



Limitations of the Implementation of Polycentric Governance over Iran's Raw Steel Production Inputs (with Emphasis on Iron Ore)

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ABSTRACT

The aim of this study is to examine the tragedy of the commons in Iran's iron ore mining sector. To do so, the theory of polycentric governance was employed, taking into account the lack of legal and distributional frameworks for common resources, and incorporating the theories of Commons and Nozick. The steel industry faces several challenges, such as pollution, raw material supply, lack of cooperation between miners and steel producers, lack of energy in raw steel production, and government intervention and sanctions, which all stem from the monocentric decision-making system. The current research begins by introducing various types of polycentric governance and then delves into the Ostrom-Commons-Nozick theory, utilizing content analysis and analytical descriptive methods. The analysis first examines the different types of polycentric governance, taking into consideration the distribution of power among institutions and the legal rules outlined by Commons. Polycentric governance is concerned with the negotiation process. The vulnerability index is used to assess the consequences of government intervention and monocentric governance. The study's findings reveal a fragmented polycentric governance in operation in the national steel industry. Due to recent imposed sanctions and the multitude of government institutions, strong polycentric governance is not feasible in Iran, given the existing structural inequalities, such as the country's degree of development and climatic conditions. A consistent choice could not be attained.

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1. Introduction

The tragedy of the commons in the steel industry and its inputs has been among the recent headlines. These inputs include land, weather, and iron ore mine and the current study focuses on iron ore as its case study. Over the past few years, the over-extraction of iron ore mines has led to significant environmental issues, including air and water pollution, the release of fine dust and industrial waste from steel production, the loss of animal life, and a disruption to the natural balance of the environment. Other industries including copper are subject to these problems, as well. Over the years, countries like Iran have been heavily extracting natural resources, such as iron ore, resulting in several environmental and industrial repercussions. These consequences may pose significant challenges to future generations. Issues such as air and water pollution, fine dust, and industrial effluents, all of which result from steel production, have led to the death of living creatures and disturbance in the balance among environmental forces. Given the significance of this issue, the majority of countries prioritize the following matters during steel production: 1) Further use of iron scrap as raw material in electric arc furnace; 2) Paris Agreement; 3) Price reduction of raw materials while using scrap iron through the electric arc furnace method; 4) Application of new technologies for producing steel products and use of hydrogen gas in the production process (Comprehensive Steel Studies Plan, 2019). Due to the economic sanctions imposed on Iran, the steel industry, deemed as its strategic industry, is gaining the upper hand over the oil industry. In Iran's 2026 Vision Document, the issue of increasing iron ore extraction up to 55 million tons is mentioned along with subsidies provided for these inputs. It should be noted that removing these subsidies would result in a significant difference in the price of production inputs. In addition, 62% of all steel dryer industry producers operate in the hot and dry regions of the country trying to earn revenue in foreign currency. Furthermore, the government's involvement in the steel market, such as making decisions about crude steel exports, prescriptive pricing, and supply in the commodity

exchange, has led to various issues, creating opportunities for rent-seeking¹. The government's decisions are mainly made without much involvement of the private sector, and its participation is top-down. Of note, there are also some problems concerning the imbalance between consumption and demand. Based on the 2014 mining census, the number of iron ore mines rose from 131 to 206. However, the distribution of mines by ownership showed a number of mines in the cooperative, private (excluding cooperatives), and public sectors, with 4, 118, and 7 mines, respectively. In 2019, the number of these mines had increased to 4 (cooperative), 190 (private), and 12 (public) sectors, respectively. The extraction of mines had also increased in both private and public sectors. As a result, the added value resulting from the activities of the mines in operation had increased significantly from IRR 34,569 billion in 2014 to IRR 683,353,750 billion in 2019.

The impact of government intervention can be observed in the form of price distortions and an increase in rent-seeking behavior. Furthermore, a rise in the production of crude steel leads to a corresponding increase in the emission of CO₂ gas. The term "polycentric" refers to a system in which there are multiple decision-making centers that are officially independent from one another, and compete with each other through making various contracts and commitments. In cases of disputes, they may resort to central mechanisms to settle their differences. The system functions as a whole due to the harmony and compatibility between these decision-making centers (Motevasseli, 2014-15, 125). Ostrom was the originator of the concept of polycentric governance, which was initially applied to river fishing at the local level. She introduced the Institutional Analysis Framework (IAD) to provide a general explanation, but she did not elaborate on the ownership rules or resource distribution. In light of this, legal perspectives on the Commons and Nozick's theory of justice should be incorporated.

1. The rent stems from the government intervention as well as the income obtained from the sales of natural resources.

In this study, the analysis first examines the different types of polycentric governance, taking into consideration the distribution of power among institutions and the legal rules outlined by Commons

2. Theoretical foundations of research

The concept of polycentricity was first introduced by Michael Polanyi in a book titled *The Logic of Liberty* (1951). Later, the term was used in some other legal studies by Lon Fuller (1978), Chayes (1976), Horowitz (1977), and Urban networks (Davoudi (2002)). In this regard, Ostrom applied the concept of polycentric governance to various fields including the public sector economics, tragedy of the commons, new institutional economics, and behavioral game theory. One of the related issues is the exploitation of common resources by beneficiaries and is analyzed using the Institutional Analysis Framework (IAD). Note that this issue had already been investigated by Hardin and Gordon. They proposed the solution that involves transferring resources to the private sector and given control over to the government. However, citing the inefficiency of the market and government mechanisms, Ostrom proposed the solution of polycentric governance (bottom-up participation) that involves four stages: free entry and exit of independent decision-making bodies, interaction of institutions with each other in the case of conflict of interest, experiment, and learning. According to Ostrom, polycentric governance is characterized by the diversity of decision-making centers, their independence, freedom of entry and exit for institutions, negotiation between institutions, experimentation and imitation, and learning from other experiments. Ostrom noted that due to the difference between different institutions, institutional propositions are cited as exogenous factors and they can be made in either oral or written forms. (Crawford and Ostrom, 1995). Here, these propositions contribute to achieving sustainable development goals. Ostrom relied on his local knowledge and argued against the efficiency of the market mechanism. Based on his observations, he believed that local people know their

neighborhood best and can take care of their own problems without the need for outside cooperation. However, Ostrom neglected two issues: the equality of individual rights in democracy and the issue of property rights for common resources. Ostrom defined rules as the exogenous variables. Of course, Schlager and Ostrom, inspired by Commons' discussion about the legal foundations of the capitalist system, defined the property rights of the systems as "the right to access, the right to withdraw, the right to manage, the right to exclude, the right to transfer ownership", but they did not provide a detailed definition (Ostrom, 2010). Block and Jankovic (2016) criticized Ostrom's definition of ownership by pointing to privately-owned pastures in the Alps where individuals could deprive others of access. In this regard, Common and Nozick's theories were taken into account. The theoretical framework of governance from the perspective of Commons is established based on three axes: conflict and opposition, agreement based on the mutual need, and order. Both Ostrom and Commons considered the conflict resolution to be the least expensive means of reducing disputes through work rules. Negotiations and bargaining between the stakeholders should be done on equal terms, and the drafting of laws should be issue-oriented (Commons, 1950). Nozick argues that the equality of laws should depend on a distribution based on the merit and competence of individuals. Further analysis in this field can be divided into two categories: one based on theoretical foundations, with reference to Ostrom's theory, and the other based on statistical data extracted from databases.

One significant study obtained from primary sources is Melville's (2017) analysis of the polycentric governance system in the energy industry. Using content-analytical methods, Melville identified problems caused by the high complexity of energy industry codes, structural gaps between climate and energy policies, and a lack of geographical coordination in the deployment of smart meters. Melville also found that increasing local diversity in energy markets, and increasing accountability and democracy through public ownership of infrastructure, could help address these issues. Cole (2015)

theoretically elaborated the benefits of polycentric governance for formulating climate change policies. Due to the growing formation of formal and informal interactions (bilateral and multilateral), mutual trust among people increased. Araral and Kris (2013) conducted a comparative study of the performance of polycentric governance in Thailand and San Francisco. They found that informal institutions in the Thai environment, such as MTP, were ineffective due to a lack of accountability. However, in San Francisco, the flexibility of institutions allowed them to adapt to global governance models. Bauwens (2017) used analytical and descriptive methods to study polycentric governance approaches for low-carbon transitions and identified socio-institutional factors as obstacles in energy systems. In their study on the factors affecting polycentric governance in the United Kingdom's climate change policy, Gillard et al. (2017) highlighted the lack of normative clarity caused by structural inequality, high complexity, deep structural gaps, and failures in collaboration. Berardo and Lubell (2019) elaborated on the ecology of games as polycentric governance. Kaiser (2022) emphasized the role of common rules at the international level in the North-South imbalance in transnational climate change governance. The following studies, which are considered secondary sources, will help further contextualization. Sanderlin et al. (2015) studied 23 sub-national plans in 6 countries from December 2012 to June 2013 (Brazil, Peru, Cameroon, Tanzania, Indonesia, and Vietnam). Pursuing the objective of carbon emission reduction through deforestation, he assessed the effectiveness of polycentric governance. Gallemore (2016) examined the role of transaction costs in the evolution of polycentric governance and concluded that polycentric governance could not be implemented at low transaction costs. Moftakhari et al. (2020) investigated polycentric governance in the field of non-financial capital and used four mechanisms involving technical investment, institutional promotion, science production, and environmental protection. Eldidi et al. (2021) examined the role of foreign actors including NGOs in the polycentric governance of common resources in India and then pointed to

the need for the realization of the cooperation of NGO organizations with farmers and government institutions. Cong et al. (2020) applied the polycentricity method to China's textile industry parks, employed the multilevel partnership model, and highlighted the requirement of implementing the polycentric governance deemed as the political support from the government and regulatory policies and building capacity for the players. Patala et al. (2022) described the polycentric governance in the United States, Spain, and Finland, emphasizing the coordination between the private and public sector organizations and information sharing. Fortnam et al. (2022) investigated different types of polycentric climate governance in Malaysia, Philippines, Vietnam, and Indonesia using Ostrom's theory and introduced polycentricity as a function of two variables, namely power distribution and collaboration. They highlighted strong climate polycentric governance in the Philippines, centralized or directional governance in Vietnam, fragmented polycentric governance in Indonesia, low polycentric governance in Malaysia. They also took into account the components of religious diversity and ethnic diversity related to seafood products. Rezapour et al. (2021) cited two factors including excessive use and depletion of resources (drying of wetlands, lakes and rivers, subsidence of plains, etc.) as the reasons behind market and government failures in the management of common resources. Finally, according to Ostrom, the above authors concluded that about 70% of the individuals supported adopting a local participatory management solution, while the rest supported the market or government solution. Motvaseli et al. (2019) discussed the application of Elinor Ostrom's institutionalism in development planning and proposed that the formation of democratic collective action should be decentralized and social, starting from the bottom up.

This research stands out for utilizing theoretical methods and empirical evidence to explore different forms of polycentric governance. The study first described the current state of affairs, identified the ideal conditions for polycentric governance in Iran, and compared these two situations.

Moreover, the benefits of employing polycentric governance in crude steel production were highlighted.

Table 1. Number of mined mines

Year	Mines	Cooperative	Private (Non-Cooperative)	Public
2015-2016	131	7	118	7
2016-2017	119	7	104	7
2017-2018	135	6	122	7
2018-2019	131	6	113	12
2019-2020	-	-	-	-
2020-2021	206	4	190	12

Source: Iran Statistics Center (project of mining statistics results): www.amar.org

Table 2. Amounts of consumption and investment of steel production inputs

Year	Value Added IRR Million	Investment value of mines (IRR million)	Natural Gas km ³	Electricity kw/h	Electricity produced and consumed in the domestic power plant (1000 kw/h)	Water (km ³)
2015 2016	34569405	16191453	109561	1452808	7121	19424
2016 2017	53151619	13395910	173408	1656926	143738	17586
2017 2018	121683038	13420985	238842	2315593	126803	18546
2018 2019	229058601	7529041	164763	3982311	45280	16788
2019 2020	246080726	7707455	413677	4818660	73884	107276
2020 2021	683353750	27097479	305081	4009933	47484	19681

Source: Iran Statistics Center (project of mining statistics results), from: www.amar.org

In both 2015 and 2016, a total of 33 and 35 operating mines respectively made investments in the environment sector. On average, approximately one quarter of these mines made investments in the environment sector. This trend highlights the tragedy of the commons, in line with the Sustainable Development Goals. Given the inefficiencies of both government and market approaches, Ostrom's polycentric governance theory was employed in the analysis, drawing on existing literature. To determine the degree of the government inefficiency, we reviewed the government's circulars in this industry, which are presented below in brief.

Table 3. An overview of the government's circulars in the steel industry

No	Circulars	Result
1	Intervening in the pricing of steel by the government and banning any rise in the price of steel until the end of June 2018	No increase in the prices is acceptable and due to the increase in global prices, exchange rate, and price of steel production inputs such as graphite electrodes, etc., the producer must compensate for the increase in the total price from his own pocket.
2	Lowering the price of steel to pre-currency fluctuation levels by increasing its supply in the commodity exchange through actions taken by Iran's steel industry (2016).	Due to the government's emphasis on stabilizing the price of steel in the commodity exchange and increasing the exchange rate in the open market, the exchange rate also increased and the Ministry of Security defined the base price formula in the commodity exchange as 95% of the FOB price of the Persian Gulf multiplied by the exchange rate.
3	Emphasis on the supply of steel in the stock market at a rate of 4200 Tomans in 2018	Only the producers registered in the Behinyab system were able to buy steel and other metals from the commodity exchange.
4	Organizing the export of metals and fulfilling the obligations of the production units in the stock market (monthly supply of 25 thousand tons of steel) in 2017	Prescriptive control of the steel price in the commodity exchange, increase in its distance from the market price, and some other abuses made the Ministry of Security announce a conditional ban on steel exports.
5	Restriction on steel exports under the pretext of meeting domestic needs	Considering the surplus supply of 10 million tons of steel in the country, the export of steel was limited by the Ministry of Security to a few companies or their representatives.
6	The involvement of Competition Council in steel pricing	Replacing the free currency or the currency market with the proposal to correct the price and use the CFR formula resulted in huge losses for many shareholders of the stock exchange.

Source: The website of Ministry of Industry, Mine, and Trade (mimt.gov.ir)

3. Research methodology

The adopted methodology centers on descriptive analysis and content analysis methods. In general, there are four types of governance: polycentric, fragmented, centralized coordinated, and centralized rent-seeking, as depicted in the figure below. Elinor Ostrom only explained the case of strong polycentricity. Her emphasis on the pluralism of institutions is within the framework of the theory of cooperative games. She argues that independent decision-making institutions with discretionary power in a cooperative game shall reach an agreement through negotiation and coalition. In the real world, there are no equal rights among the decision-making institutions in all societies which is the reason why this issue should be considered. By taking into account the ideas of Commons and Nozick, which pertain to institutional rights and merit-based distribution, respectively, we can eliminate the flaw in Ostrom's polycentric governance theory. Given that Ostrom has depicted this governance model for the European Union, with reference to Figure (1), there are various scenarios to consider. Ostrom's definitions and assumptions hold true for the EU, which comprises 27 nations and functions as a grassroots collaboration. Cities, being the most fundamental unit of society, possess the requisite influence and jurisdiction to install pollution measuring tools and impose pollution taxes on manufacturers accordingly. In the context of the steel industry, various stakeholders come into play, including steel producers, politically engaged citizens and journalists, government bodies, environmental advocacy groups, and the World Trade Organization (WTO).

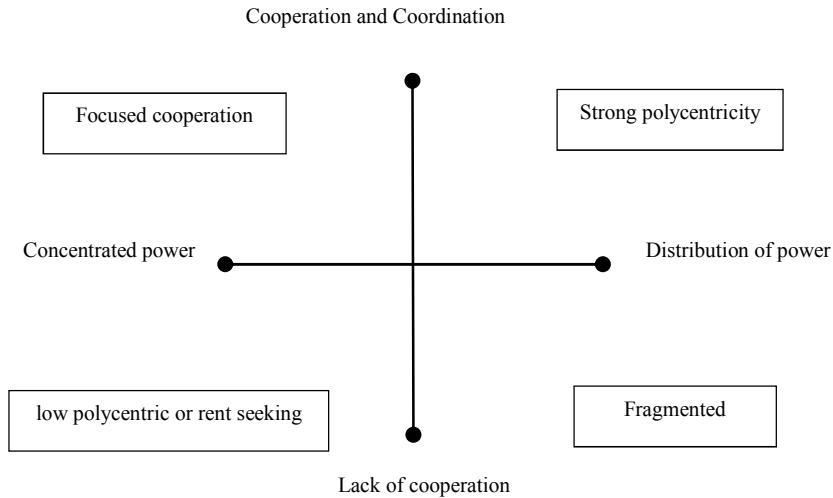


Fig 1. Classification of governance regimes in a two-dimensional network of power distribution and degree of coordination/cooperation.

Source: Pahl-Wostl and Knieper, 2014, 141.

Polycentric regimes combine the distribution of power and authority with effective coordination between different centers across spatial levels. In polycentric systems, flexibility and capacity increase followed by shock and disruption. Decision centers enjoy a degree of autonomy that supports experimentation and learning. Fragmented governance structures suffer from a lack of collaboration due to the distribution of power and authority, as well as overlapping decision-making centers, which leads to disharmony and contradictions in their efficacy. Centralized regimes operate under a hierarchical government and the government holds the highest position of power. Centralized regimes lack responsiveness and flexibility. Rent-seeking prevents cooperation and implies the abuse of government representatives and bureaucrats who increase their power hierarchically. In centralized and rent-seeking regimes, elites have little motivation to deal with problems. In centralized cooperation regimes, a top-down hierarchical structure is

established, but there is a lot of interaction and cooperation between institutions. Centers have limited autonomy, and the execution of decision typically occurs at a higher level, leading to conflicting governance problems. In the above figure, decentralization of power in polycentric governance is at a greater level than in other scenarios, because institutions enjoy freedom of expression and conditions of equal rights and equal opportunities. Since polycentric governance is influenced by the behavior of agents and beneficiaries, we will identify the affecting factors. One of the important components of polycentric governance in Ostrom's definition is self-organization, which should identify and prioritize the preferences of decision-making institutions, and the condition of self-organization is the recognition of institutions and the granting of voting rights to them. In a robust and fragmented polycentric system, institutions possess equitable authority, whereas this is not the case in centralized and less polycentric structures, where institutions have minimal rights due to centralized power. The manner in which institutions interact with one another determines the type of governance in place. It is worth noting that fundamental causes play an important role here. Fundamental causes may include political diversity in the governance of societies as well as deep ideological and historical differences. Undoubtedly, other factors must be taken into account in the interplay between institutions, such as the harmony of their goals and conduct. However, these elements can have varying impacts on the diverse forms of polycentric governance.

The following section first outlines the current situation before proposing a model rooted in Ostrom-Commons-Nozick theory.

4. Discussion and investigation

First of all, we have to examine the current situation and then the external consequences of the steel production are examined and later we explain the model by referring to the problems in the monocentric governance system.

4-1- The status of steel in Iran

Steel factories in Iran are managed by the government, because 96% and 70% portions of raw and finished steel are respectively produced by state-owned companies, and the largest steel producers of the country are state-owned (Mubarake steel, Khuzestan steel and Isfahan iron smelter with market shares of 47, 23, and 20 percent, respectively). In the last four decades, more than 150 million tons of crude steel have been produced in Iran, out of which 200 million tons of steel were used in the construction of residential buildings and factories, development of communication routes, car production, energy, fluid transfer, etc. According to Iran's strategic vision, the country's steel production should reach more than 50 million tons per year by 2025. This projection is aligned with the predicted growth of global steel demand (from 1.410 million tons in 2010 to 2.200 million tons in 2050) (Ghazi Noory et al., 2021, 2). In Iran, due to varying production methods, success in practice has been limited, largely due to government intervention in the industry. Specifically, the government intervenes in three sectors of the iron and steel production chain: stock exchange, policy, and export duties. Decision-making institutions in the steel industry are listed as follows:

- Steel and Iron Association (producers and exporters): Aiming to organize the country's production process and maintain balance and order.
- Iranian Iron and Steel Association: Improving the business environment.
- Ministry of Security: Making decisions on steel import tariff, imposition of export tax, product pricing, and stock exchange.
- Ministry of Economy and Finance and Ministry of Security: Making decisions on production, import, and export, pricing, etc.
- Ministry of Energy: Supplying water and electricity needed by steel producers.
- Iron and Steel Council: Aiming to reduce the interference from the Ministry of Security, especially in pricing matters.
- Iran National Gas Company: Supplying gas needed by steel producers

- The country's management and planning organization: Making development plans in strategic products, including steel.
- The Islamic Council as a legislator.
- Commodity exchange organization: Involved in pricing of all kinds of steel products and supply of products
- Environment Department: this organization does not even have official statistics on environmental pollution.
- Municipal organization: receiving duties from polluting industries
- Water and Wastewater Company: Supplying water needed by steel factories. We do not have official statistics on water pollution.

Iron ore miners face several challenges, including a 25% income tax, a 9% value-added tax, and other issues related to environmental and agricultural pollution. To discourage the sale of raw ore, iron ore duties are higher compared to other products, which has hindered investment in downstream industries such as concentrates and pellets.

Table 3. The cost of energy carriers and water for the production of one ton of steel in 2018 (accumulation of the chain) (figures in Tomans)

Technology energy carrier	EAF	IF (Induction Furnace)	BOF (blast furnace)
The cost of electricity	98745	71775	46545
Cost of natural gas	110500	57200	7040
Water cost	7200	4300	7200
Total	216445	133275	60785
The ratio of the cost of energy carriers to the selling price of steel ingots (%)	5/4	3/3	1/5

Source: Deputy of production studies (2021)

The share of energy carriers' costs in the two companies of Isfahan Mobarake Steel and Khuzestan Steel was about 7% in 2018, which differs

significantly from other countries in the world. For iron smelting, it is 49% (Deputy of production studies, 2021, 20). Several companies, such as Foulad Mobarakeh, have taken effective measures to reduce their environmental impact. For instance, they manage slag from steel production to prevent desertification and reduce dust, invest billions of dollars in environmental projects, and utilize hybrid methods to prevent water wastage. Among the steel producing companies, only two iron smelting and Zarand steel companies use the blast furnace method. Hadid Azar steel companies, Kavir Damghan steel company, Urmia steel company, Malair steel company, and Shahroud steel company use the induction furnace method. Some manufacturers recover scrap steel. In Iran, the government has the authority to appoint managers of the steel company. In other words, the government has the upper hand in the decision-making process and the hierarchy is established from top to bottom (Figure 3). In order to produce more steel, Sweden has initiated extracting from Kalak mine, which endangers the ecosystem and prevents the migration of reindeer. In addition to the natives of the region, UN, and UNESCO experts, environmental activists have opposed the implementation of this project. This situation is a clear example of how governments that do not prioritize sustainable development can be ineffective.

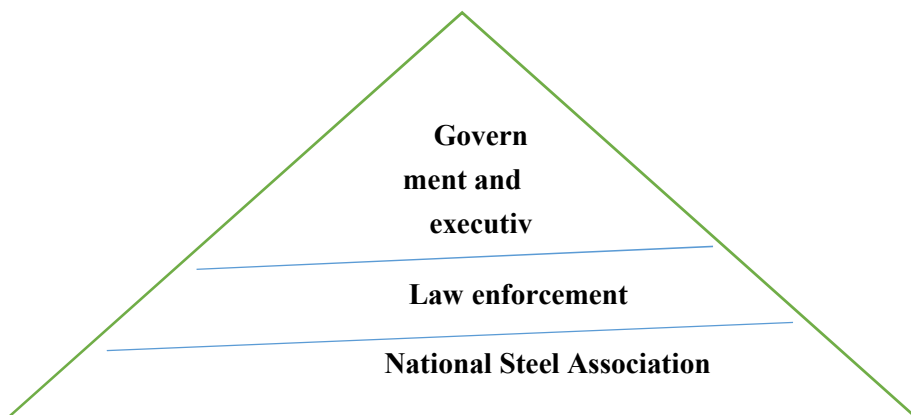


Fig 3. Management of the steel industry in Iran

Source: research findings

4.2. External consequences of steel production

Direct emission from the steel industry accounts for about 7% of global energy-related emissions, resulting in about 8% of global final energy consumption. Three technological pathways that can reduce greenhouse gas emissions in the steel industry are direct iron reduction using green hydrogen, CO₂ capture and storage (CCS), and environmentally-friendly steelmaking. Hydrogen-based steelmaking may lead to a nearly CO₂-neutral steel industry as a single technology. CCS reduces emissions by 70% and bio-based steelmaking is able to decrease the rate of emission by 50%, but must be combined to achieve a CO₂-neutral industry (Swennenhuis et al., 2022). The amount of CO₂ emission varies depending on the steel production method adopted in Iran and other countries. On average, its emission per ton of steel in the EAF and BOF production methods is 1.2 and 2.2 tons of CO₂, respectively.

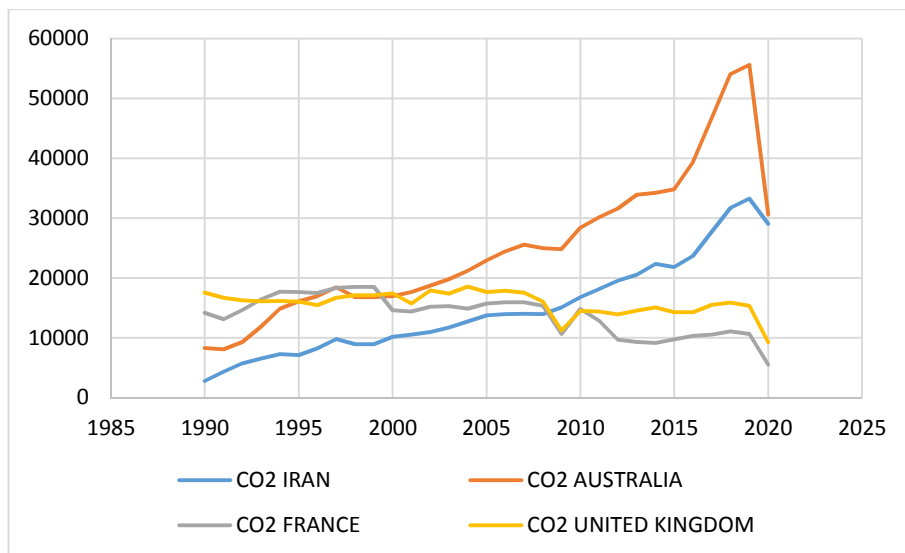


Fig 4. Average annual CO₂ emission per ton of raw steel production

Source: Worldsteel.org

In 2019, the Covid-19 epidemic caused a decrease in the global demand for crude steel, resulting in a reduction in its production worldwide. The figure shows that both Iran and Australia, as crude steel exporters, contribute more to pollution than importing countries like France and Great Britain. It's worth noting that Australia is the world's largest crude steel exporter, while Iran ranks 10th. Unfortunately, this pollution has significant external consequences, including global warming, loss of biodiversity, and human deaths. To address this issue, economic thinkers such as Coase and Pigou have proposed solutions. Coase emphasized the importance of transaction costs, but it's challenging to calculate these costs for climate, which is a global public good. On the other hand, Pigou suggested implementing a pollution tax, but this approach has its drawbacks. For example, it requires government intervention, and measuring pollution levels accurately requires specialized equipment. However, the private sector is often unwilling to invest in such equipment due to cost-benefit considerations, necessitating government intervention.

Despite the implementation of pollution taxes and the installation of specialized equipment, factories still produce high levels of pollution, making it challenging to accurately measure the social costs of crude steel production. Additionally, the inefficiency of government and state-owned companies in addressing this issue further complicates matters. Developed countries have formulated different policies to solve this problem. For example, the United States and the European Union directed the policy of changing trade tariffs in order to reduce the consumption of steel and reduce the emission of pollutants (Swennenhuis et al., 2022). Denmark has implemented several environmental taxes to address pollution caused by the burning of fossil fuels. For instance, in 1982, the country implemented a coal tax, followed by a carbon dioxide tax in 1992, and natural gas and sulfur taxes in 1996. The combined revenue generated from these taxes was approximately \$9 billion in 2005 and \$25 billion from 1980 to 2005. Despite the drop in fossil fuel costs in the 1980s and 1990s, energy taxes remained

high in Denmark. These taxes played a crucial role in curbing pollution levels in the country and incentivizing individuals and businesses to shift towards renewable energy sources. These taxes helped optimize the electricity industry. It should be noted that the fair distribution of electricity among users and the provision of energy production costs through taxes were equal to the cost spillover among users (Sovacool, 2011). We have identified the problems in the single-center governance of raw steel in Iran:

- Government intervention and approval of export duties in order to support downstream industries;
- Government intervention in the pricing and supply of steel products in the commodity exchange or rent-seeking resulting from the allocation of foreign exchange and capital flight from the country (for example, the export of steel sheets under the title of steel scrap);
- Lack of balance between production and consumption;
- Developing countries have become an attractive destination for crude steel production, catering to the needs of developed nations such as Germany. Iran, for instance, has increased its steel exports to cope with the effects of oil sanctions, while Germany has been increasing its steel exports to produce low-carbon steel or "green steel." The increasing demand for Iranian steel has been observed in countries like Germany, where companies such as Sabz have been seeking to procure Iranian steel.
- Non-use of the electric arc method in most factories due to the low cost of production, inexpensive energy, and limited government budget for supporting industries and providing new technologies in production;
- Establishing participation from top to bottom and no voting rights for producers and exporters;
- The difference between the global price and the domestic price of steel;
- The policy of crude steel export to other countries merely due to its currency;
- Steel factories are not only situated near iron ore mines but also in surrounding provinces. Also, most factories are located in hot and dry

areas, leading to high water and energy consumption, which can result in severe environmental damage.

- The problem of supplying raw materials for steel factories (for example, non-cooperation of miners with steel factories and lack of gas, etc.)
- Despite compliance with the environmental standards of Mobarakeh Steel Factory, due to the foreign currency allocation policies and even their negative trade balance in 2017, rentier areas emerged.
- Another reason for the lack of polycentric governance in Iran's steel industry is that most listed steel companies are either state-owned or government-affiliated. As a result, they lack the necessary authority to make independent decisions and are required to follow the government's orders, indicating that the government holds a monocentric position in this industry.

4.3. Designing a model for polycentric governance in Iran

The regions with iron ore in Iran include Arak-Malair region, Kerman Yazd region (Jalalabad iron ore mine, Zarand, Gol Gohar mine, Chaghart iron mine, Chaghez Bafq iron mine, Se Chahun Bafq iron mine), Isfahan region - Kashan, Khorasan region, Tehran-Qom-Qazvin region, Persian Gulf, and Kovar region. Manufacturing factories have also been built in the same regions or neighboring provinces. The level of access of crude steel producers to water sources, the distance between mines and manufacturing plants, and the inequality of rights between institutions, etc. should be considered in the analysis. In order to establish a framework for polycentric governance in Iran's steel industry, it is important to establish certain conditions. For instance, the Iron and Steel Council, the Iran Steel Association, and the Iron Ore Association must recognize and negotiate with other government institutions. However, it's worth noting that having too many institutions can lead to excessive complexity within the system and hinder the realization of polycentric governance. From the viewpoint of Commons, the best approach is to resolve the conflict through negotiation so that the institutions can express their opinions with the right to vote and

reach a unified opinion. Buchanan considers conditional democracy inefficient due to the profit-seeking of powerful political parties. Hayek regarded democracy as an ideal state, but believed in self-organization without government intervention, and preferred the market mechanism. However, he acknowledged that free-riding in the system could also render it ineffective. On the other hand, Nozick proposed a model of distributive justice that emphasized minimum government and the distribution of assets based on the merit of institutions. However, there is a risk that this meritocracy may increase the grounds for rent-seeking in society, leading to the rule of political elites and the inefficiency of the political system. Therefore, in order to prevent collusion between the aforementioned institutions, there should be a top-down partnership at the same time. Participation from top to bottom means that international environmental organizations such as UNEP should monitor the actions of countries according to standard environmental indicators.

By presenting her analytical and institutional framework, Ostrom only provided a general outline and did not offer specific implementation guidelines. She believed that there should be rules in place, which can vary based on time and location and can be expanded to 12 different rules depending on the types of citizens, organizational membership, and individual characteristics. The historical pattern of property ownership and its transfer to individuals in various ways should serve as a foundation for law enforcement. The discussion of commons in defining rules is considered an endogenous variable and should be included in the model. Property rights and the decision-making of mine owners are critical in this regard. The polycentric governance model should be based on the distribution of power and stakeholder interactions. Governing rules should be accompanied by information transparency to prevent corruption as much as possible. Consequently, her theory is based on informational rules, aggregation rules, and reward and punishment rules, while Nozick's model of fair distribution is situated within the cost-benefit framework. Definition of the factors has

been provided earlier. The rules of the game can be summarized as follows:

- External variables: economic shocks such as sanctions and the Covid-19 crisis that affect the government's decision-making. Also, environment is one of the vital factors in this case.
- Action situations and evaluation criteria that have been discussed based on the theories of Nozick and Commons.
- Dependence of the interaction of the players on the situation they are in. These conditions include normal times, periods of recession or economic boom, or even economic embargo (inequality of countries' rights at the international level).
- Determining the structure of the game: the game is multi-stage, where in the first stage, the relevant institutions in Iran's steel industry identify their problems and negotiate among themselves from the bottom up. Among the executive bodies, only one institution should be responsible for negotiating with informal institutions. According to Commons and Nozick's model, each entity is granted voting rights. In this way, new laws which are ideal for all institutions are passed. The index of polycentricity should be defined by the index of social, economic, and environmental vulnerability. It is worth mentioning that the index of vulnerability consists of three indicators, namely economy, environment, and society. Indicators of economic vulnerability include economic openness, dependence on strategic exports and imports, and foreign development aid (ODA). The environmental vulnerability indicator includes the death of people due to the emission of greenhouse gases such as CO₂. Of course, we can consider the reduction of gas and water reserves, etc. In Iran, the Mobarakeh steel factory has operated according to international standards, but its managers are chosen by the government and unfortunately, the private sector does not have the right to vote. Also, this factory is located in a hot and dry area for political reasons (Iran-Iraq war). Based on the mentioned contents, the algorithm of multicenter governance in the steel industry is drawn below.

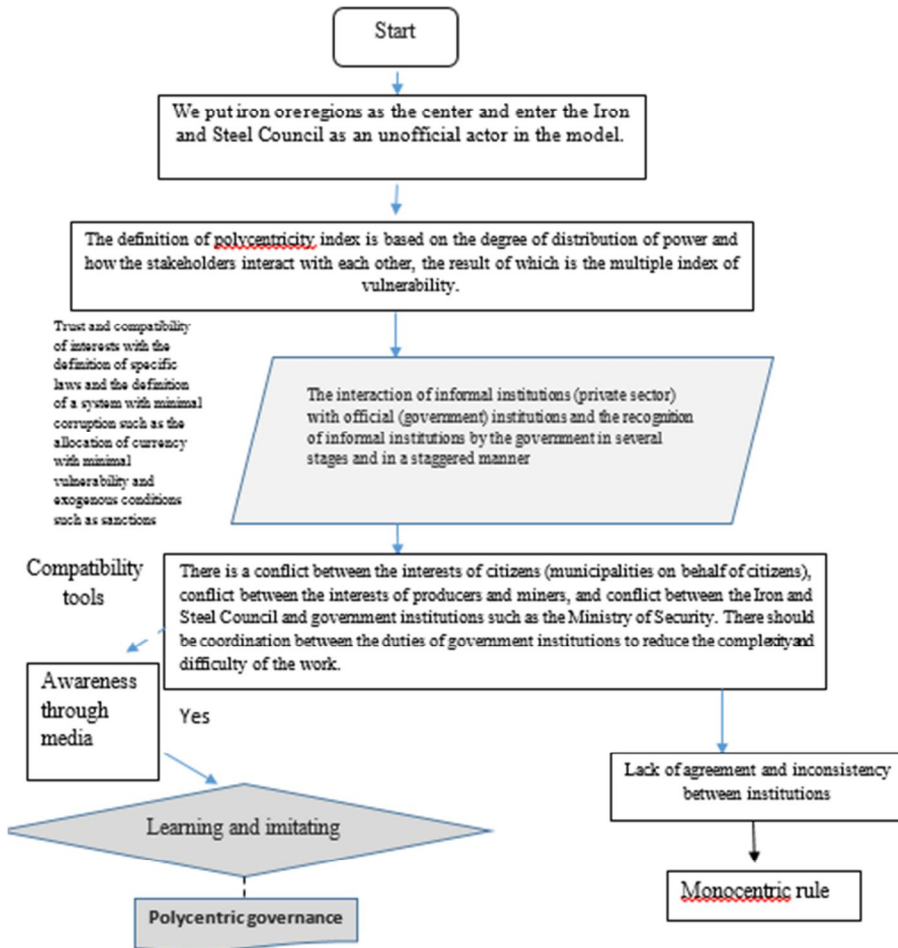


Fig 5. Design of the polycentric governance algorithm for Iran's steel industry

Source: Research findings.

5. Conclusion

In conclusion, according to Ostrom, Commons, and Nozick, Iran's steel industry is currently governed under monocentric governance. To achieve polycentric governance, the government must first recognize all governmental and non-official institutions such as the Iron and Steel Council and the National Steel Association and grant those voting rights and authority.

Although full cooperation at the national level may be difficult, incremental polycentric governance seems to be the ideal state. Without the recognition of informal institutions, interactions between institutions may not be based on the merit of the institutions, and the distribution of power may not be fair, leading to lack of participation from the bottom up. Currently, due to existing restrictions at national and transnational levels, interactions between institutions are limited, and the centralized power of the government is dominant. However, in strong polycentric governance, interactions between all institutions at local, national, and transnational levels must be comprehensive to prevent collusion between institutions at any level. Additionally, institutions must recognize and help each other to achieve polycentric governance. Fragmented polycentric governance may occur when there is no interaction between transnational and other institutions and when there is an unequal distribution of power among institutions. However, when informal institutions are recognized, financial restrictions and inequality of rights are eliminated, and strong polycentric governance can be implemented, leading to minimal social, economic, and environmental vulnerability. Structural inequalities in the steel industry, such as property rights and climatic conditions in Iran, pose challenges to achieving strong polycentric governance. Furthermore, fundamental causes such as differences in economic complexity, cultural and social differences, and geographical conditions may hinder countries' efforts to converge in preserving environmental resources and promoting clean energy and intergenerational justice.

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All authors had contribution in preparing this paper.

Conflicts of interest

The authors declare no conflict of interest

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