Similarly, as there is potential for some sort of "market failure", there is the additional potential for "government failure" (Guasch and Hahn, 1999).

Financial regulation is a division particular in nature and has a tendency to recommend specific market leads instead of simply banishing general classes of anti-competitive direction. Financial regulation along these lines gives a sort of substitute to the competition market train by copying the competitive result (Sappington and Weisman, 2010; Tardiff, 2010). Monetary regulation as a discrete classification of state supervision for controlling the market has been more than once perceived by financial approach creators (DTI, 2006). Inside the regulatory financial aspects, competition law has been distinguished as a third feature in close relation to monetary and social regulation (MacAvoy, 1992; Viscusi et al., 2018). In this manner, it is conceivable to observe an idea of monetary regulation which is unmistakable.

There are a number of well-recognized reasons commonly given for regulating as presented in Table 1 (Baldwin, Cave, and Lodge, 2015). It should be emphasized that in any one sector or industry, the case for regulating may be based not on a single but on a combination of rationales, market failure, human rights, or social solidarity (Breyer, 1982).

Table 1

Rationales for regulating (Baldwin et al., 2015)

Rationale	The main aims of regulation	Example
Monopolies and natural monopolies	• Counter tendency to raise prices and lower output; • Harness benefits of scale economies; • Identify genuinely monopolistic;	Utilities
Windfall profits	Transfer benefits of windfalls from firms to consumers or taxpayers	The firm discovers an unusually cheap source of supply
Externalities	Compel producer or consumer to bear full costs of production rather than passing them on to third parties	Pollution of the river by factory
Information inadequacies	Inform consumers to allow the market to operate effectively	Pharmaceuticals, food, and drinks labelling
Continuity and availability of service	Ensure a socially desired level of "essential" service	Transport service to remote regions
Anti-competitive and predatory pricing behavior	Prevent anti-competitive behavior	Below-cost pricing in transport
Public goods and moral hazard	Share costs where benefits are shared but free-rider problems exist;	Standardization services, health services;
Unequal bargaining power	Protect vulnerable interests where the market fails to do so;	Health and safety at work
Scarcity and rationing	Public interest allocation of scarce commodities	Petrol shortage

Rationale	The main aims of regulation	Example
Rationalization and coordination	Secure efficient production where transaction costs prevent market efficiencies	Disparate production in agriculture and fisheries
Planning	• Protect the interests of future generations; • Coordinate altruistic intentions;	Environmental conservation
Human rights	Protection of weaker citizens	Addressing discrimination and embryology issues
Social protection	Foster social solidarity	Broadcasting regulations

The regulatory landscape of the petrochemical industry is essential for operational efficiency and economic viability, particularly in developing countries like Iran. Robust regulatory frameworks are crucial for attracting investment and ensuring sustainable growth. Key regulatory indicators—such as responsiveness, independence, and transparency—are critical for effective governance (Baldwin et al., 2011). They emphasize that effective regulation can mitigate market failures, enhance competition, and promote consumer protection. Comparative studies highlight best practices from Brazil and South Africa, where regulatory reforms have successfully enhanced market performance (Meyer, 2022; Nkosi, 2023). The historical evolution of regulatory practices reveals a transition from state-controlled frameworks to market-oriented approaches, often complicated by regulatory capture and limited legal independence of regulatory bodies (MacAvoy, 1992; Kingston, 2010a). This situation necessitates reform in Iran's regulatory institutions to enhance their effectiveness and credibility. In Iran, challenges such as weak legal frameworks and insufficient supply chain integration hinder both foreign and domestic investment, aligning with findings from Black (2001) and Azimzadeh Arani (2016) regarding regulatory inefficiencies.

The petrochemical industry plays a pivotal role in economic development, particularly in resources-rich countries like Iran. Historically, Iran's petrochemical sector has significantly evolved since the 1960s, becoming a critical player in the global market (Fadaei et al., 2023). Comparatively, nations such as Venezuela and Nigeria face similar regulatory challenges, emphasizing the need for effective governance in resources management (Smith, 2021; Johnson, 2022). Iran's petrochemical industry faces significant challenges, including weak legal frameworks that deter foreign investment and a lack of integration across the supply chain (Zarif, 2023). Research has shown that these regulatory weaknesses lead to inefficiencies and reduced competitiveness. Empirical studies further illustrate the economic impact of these challenges, with estimates suggesting substantial losses in potential revenue and investment (Ahmad and Reza, 2023). Evidence-based policy recommendations are essential for addressing the identified challenges. Successful case studies from other countries suggest that establishing independent regulatory bodies and enhancing stakeholder engagement can lead to improved outcomes (Khan and Ali, 2022; Freeman, 2023). Tailoring these strategies to the Iranian context will be crucial for effective implementation.

Regulation is a multifaceted concept that intersects with various domains within politics and sociology, reflecting its growing significance in contemporary discourse (Selznick, 1985). The recent economic crises have heightened interest in regulation, emphasizing its role in shaping market dynamics. This surge can be attributed to the evolution of regulation as an academic field, prompting increased exploration of its complexities (Black, 2001). At its core, the regulation aims to control and guide activities according to established rules, encompassing state interventions that influence behavior through market oversight, contract enforcement, and criminal law (Prosser, 1997; Veggeland, 2009). While competition law intersects with social regulation, conflicts may arise, as competition enforcement does not always address the market failures associated with social regulation (MacAvoy, 1992; Kingston, 2011b; Stewart, 2000).

Economic arguments for regulation often center on correcting market failures or addressing transactional considerations. Social regulation justifies intervention to mitigate broader social costs neglected by individual firms, while economic regulation seeks to enhance production efficiency within sector-specific contexts (Guasch and Hahn, 1999; Sappington and Weisman, 2010). Numerous rationales for regulation are articulated: market failures, human rights considerations, and social solidarity (Breyer, 1982). Regulation's significance has grown amid global economic challenges, environmental crises, and technological advancements (Levi-Faur, 2020). The growing complexity of regulatory frameworks necessitates a deeper understanding of their implications for market dynamics and social welfare (Baldwin et al., 2015). Recent studies emphasize the evolving nature of regulation, highlighting its dual role in promoting competition while addressing social concerns as well. For instance, the interplay between economic regulation and competition law has been a focal point, with scholars arguing that effective regulation can mitigate market failures and enhance consumer protection (Costinot and Werning, 2023). This perspective aligns with the notion that regulation should not only prevent anti-competitive practices but also foster an environment conducive to innovation and economic growth (Khan, 2020).

The rationale for regulation is multifaceted, encompassing economic, social, and environmental dimensions. Recent literature underscores the importance of addressing externalities, such as climate change and public health crises, through targeted regulatory measures (Gunningham, 2020). For example, regulatory frameworks aimed at reducing carbon emissions have gained traction, reflecting a shift toward sustainability in economic policy (Smith and Jones, 2023). Effective regulation is essential for fostering investment and ensuring market efficiency. Theoretical frameworks such as public interest theory and capture theory provide insights into regulatory dynamics (Stigler, 1971; Posner, 1974). Recent studies indicate that robust regulatory frameworks can mitigate market failures, particularly in capital-intensive sectors like petrochemicals (Smith and Jones, 2023; Karami, 2023). Moreover, the concept of "regulatory capture" remains a significant concern as industries often influence regulatory bodies to favor their interests, potentially undermining public welfare (Stigler, 1971). This highlights the need for transparency and accountability in regulatory processes to ensure that regulations serve the broader public interest rather than narrow corporate agendas.

The recent literature also explores the implications of digital transformation on regulation. The rise of digital platforms has introduced new challenges, prompting regulators to adapt existing frameworks to address issues related to data privacy, market dominance, and consumer rights (Zengler, 2023). Scholars advocate for a proactive regulatory approach that anticipates technological advancements rather than reacting post-factum (Bennett and Hargreaves, 2023).

The Delphi method has been widely employed to gather expert opinions in various sectors, proving effective in identifying regulatory challenges (Linstone and Turoff, 2002). Previous research has successfully utilized this method to prioritize challenges and identify regulatory indicators, underscoring its relevance in the context of the petrochemical sector (Hsu and Sandford, 2007). By integrating expert insights, this study aims to fill existing gaps in the literature regarding the specific regulatory needs of Iran's petrochemical industry. Moreover, the literature indicates a growing trend toward sustainability and environmental considerations within the petrochemical sector. Recent global shifts toward greener practices necessitate a re-evaluation of regulatory frameworks to accommodate these changes (Stern and Holder, 1999). This study aims to contribute to this discourse by proposing actionable policy recommendations that align with both local and international regulatory standards.

In summary, this literature review underscores the critical role of effective regulation in overcoming the challenges Iran's petrochemical industry faces. By situating the findings within the broader context

of the regulatory theory and practice, this research seeks to provide a comprehensive understanding of the effective regulatory model needed to enhance the sector's performance.

3. Research methodology

3.1. Using the Delphi method for selecting regulation indicators and challenges of the petrochemical industry

For an effective regulatory design, we must first extract the indicators of regulatory for Iran's energy sector with a focus on the petrochemical industry market. Hence, probably extracted indicators were exposed to experts' opinions using the Delphi method for confirmation and rating herein.

There are some indicators, selected by researchers, for evaluating the regulations named "good regulations"; the indicators are extracted through them. These indicators are extracted by the researchers according to the different industries in different countries (Azimzadeh Arani, 2016). Thus, we must extract the indicators that match Iran's petrochemical industry, expose the challenges to experts' opinions, and rank them entirely. In summary, these indicators are listed in Table 2. Further, ranking the challenges is very important and can be very helpful for policymakers in the energy sector because they may not resolve all the challenges and only can eliminate the significantly important challenges.

This study refers to the people who are expert in the energy sector especially the petrochemical industry. The Delphi method is selected as the best method to accomplish the research object based on consultation and interviews with experts.

Table 2

Extracting regulation indicators

Author(s)	Indicators
Lodge, 2004	Responsiveness and transparency
Correa et al., 2006	Responsiveness, independence, decision process, and decision tools
OECD, 2011	Responsiveness and independence
Lodge, 2004	Responsiveness and transparency
Correa et al., 2006	Responsiveness, independence, decision process, and decision tools
OECD, 2011	Responsiveness and independence
Gilardi, 2001	Independence (agency head status, relationship with government and parliament, financial, and organizational autonomy)
Norton, 2004	Proportionality, purposefulness, transparency, and responsiveness
Stern and Holder, 1999	Clarity of roles and objectives, independence, responsiveness, participation, transparency, and predictability
Berg et al., 2000	Consistency, consultation, flexibility, predictability, effectiveness and efficiency, responsiveness, communication, transparency, and independence
Thomadakis, 2007	Transparency, proportionality, flexibility, necessity, and effectiveness

Author(s)	Indicators
Tern and Cubbin, 2005	decision process, transparency, predictability, decision tools, participation, and responsiveness
Brown et al., 2006	Independence, responsiveness, transparency and public participation, predictability, completeness and clarity in rules, proportionality, requisite power, appropriate institutional characteristics, and integrity
Newbery and Pollitt, 1996	Allocation of regulatory responsibilities, regulatory discretion, public participation, transparency, responsiveness, and applicable regulatory framework
UNIDO, 2006	Independence, transparency, investor, and consumer protection
Better regulation task force (BRTF), Black et al., 2007	Proportionality, responsiveness, consistency, transparency, and targeting
Noll, 2000	Responsiveness, capacity, coherence, independence, predictability, and transparency
Abraham, 2003	Independence, responsiveness, transparency, and public participation
Brown and Paula, 2004	Human and financial resources, responsiveness, transparency, participation, and decentralization
Moscote et al., 1995	Independence, tariff-setting authority, authority over the wholesale market, and quality of service
Steyn, 2011	Capacity, transparency, public participation, and responsiveness
Vincent-Jones, 2006	Transparency, proportionality, purposefulness, and responsiveness
Aldrich and Meyer, 2015	Regulatory responsiveness, transparency, and independence
Perrotton and Massol, 2020	Regulatory effectiveness, independence, and public participation
Fischer and Newell, 2021	Independence, regulatory clarity, and responsiveness
Jamasb et al., 2021	Transparency, public participation, and regulatory effectiveness
Kumar et al., 2020	Responsiveness, independence, decision-making processes, and public participation

The Delphi technique was initially created in the 1950s by the RAND Corporation in Santa Monica, California. The Delphi technique is particularly useful for long-go anticipating (20–30 years). In the interim, the correspondence impact of Delphi ponders (in this way, the procedure estimation in that capacity) is additionally recognized (Cuhls, 2023). The Delphi system is appropriate as a strategy for working with utilizing a progression of polls conveyed. Further, it helps utilize numerous emphases to gather information from a board of chosen subjects (Hsu and Sandford, 2007).

The first reason for selecting the Delphi method to extract regulation challenges in the energy sector is that there are not enough resources, documentation, information or data related to the industry challenges in Iran's petrochemical industry. Therefore, we must refer to the expert opinions. Secondly, previous studies show that researchers used the Delphi method to find different issues and rank the challenges. This study aims to find and rank the indicators and challenges of regulation. It seems that using the Delphi method can be compatible with previous studies. Finally, the Delphi method is designed for collecting opinions and is appropriate for this study; it is the most appropriate technique among the qualitative methods (Azimzadeh Arani, 2016).

3.2. Data analysis method

The results of the Delphi method application are analyzed by related statistical methods, including binomial and Friedman tests, for robustness purposes. Each test is briefly described below.

3.2.1. Binomial test

In statistics, the binomial test is exact. It tests the statistical significance of deviations from a theoretically expected observation distribution into two categories. The binomial test is nonparametric and evaluates success (existence) and failure (absence) based on a quantity or characteristics (Wagner-Menghin, 2014). In this research, the questionnaire questions have the Likert scale, and Table 3 is used to quantify them. In this spectrum, numbers 1 to 6 are considered for unimportant, very low, low, moderate, high, and very high options, respectively.

Table 3

Likert scale of the questionnaire (Likert, 1932)

1	2	3	4	5	6
Unimportant	Very low	Low	Moderate	High	Very High

Based on this categorization, all experts can be divided into two categories: experts who agree (with very high, high, and moderate opinion) and those who disagree (with unimportant, very low, and low opinion). Accordingly, the hypotheses of the binomial test are as follows:

$$H_0: p >= \alpha; \alpha = 0.5$$

$$H_1: p < \alpha; \alpha = 0.5$$

The null hypothesis is equivalent to negative answers: people who have chosen unimportant, very low, and low options; the alternative hypothesis is equivalent to positive answers: people who have chosen very high, high, and moderate options. Since this test is usually performed at an error level of 5%, the level of significance should be less than 0.05 to prove the existence of the desired variable.

3.2.2. Friedman test

The Friedman test is a nonparametric statistical test created by Milton Friedman. The methodology includes positioning each line (or square) together, at that point thinking about the position's estimations by segments (Friedman, 1937).

4. Empirical results and discussion

This study uses the Delphi method to identify and prioritize the most important Iran's petrochemical industry challenges of analyzing the questionnaire survey results gathered from 30 experts. In this study,

to quantify the relative measurement scales (the Likert scale) in the questionnaire, we used the indicators mentioned in Table 3. Then, we calculated the reliability of the questionnaire using Cronbach's alpha and applied the binomial and Friedman tests for comparing the average rating and ranking the factors. The SPSS software was used for data analysis purposes.

According to documentary and similar studies and preliminary interviews with experts in this industry, a list of the most important energy sector challenges in Iran with emphasis on the petrochemical industry is outlined in this section:

1. The lack of systemic attitude and multiplicity of decision-making centers in the energy sector;
2. Not paying attention to the restructuring process (separation, regulation, liberalization, and transfer of ownership);
3. The lack of political independence of the Ministry of Petroleum as an energy regulator;
4. The lack of financial independence of the Ministry of Petroleum as an energy regulator;
5. The weakness of laws to attract foreign and domestic investors in the petrochemical industry;
6. The absence of a specific process for the proceeds return from sales for the petrochemical project development;
7. The low attendance of specialized organizations in the decision-making process;
8. The problem of supplying feedstock between the plants;
9. The lack of transparency of HSE requirements in the privatization of petrochemical companies;
10. Inconsistencies in the supply of petrochemical products in domestic and international markets;
11. Problems in pricing petrochemical feeds;
12. Government restrictions on investment in development projects, especially in less developed regions;
13. The nonrequirement of companies to provide all information related to production, sale, and physical projects progress;
14. The nonrequirement of the companies to stop, change, or sell units' products to control the market in crises;
15. The lack of codified planning for exporting petrochemical products;
16. The problems in determining the price of petrochemical products;
17. The lack of trust in the petrochemical industry;
18. The lack of integration in the industry from upstream to downstream;
19. The improper location for the construction of petrochemical projects;
20. The absence of petrochemical parks;
21. The problem of determining the price of feedstock between the plants;
22. Developing standards, regulations, and guidelines for monitoring manpower;
23. The change in the price of feedstock annually, leading to a reluctance of domestic and foreign investors;

4.1. The findings from applying the Delphi method to identify and rank challenges in the petrochemical industry

This section considers the challenges of the petrochemical industry using the related statistical tests and their ranking. Table 4 presents the results of the binomial test. According to the results, the calculated significance level for all the challenges is less than 5%. As a result, the null hypothesis is rejected, and it can be claimed that the experts agree with these challenges.

Table 4

The binomial test for the petrochemical industry challenges

Challenge No.†	Exact Sig. (2-tailed)	Significance level	Percentage of agreement	H_0	Challenge No.‡	Exact Sig. (2-tailed)	Significance level	Percentage of agreement	H_0
1	0.000	0.05	100	Reject	13	0.006	0.05	87	Reject
2	0.004	0.05	100	Reject	14	0.015	0.05	87	Reject
3	0.008	0.05	97	Reject	15	0.003	0.05	100	Reject
4	0.011	0.05	93	Reject	16	0.000	0.05	83	Reject
5	0.008	0.05	100	Reject	17	0.004	0.05	100	Reject
6	0.001	0.05	97	Reject	18	0.024	0.05	100	Reject
7	0.013	0.05	100	Reject	19	0.001	0.05	100	Reject
8	0.008	0.05	93	Reject	20	0.018	0.05	90	Reject
9	0.006	0.05	100	Reject	21	0.045	0.05	93	Reject
10	0.035	0.05	97	Reject	22	0.000	0.05	97	Reject
11	0.016	0.05	97	Reject	23	0.016	0.05	100	Reject
12	0.000	0.05	97	Reject					

The null hypothesis indicates that the perceived importance of challenges among experts is equal for all challenges to test Friedman's variance analysis. Conversely, the alternative hypothesis implies that there is a significant difference in importance between at least two of the challenges. The results of this analysis are presented in Table 5.

Table 5

Friedman's analysis of variance test related to the ranking of challenges.

χ^2	Degrees of freedom	p-value	Significance level	H_0
98.894	22	0.012	0.05	H_0 reject

Accordingly, the null hypothesis is rejected, and the alternative hypothesis is accepted. Therefore, there is a significant difference between the 23 indicators at a significance level of 5%. According to the test results, the order and priority of the challenges in Iran's petrochemical industry are listed in Table 6. It can be concluded from Table 6 that in the expert's opinions, the three most important challenges of the petrochemical industry in Iran are as follows:

1. The weakness of laws to attract foreign and domestic investors;
2. The lack of trust in the petrochemical industry;
3. The lack of integration in the industry from upstream to downstream;

Obviously, the challenges can be solved based on the priority given by the establishment of a regulator in the petrochemical industry.

Table 6

The ranking of the challenges in Iran's petrochemical industry

Rank	Challenges
1	The weakness of laws to attract foreign and domestic investors
2	The lack of trust in the petrochemical industry
3	The lack of integration in the industry from upstream to downstream
4	The absence of a specific process for the return of proceeds from sales of petrochemical projects

† Based on the Section 5.2.
‡ Based on the Section 5.2.

Rank	Challenges
5	The lack of political independence of the energy regulator
6	The lack of a systemic attitude and multiplicity of decision-making centers in the energy sector
7	The lack of transparency of HSE requirements in the privatization of petrochemical companies
8	Government restrictions on investment in development projects, especially in less developed regions
9	The low attendance of specialized organizations in the decision-making process
10	Not paying attention to the restructuring process
11	Developing standards, regulations, and guidelines for monitoring manpower
12	The problem of supplying feedstock between the plants
13	The problems in determining the price of petrochemical products
14	The lack of financial independence of the energy regulator
15	Inconsistencies in the supply of petrochemical products in domestic and international markets
16	Problems in pricing petrochemical feeds
17	The change in the price of feedstock annually leads to a reluctance of domestic and foreign investors
18	The lack of codified planning for exporting petrochemical products
19	The improper location for the construction of petrochemical projects
20	The problem of determining the price of feedstock between the plants
21	The nonrequirement of companies to provide all information related to production, sale, and physical progress of projects
22	The nonrequirement of the companies to stop, change, or sell units' products to control the market
23	The absence of petrochemical parks

4.2. The outcomes of applying the Delphi method for identifying and ranking an effective regulatory indicator

According to the authoritative scientific sources, five important indicators have been extracted for the regulatory authority, as listed in Table 7.

Table 7

A description of the regulatory indicators in Iran's petrochemical industry (Azimzadeh, 2016)

Regulatory Indicators	Description
Political independence	The officials of these institutions should be separated from the politics in the decision-making process and government policies.
Financial independence	Regarding the regulator institution funding, the members of the regulator do not feel dependent on the organization or system at all.
Legal independence	The existence of a law about the regulator's role and legal arrangements for the change of the regulator's authority are the factors that can have a significant impact on strengthening the legal independence of these institutions.
Responsiveness	The independence of these institutions, which are politically, financially, and legally observed, requires their responsiveness to the activities they are doing.
Proportion	The combination of effective actors in regulators should ensure that the proportion of government agents, private sector representatives, and active civil society actors should be observed especially in the field of consumer protection, and the private sector and civil society should have a chance to comment and participate in the codification of policies.

4.2.1. Responsiveness

The main problem here is that the decisions of the Competition Council are decisive, and there is no judicial control over them against international standards. The council is not responsive to any institution or organization. While in other countries, the decisions of similar councils are under the control of democratic legal institutions.

4.2.2. Financial independence

One of the most important indicators of the regulator is the lack of financial and budgetary dependence on a particular organization or institution. While the budget of the Competition Council is determined by the government. In fact, the members of this institution receive their salaries from the government, while the costs of this council should be provided through companies, clients or consumers, and related industries.

4.2.3. Legal independence

Based on Article 62, which was mentioned in the previous section, before the Competition Council's establishment, the duties and authority of this institution were the other organizations' responsibilities. These organizations were involved in handling complaints related to anti-competitive behaviors and market disruptions. As stated, interference between authorities of the Competition Council and other organizations can lead to the loss of the legal Counsel's independence. As a result, these organizations should refrain from performing tasks which are similar to those of the Council.

4.2.4. Political independence

However, based on Clause 4 of Article 56 of the law, the Competition Council has full independence in order to investigate and make decisions per regulations. However, according to Article 54, the central competitive council will be formed to serve under the President's supervision as an independent government. The body of the center will be named on the proposal of the Ministry of Economic Affairs and Finance and the cabinet approval. On the other hand, most members of the council and the chairman are elected by the president's decree (Law on the Implementation of General Policies of Principle). Therefore, this council has no full political independence.

4.3. Policy proposals for the development of an effective regulatory framework for Iran's petrochemical industry

According to Article 95 of the Law of the Third Development Plan (Law of the Third Development Plan of Iran, n.d.), and Article 15 of the Law of the Fourth Development Plan (Law of the Fourth Development Plan of Iran, n.d.) in Iran, the oil, gas, and petrochemical exchanges were approved by the Securities and Exchange High Council in 2005 (Law on the Securities Market of the Islamic Republic of Iran, n.d.). The Securities and Exchange High Council is a Regulator of Iran's financial market. The Minister of Economic Affairs and Finance shall act as chairman of the council. Moreover, the government designated 8 of the 11 council members. Therefore, unlike the developed countries, this council does not have sufficient independence and is subordinated to the government. Hence, the structure of this council must be reformed before acting as a regulator.

Regarding the above-mentioned cases, the existence of two regulatory councils is essential for Iran's petrochemical industry. The Competition Council is the regulator in the physical market (feedstock and products), and the Securities and Exchange High Council is considered the regulator in the financial market. Accordingly, the following structure in Figure 2 is proposed for the regulator in the petrochemical industry.

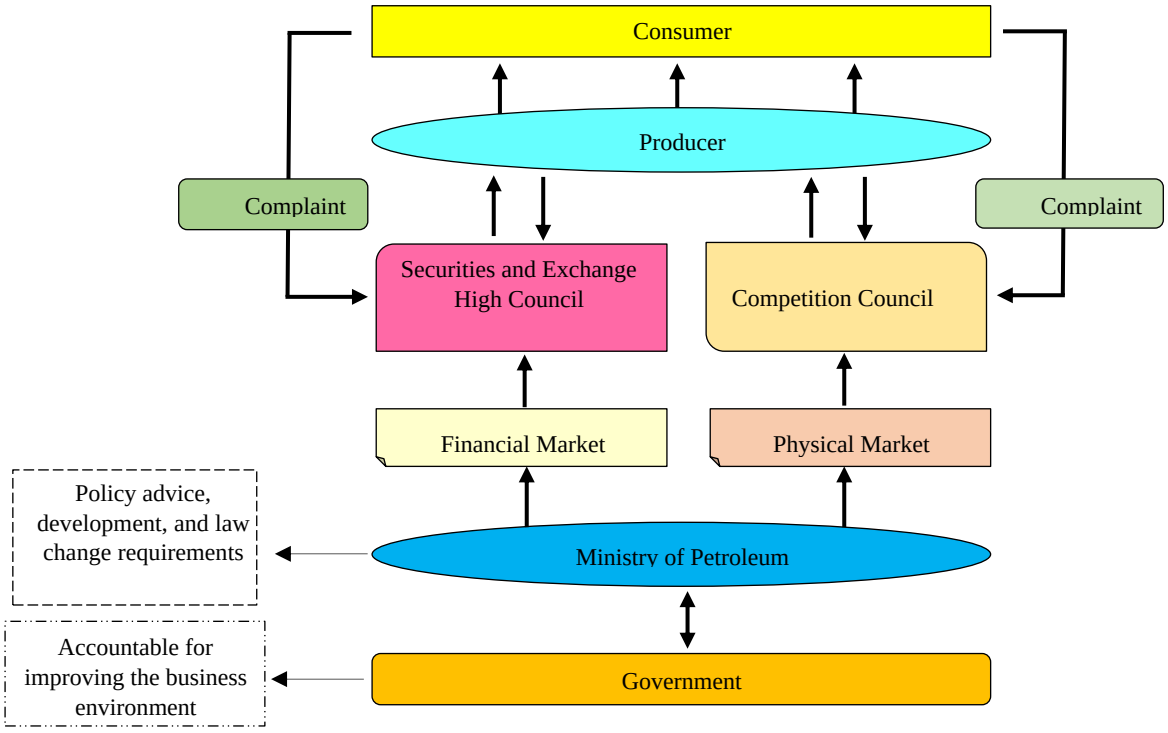


Figure 2

The effective regulatory model for Iran's petrochemical industry

Regarding the establishment of the regulator, some policy recommendations are proposed in Table 8.

Table 8

Policy recommendations proposed for the establishment of an effective regulatory framework

No.	Policy Recommendations
1	The regulatory acts in a fully independent manner, and it is protected from the influence of any institution, organization, ministry, party, or person.
2	The decisions of this institution must be implemented by the government, institutions, private sector, guilds, and other organizations.
3	The Competition Council has to use petrochemical experts as institutional members in the regulatory body that it will set up and take the opinion of petrochemical experts before issuing instructions and regulations.
4	After the approval of regulatory provisions, all previous instructions and regulations that are inconsistent with the new regulations must be removed, and only one reference for monitoring and control is taken into consideration.
5	According to the price and amount of feedstock and the price of products, this institution must decide not the Ministry of Petroleum, nor any other ministry or organization.
6	The Ministry of Economy will have the right to vote in this institution only in respect of taxes and matters within its discretion.
7	Ministry of Industry, Mine, and Trade will only be involved in licensing production.
8	HSE management as a guarantee of sustainable development such as the Department of Environment should be established in all companies, and organizations should monitor their activities continuously.
9	It is completely essential for the industry that the National Petrochemical Company (NPC) should have the facilitating tasks for the growth of the industry: transferring technical expertise, identifying investors, recognizing the market, ensuring the government's sovereignty for the investors, helping implement the infrastructure plans such as land supply.
10	Excessive regulatory frameworks should be avoided because they reduce creativity and flexibility and lead to productivity reduction, high-cost production, and rising prices.

This paper identifies significant regulatory challenges within Iran's petrochemical industry, emphasizing the need for stronger laws and better integration between upstream and downstream operations. This aligns with the findings of Azimzadeh Arani (2016), discussing the critical regulatory hurdles the industry faces, thereby highlighting the lack of effective governance. Similarly, Kumar et al. (2020) provided a comparative analysis underscoring the importance of robust regulatory frameworks in enhancing operational efficiency and thus echoing a call for reform. Studies by Baldwin et al. (2015) and Guasch and Hahn (1999) further supported the notion that regulatory independence and clarity were essential for attracting investment and ensuring market stability. Moreover, this study's use of the Delphi method for gathering expert opinions parallels the methodology discussed by Hsu and Sandford (2007), which validates our approach in assessing regulatory indicators. The emphasis on regulatory independence and competition, as noted by Kingston (2011b) and MacAvoy (1992), supports our findings regarding the necessity for independent regulatory bodies like the Competition Council and Securities and Exchange High Council to foster a more attractive investment climate.

In addition, the findings on Iran's regulatory inefficiencies align with studies by Ahmad and Reza (2023), which highlighted significant barriers to foreign investment and market competitiveness. Similar to the estimates by Zarif (2023) regarding revenue losses in the petrochemical sector, our research underscores the economic implications of regulatory shortcomings, suggesting potential revenue losses. Our recommendations for adopting best practices from Brazil and South Africa resonate with Meyer (2022) and Nkosi (2023), discussing successful regulatory reforms that improved market performance in their respective countries. While our research delves into specific regulatory policies affecting the petrochemical sector, other studies, like Johnson (2022), take a broader approach, examining regulatory frameworks across multiple industries. Our research focuses on Iran, whereas studies like Nkosi (2023) analyze regulatory reforms in South Africa, leading to different contextual implications and recommendations. This study's policy recommendations may differ in scope and specificity compared to those of Meyer (2022), suggesting more generalized best practices without tailoring them to the Iranian context.

Overall, our research not only identifies significant regulatory challenges within Iran's petrochemical industry but also situates these findings within a broader context of regulatory theory and practice. By proposing actionable policy recommendations and emphasizing the need for structural reforms in regulatory agencies, this study provides a comprehensive framework that can guide future improvements in the sector. This alignment with global best practices underscores the importance of our findings in contributing to the discourse on regulatory effectiveness and market competitiveness in the petrochemical industry.

5. Concluding remarks

In this study, the challenges and complexities the Iranian petrochemical industry faces as well as the criteria for the effective regulations were identified. We extracted and ranked the critical challenges and the effective regulatory indicators in Iran's petrochemical industry using the Delphi method. The final research findings show that the most fundamental challenges are the laws' weaknesses in the petrochemical industry for absorbing foreign and domestic investors and the lack of trust and integration from upstream to downstream. Further, there is a vital need for the existence of two regulatory agencies: the Competition Council in the physical market and the Securities and Exchange High Council as regulators in the financial market; the structure of these councils must be reformed before acting as a regulator.

Proportion, responsiveness, financial independence, legal independence, and political independence were identified and ranked as the most important effective regulatory indicators in Iran's petrochemical

industry. It is highly recommended that they should be considered by the regulator because by creating an effective regulatory body based on the indicators and the above-mentioned characteristics, existing challenges and complexities will be resolved based on the designated priority.

We also identified critical challenges and effective regulatory indicators for Iran's petrochemical industry, emphasizing the weaknesses in laws, the lack of trust, and the need for two distinct regulatory agencies. This aligns with findings from Brown et al. (2006), highlighting the importance of regulatory clarity and public participation in fostering investor confidence and addressing market inefficiencies. Similarly, Noll (2000) emphasized that a lack of coherent regulatory frameworks could deter both domestic and foreign investment, echoing your concerns about legal weaknesses.

This study's conclusion also stresses the necessity for effective regulatory bodies, which resonates with Gilardi (2002), arguing that independence and transparency are crucial for regulatory agencies to function effectively. The suggestion for reforming the Competition Council and the Securities and Exchange High Council is supported by Perrotton and Massol (2020), noting that regulatory bodies often require structural adjustments to enhance their efficacy in managing complex industries.

Furthermore, the identification of key indicators—proportionality, responsiveness, and independence in this paper—reflects the findings of Stern and Holder (1999), advocating for these attributes as essential for effective regulatory performance. The emphasis on financial and legal independence in our work is particularly pertinent, as Kumar et al (2020) highlighted similar factors as critical for ensuring that regulatory bodies can operate free from political interference.

Overall, this paper contributes to the existing literature by providing a structured approach to identifying and prioritizing regulatory challenges and indicators specific to Iran's petrochemical sector, reinforcing the need for comprehensive reforms in regulatory practices to foster a more conducive investment environment.

Despite existing studies, gaps remain in understanding the long-term impacts of regulatory reforms in Iran's petrochemical sector. Future research should focus on longitudinal analyses to assess the effectiveness of proposed changes and explore the socio-economic implications of a reformed regulatory framework.

Nomenclature

BRTF	Better regulation task force
HSE	Health, safety, and environment
OECD	The Organization for Economic Cooperation and Development
RAND	Research and Development
SPSS	Statistical Package for Social Sciences
UNIDO	The United Nations Industrial Development Organization

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