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Identification of Factors Affecting Production Policy Scenarios in the Steel Industry Using a Futures Studies Approach

Hossein Safari[1], Foad Makvandi[1]*, Reza Rostaminia[2], Ghanbar Amirnejad[3], Mahmood Daniali Deh Houz[4]

1. Department of Public Administration, Sho.C., Islamic Azad University, Shoushtar, Iran
2. Department of Accounting, Sho.C., Islamic Azad University, Shoushtar, Iran
3. Department of Public Administration, SR.C., Islamic Azad University, Tehran, Iran
4. Department of Public Administration, Ahv.C., Islamic Azad University, Ahvaz, Iran

*Correspondence: foad.makvandi@iau.ac.ir

Abstract

The steel industry, as one of the country's strategic and infrastructural industries, plays a decisive role in economic growth, employment generation, and the development of non-oil exports. Therefore, the formulation of effective production policies in this sector is of particular importance. The present study aimed to identify the factors affecting production policy in the steel industry. In terms of purpose, this study is applied, and in terms of nature, it is qualitative. The participating sources consisted of two categories: first, upstream documents and official policies issued by governmental institutions, including the Ministry of Industry, Mine and Trade, the Ministry of Economic Affairs and Finance, the Ministry of Commerce, and the Islamic Consultative Assembly, in the fields of production and the steel industry; and second, documents, production policies, and quality policies of 35 active national companies, including Mobarakeh Steel Company of Isfahan, Isfahan Steel Company, Khuzestan Steel Company, and others. Data were analyzed using a coding method. From a total of 166 initial indicators, 41 main components were identified and classified into eight key policy domains: customer orientation, knowledge management, economic and financial policy, research and development, competition and marketing, technology, human resources, and institutional-environmental policy. The most important identified components included investment in the steel industry, financial structure, application of technological equipment, competitive strategies, knowledge management, research and development, innovation, governmental laws and regulations, implementation of standards, risk management, the environment, iron ore reserves, the money market, and the capital market. The findings indicate that production policy in the steel industry is a multidimensional and complex phenomenon whose success requires the simultaneous integration of economic, managerial, technological, environmental, and institutional approaches, as well as coordination among the government, steel enterprises, the financial system, and the technological system. The results of this study can serve as a basis for policymaking, planning, and improving production performance in the steel industry.

Keywords: Production Policy, Steel Industry, Content Analysis, Industrial Policymaking.

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1. Introduction

The steel industry occupies a central position in national industrial systems because of its extensive upstream and downstream linkages, its role in infrastructure development, and its influence on manufacturing capacity, employment, exports, technological upgrading, and capital formation. Steel is not merely an industrial commodity; rather, it is a strategic input for construction, transportation, energy, machinery, automotive manufacturing, defense-related industries, and a wide range of capital-intensive activities. Consequently, the performance of the steel industry is closely connected to broader patterns of industrialization and economic development. In economies seeking to expand domestic production and reduce dependence on imported industrial inputs, steel production policy becomes an important component of national industrial policy. At the same time, contemporary steel production is increasingly shaped by pressures related to environmental sustainability, energy efficiency, technological change, global competition, and the restructuring of international supply chains. These developments have made the design of production policies more complex and have increased the need for integrated policy frameworks that simultaneously address economic, technological, environmental, organizational, and institutional factors (Andrade et al., 2024; Chang & Andreoni, 2020; Ferrannini et al., 2021).

Public policy in industrial sectors is generally concerned with deliberate governmental choices regarding the definition of problems, prioritization of objectives, allocation of resources, selection of instruments, and coordination of relevant actors. Public policy is therefore not limited to formal laws and governmental directives but includes the set of decisions, institutional arrangements, incentives, regulations, and implementation mechanisms through which public authorities seek to influence economic and social outcomes (Soudagar et al., 2018). From this perspective, industrial production policy can be understood as a coordinated set of governmental and organizational measures intended to influence the volume, composition, efficiency, technological level, competitiveness, sustainability, and future direction of production. The interpretation of policy problems is itself a critical part of policymaking because how a problem is defined directly affects the range of solutions considered legitimate or feasible. Interpretive and problematization-based approaches emphasize that policies are constructed around particular representations of problems and are influenced by institutional assumptions, dominant discourses, and policy actors' perceptions (Bacchi, 2015; Beigi, 2015). Accordingly, identifying the components influencing steel production policy requires attention not only to measurable economic variables but also to institutional interpretations, policy priorities, managerial assumptions, and organizational practices.

In the Iranian context, the analysis of public policy also requires attention to the interaction between governmental institutions, legislative bodies, public and private enterprises, financial systems, and sector-specific regulatory structures. Policy analysis models developed for Iran have emphasized the importance of considering contextual, institutional, executive, and environmental dimensions simultaneously, particularly where public policies involve multiple organizations and competing objectives (Asadifard et al., 2016). Policymakers' mental models and cognitive frameworks can further affect the way policy problems are perceived, interpreted, and translated into decisions. Cognitive mapping research indicates that policymakers' assumptions about causal relationships, implementation conditions, and policy consequences may significantly shape both policy design and execution (Teymouri Naghadeh et al., 2023). This issue is especially important in the steel industry, where policy decisions concerning production capacity, pricing, energy, trade, investment, technology, raw materials, environmental standards, and infrastructure are highly interdependent.

Industrial policy has regained prominence in contemporary economic debate because market mechanisms alone may not adequately address structural transformation, technological upgrading, coordination failures, environmental externalities, or strategic production capabilities. Modern industrial policy is increasingly understood as a multidimensional process involving learning, innovation, institutional coordination, productive capacity development, and strategic interaction between the state and firms (Chang & Andreoni, 2020). This perspective has become even more important after major global disruptions, including the COVID-19 crisis, which revealed the vulnerability of international production networks and reinforced the importance of resilient, sustainable, and human-centered industrial development (Ferrannini et al., 2021). For industries such as steel, policy design must therefore extend beyond short-term production targets and incorporate long-term issues such as sustainability, technological transformation, value creation, workforce development, energy security, and resilience.

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Competitiveness is one of the central concerns of steel production policy. Firms operating in capital-intensive industries are required to achieve high levels of productivity, quality, cost efficiency, innovation capability, market responsiveness, and organizational excellence. Research on firm competitiveness suggests that sustainable competitiveness results from the interaction of operational excellence, entrepreneurial capabilities, organizational resources, market capabilities, and strategic adaptation (Biswas, 2022). Investment is also a major determinant of competitiveness because industrial firms require substantial financial resources for modernization, capacity expansion, technological upgrading, environmental compliance, and product development. Evidence from international contexts shows that investment and competitiveness are closely connected, while trade conditions and investment patterns can significantly influence industrial performance (Bardazzi & Ghezzi, 2018; Berndt, 2016). In the steel sector, these relationships are particularly significant because production facilities require substantial fixed capital, long investment horizons, advanced technologies, and continuous modernization.

The financial structure of steel firms is therefore a key component of production policymaking. Access to financing affects firms' ability to invest in machinery, technology, raw materials, infrastructure, innovation, environmental projects, and capacity expansion. Research focusing specifically on large steel companies has demonstrated that the design of appropriate financing models is essential for improving financial sustainability and supporting long-term industrial development (Shafiei & Mirabi, 2020). Moreover, monetary policy can affect corporate investment through financing costs, liquidity conditions, credit availability, and expectations. Empirical research using advanced econometric approaches has shown that corporate investment decisions can respond significantly to monetary policy conditions (Caraiani, 2022). Accordingly, money markets, capital markets, exchange-rate policy, interest rates, fiscal measures, and financial instruments should be treated as integral elements of steel production policy rather than as external macroeconomic variables.

Innovation constitutes another fundamental pillar of sustainable steel-industry development. Firms increasingly compete through technological capabilities, product differentiation, process improvement, digitalization, and organizational innovation. Research on regional innovation systems demonstrates that knowledge production, innovation capacity, institutional context, and regional resources can collectively influence economic and industrial development (Ali, 2024). At the firm level, investments in research and development can improve technological capabilities and strengthen competitiveness, particularly in industries where rapid technological change requires continuous adaptation (Bočková & Meluzín, 2016). Innovation also depends on internal organizational conditions. Knowledge-oriented leadership, human resource development, and organizational innovation have been shown to contribute to sustainable competitive advantage by strengthening firms' capacities to generate, absorb, and apply knowledge (Banmairuroy et al., 2021). Thus, knowledge management, research and development, employee development, organizational learning, and innovation capability are critical dimensions of production policy.

Quality management is similarly linked to competitive advantage. In industrial environments, quality performance can mediate the relationship between organizational factors and competitive outcomes, indicating that organizational resources and managerial systems generate competitive benefits partly through their effects on product and process quality (Ferdousi et al., 2019). This relationship has particular relevance to the steel industry, where product specifications, dimensional accuracy, metallurgical properties, reliability, standardization, and compliance with national and international standards directly influence market access and customer satisfaction. Consequently, policies related to standards, quality systems, customer orientation, process control, and continuous improvement constitute important components of production-policy architecture.

Human resources and managerial capabilities are also essential because advanced industrial production depends on skilled workers, engineers, managers, researchers, and technical specialists. The effectiveness of technology and capital investment is contingent on the availability of appropriate human competencies and organizational capacities. Qualitative research in management emphasizes the importance of systematically identifying underlying concepts, categories, and relationships within complex organizational phenomena, particularly where multiple institutional and managerial factors interact (Khanifar & Moslemi, 2016). In policy-oriented research, such qualitative approaches can facilitate the identification of components that may not be fully captured through conventional quantitative indicators. Furthermore, industrial stagnation studies have shown that managerial, financial, organizational, environmental, and structural factors may jointly contribute to weak firm performance, demonstrating the need for multidimensional analysis rather than single-factor explanations (Amiri et al., 2020).

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Production policy should also account for the systemic and dynamic nature of the steel industry. Steel production is embedded in interconnected systems of raw material supply, energy, transportation, finance, technology, labor, markets, environmental regulation, and governmental decision-making. System dynamics provides a useful conceptual basis for understanding such environments because it emphasizes feedback loops, delayed effects, interdependencies, and nonlinear relationships among variables (Hamidizadeh, 2020). Decisions intended to improve one aspect of production may generate unintended effects elsewhere in the system. For example, rapid capacity expansion without adequate attention to raw materials, energy, transportation, or market demand can create structural imbalances, while restrictive financial conditions can reduce investment in modernization and environmental technologies. Therefore, policy formulation requires an integrated rather than fragmented understanding of the production system.

Recent technological developments have further increased this complexity. Industry 4.0 technologies, including digital integration, smart production systems, artificial intelligence, advanced analytics, automation, and cyber-physical systems, are transforming industrial operations. Evidence indicates that Industry 4.0 manufacturing practices can improve operational performance through greater production-system integration and supply-chain agility (Turan, 2026). Sustainable Industry 4.0 transformation also requires coordination across supply chains, organizational structures, technological capabilities, and sustainability objectives (Pervez et al., 2026). In process industries, intelligent production scheduling based on knowledge graphs and advanced multi-objective optimization algorithms represents an emerging approach for improving production planning, resource utilization, and operational efficiency (Sun et al., 2026). These developments suggest that technological equipment, information systems, digital production, integrated scheduling, and organizational readiness for technology adoption should be incorporated into future-oriented steel production policies.

Environmental sustainability is another increasingly influential determinant of steel policy. Steel production is energy-intensive and carbon-intensive, and governments and firms are under growing pressure to reduce greenhouse gas emissions and environmental impacts. Life-cycle assessment studies demonstrate that the carbon footprint of the iron and steel industry is distributed across raw material extraction, production processes, energy consumption, product use, and other stages, requiring integrated cleaner-production strategies rather than isolated interventions (Wu et al., 2026). Research has also identified opportunities for the steel industry to move toward net-negative emission pathways through combinations of decarbonization technologies, carbon capture, biomass, renewable energy, and process transformation (Andrade et al., 2024). Green hydrogen is becoming particularly important in long-term steel decarbonization strategies, especially in regions combining high-quality renewable energy resources with accessible iron ore deposits (Devlin et al., 2023). These developments reinforce the need to integrate environmental management, energy strategy, resource efficiency, technological modernization, and clean production into steel production policy.

For Iran, energy and raw-material availability are especially important structural considerations. Steel production is closely linked to national energy systems, and changes in energy supply, energy prices, and infrastructure can directly affect production costs, capacity utilization, and competitiveness. National energy data and hydrocarbon balances provide an important basis for assessing the availability, allocation, and consumption of energy resources across economic sectors (Institute for International Energy, 2016). Likewise, the National Comprehensive Steel Plan provides sector-specific evidence concerning steel capacity, raw materials, infrastructure, production chains, technological requirements, and long-term development priorities (Foolad Technic International Engineering et al., 2016). Such sectoral planning documents are essential because policy choices regarding steel production cannot be separated from iron ore reserves, concentrate and pellet production, direct-reduced iron, crude steel capacity, transportation infrastructure, energy, export markets, and downstream demand.

The broader business environment also affects the implementation of production policy. Reports from business institutions indicate that industrial firms operate within a context shaped by regulatory conditions, financing constraints, taxation, trade policy, investment climate, market uncertainty, and administrative procedures (Tehran Chamber of Commerce & Agriculture, 2019). Public policies can either reduce or intensify barriers to firm growth and internationalization. Comparative research on small and medium-sized enterprises has shown that administrative, financial, institutional, and regulatory barriers can constrain international expansion and that appropriately designed public policies may facilitate firms' entry into foreign markets (Cardoza et al., 2016). Although the steel industry differs structurally from small and medium-sized enterprises, the

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underlying principle remains relevant: regulatory quality, trade policy, financing support, institutional coordination, and market access directly influence firms' capacity to compete internationally.

From a policy-evaluation perspective, production growth should not be assessed solely by changes in output volume. Effective industrial policy must also consider productivity, innovation, technological capability, employment quality, competitiveness, value added, environmental performance, market development, and institutional effectiveness. Research on evaluating industrial policies with a production-growth orientation highlights the importance of multidimensional components and indicators for assessing policy outcomes (Shahsavari et al., 2022). Similarly, policy models developed for the promotion of enterprises emphasize innovation, institutional support, implementation mechanisms, and coordination among policy actors (Hosseini et al., 2018). These findings suggest that steel production policy should be analyzed through a broad framework capable of integrating organizational, economic, technological, regulatory, human, and environmental dimensions.

The strategic significance of competitive advantage also requires attention to investment, market positioning, technological modernization, and value creation. Economic evidence indicates that investment is closely linked to trade competitiveness, while insufficient investment may constrain productivity growth and industrial modernization (Bardazzi & Ghezzi, 2018; Berndt, 2016). Within steel markets, firms must simultaneously manage production cost, product quality, technological capability, branding, market diversification, export standards, and customer requirements. These factors interact with broader public policies concerning exchange rates, taxation, energy, exports, finance, and industrial development. Therefore, the distinction between firm-level strategy and public production policy is not absolute; rather, both levels are interconnected and jointly determine production outcomes.

A futures-oriented perspective is especially appropriate for the steel industry because major determinants of its future are characterized by uncertainty, long investment cycles, technological disruption, environmental constraints, geopolitical changes, and evolving market structures. Policy decisions made today concerning production capacity, technology, energy, raw materials, human resources, financing, environmental compliance, and infrastructure may shape sectoral performance for decades. Futures studies can therefore contribute to the identification of drivers, uncertainties, and policy variables that should be considered when constructing plausible production-policy scenarios. Rather than assuming a single linear future, scenario-based thinking allows policymakers to consider alternative combinations of economic, technological, institutional, and environmental conditions and to develop more resilient and adaptive policies. This approach is particularly valuable in industries such as steel, where investments are capital-intensive and difficult to reverse and where delayed policy effects can generate significant long-term consequences.

Despite the existence of studies addressing industrial policy, investment, competitiveness, innovation, financing, environmental sustainability, Industry 4.0, and public policymaking, the available literature remains fragmented across disciplinary and analytical domains. Some studies focus on industrial-policy frameworks (Chang & Andreoni, 2020; Ferrannini et al., 2021), while others emphasize competitiveness, investment, and innovation (Ali, 2024; Biswas, 2022; Bočková & Meluzín, 2016). Another group focuses on financing and monetary conditions (Caraiani, 2022; Shafiei & Mirabi, 2020), whereas emerging research increasingly highlights digitalization and sustainable production (Pervez et al., 2026; Turan, 2026; Wu et al., 2026). At the same time, Iranian policy research has underscored the importance of institutional context, policy-analysis models, cognitive frameworks, and policy-evaluation indicators (Asadifard et al., 2016; Shahsavari et al., 2022; Teymouri Naghadeh et al., 2023). What remains insufficiently developed is an integrated identification of the components that should form the basis of future production-policy scenarios in the steel industry, particularly through systematic analysis of both governmental policy documents and organizational policies of steel companies.

Accordingly, the aim of the present study is to identify and classify the components affecting production policy scenarios in the steel industry through a futures studies approach.

2. Methods and Materials

The present study is applied in terms of purpose and qualitative in terms of nature. The participating sources consisted of two categories: first, upstream documents and official policies of governmental institutions, including the Ministry of Industry, Mine and Trade, the Ministry of Economic Affairs and Finance, the Ministry of Commerce, and the Islamic Consultative

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Assembly, in the fields of production and the steel industry; and second, documents, production policies, and quality policies of 35 active national companies, including Mobarakeh Steel Company of Isfahan, Isfahan Steel Company, Khuzestan Steel Company, Khorasan Steel Complex, and Oxin Steel Company of Khuzestan. Sampling in the documentary section was conducted through a census approach, meaning that all available and relevant documents were included in the analysis without excluding meaningful cases. Data were collected through the systematic examination of various sources, including official documents issued by governmental institutions, organizational documents of steel companies, Persian- and English-language scholarly books and articles, theses and dissertations, and reputable databases. Under this approach, rather than generating data through interviews or observations, the researcher used pre-existing textual data as the primary research data. Data analysis was conducted using a coding method. First, open coding was performed, through which initial concepts were extracted from meaning units. Subsequently, conceptually related codes were classified into subcategories according to their conceptual proximity. Finally, through the aggregation of subcategories, the main categories and key components affecting production policy in the steel industry were formulated. The coding findings were ultimately interpreted, and a final framework of the influential components was developed. To ensure the rigor and validity of the findings, qualitative research criteria, including credibility, dependability, confirmability, and transferability, were observed. Accordingly, valid and official sources were used, texts were reviewed step by step, systematic coding was conducted, and codes, subcategories, and categories were continuously compared. In addition, the opinions of professors and experts were obtained to assess the appropriateness, coherence, and comprehensiveness of the categories, and the necessary revisions were implemented. Ethical considerations were also observed throughout all stages of the study through the responsible and faithful use of documents and sources.

3. Findings and Results

Table 1 presents the results of the process of extracting components and dimensions based on selected previous studies and expert interviews.

Table 1. Process of Extracting Components and Dimensions Based on Selected Previous Studies and Expert Interviews

Codes	Concepts	Dimensions (Main Category)	Components (Subcategory)	Document/Source
Q61	Commercialization of processes and creation of development infrastructures	Development and Commercialization Management	Integrated development management	Yin Hsu et al. (2016)
Q62			Continuity of development	
Q63			Number of research personnel	
Q64			Managers' attitudes toward development	
Q65			Formulation of the development process	
Q66			Soft and hard development infrastructures	
Q67	Utilization of knowledge and expertise	Knowledge Enhancement	Participation in specialized conferences and exhibitions	Dashtianeh et al. (2021)
Q68			Conducting in-service training courses	
Q69			Conducting brainstorming and deliberative meetings	
Q70			Rapid access to relevant information	
Q71	Human resource strategies in the industry	Human Resource Management	Number of production-sector employees	Dashtianeh et al. (2021)
Q72			Alignment of personnel with production requirements	
Q73			Employees' competencies in specialized fields	
Q74			Employees' educational qualifications	
Q75	Development of group-based styles and team building	Collaborative Network Management	Organizational management social networks	Dashtianeh et al. (2021)
Q76			Leadership and management style	

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Q77			Team formation and teamwork	
Q78	Use of technology	Technology Management	Access to new technologies	Tang Sai et al. (2013)
Q79			Evaluation, negotiation, and selection of contractors	
Q80			Information and communication technology management	
Q81			Technology selection	
Q82	Development of systems	Systems Engineering	Systems thinking	Lawson et al. (2012)
Q83			Value-creating culture and climate	
Q84			Decentralization and delegation of authority	
Q85			Establishment of effective communication	
Q86	Project-oriented approach	Project Management	Time scheduling	Dashtianeh et al. (2012)
Q87			Project financing	
Q88			Project financial resource planning	
Q89			Establishing appropriate relationships with other scientific centers	
Q90			Evaluation of industrial projects	
Q91			Establishment of a formalized process for acquiring appropriate projects	
Q92	Steel pricing system	Monthly Steel Price	Updating technologies	Rahnamoun Pirouj et al. (2023); policies of the Ministry of Industry, Mine and Trade, Ministry of Commerce, Ministry of Economic Affairs and Finance, and Islamic Consultative Assembly
Q93			Equipment and machinery	
Q94			Reduction of production costs	
Q95			Adoption of appropriate monetary and foreign-exchange policies	
Q96			Increasing exports through emphasis on marketing and sales of steel products	
Q97			Increasing diversity and quality	
Q98			Increasing durability	
Q99	Creation of innovation and innovation processes in the steel industry	Steel Industry Innovation	Economic innovation	Mahmoudi et al. (2023)
Q100			Marketing innovation	
Q101			Organizational innovation	
Q102			System innovation	
Q103			Technical and technological innovation	
Q104			Regulatory innovation	
Q105			Financial innovation	
Q107			Innovation in new products and services	
Q108	Development in the steel industry	Steel Industry Development Levers	General policies and governmental measures	Islamic Consultative Assembly Research Center; policies of the Ministry of Industry, Mine and Trade, Ministry of Commerce, Ministry of Economic Affairs and Finance, and Islamic Consultative Assembly
Q109			Raw materials and sustainable energy	
Q110			Macroeconomic indicators	
Q111			Leading indicators	
Q112			Steel demand	
Q113			Development and technology pathway	
Q114	Development of distinctive visions based on objectives	Steel Industry Vision	Access to raw materials and energy	Islamic Consultative Assembly Research Center; policies of the Ministry of Industry,

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				Mine and Trade, Ministry of Commerce, Ministry of Economic Affairs and Finance, and Islamic Consultative Assembly
Q115			Development of rail and non-rail transportation	
Q116			Keeping pace with technological progress	
Q117	Managerial strategies and perspectives in the steel industry	Management Systems	Survival and sustainability of the company in a competitive market	National Steel Master Plan (2024)
Q118			Achievement of the steel industry vision	
Q119			Achievement of objectives and progress in line with the company's mission	
Q120			Value creation and sustainable development	
Q121			Compliance with legal requirements and national regulations	
Q122			Implementation of ISO systems and quality management	
Q123			Commitment to and satisfaction of customers and stakeholders	
Q124	Environmental stewardship and respect for the environment as a social responsibility of the steel industry	Environment	Reduction of environmental pollutant emissions	Production policies of steel companies; policies of the Ministry of Industry, Mine and Trade, Ministry of Commerce, Ministry of Economic Affairs and Finance, and Islamic Consultative Assembly
Q125			Optimal utilization of resources and energy	
Q126			Improvement and enhancement of environmental indicators	
Q127			Sanitary control of waste and residual materials	
Q128			Prevention and control of environmental pollution	
Q129	Creation of production capacities	Nominal Steel Production Capacities	Production of intermediate steel products	Policies of the Ministry of Industry, Mine and Trade, Ministry of Commerce, Ministry of Economic Affairs and Finance, and Islamic Consultative Assembly
Q130			Production of direct-reduced iron	
Q131			Pellet production	
Q132			Iron ore concentrate production	
Q133			Crude steel production	
Q134	Mineral products of the steel industry	Production of Mineral Products	Long steel products	Steel Master Plan Studies (2024)
Q135			Flat steel products: cold-rolled and coated sheets	
Q136			Flat steel products: hot-rolled sheets	
Q137	Iron ore reserves and their major role in the steel industry	Iron Ore Reserves	Probable reserves	Steel Master Plan Studies (2024)
Q138			Mineable/designable and proven reserves	
Q139			Geological reserves	
Q140	Creation of added value to achieve competitive advantage	Higher Value-Added Production	Modern, updated, and advanced technology	National Steel Master Plan (2024)
Q141			Significant investment	
Q142			Need to procure materials from the steelmaking sector	
Q143			Limited consumption and high diversity of production grades	
Q144			Branding and international marketing	
Q138			Export standardization	

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Q145	Development of operational programs and their application to steel production	Production Operational Programs	Issuance of licenses exceeding production requirements	National Steel Master Plan (2024)
Q146			Development of exploration and extraction activities	
Q147			Processing of low-grade iron ore	
Q148			Acquisition of iron ore mines	
Q149			Digital production technology	
Q150			Human resource training	
Q151		Capital Market	Mobilization and allocation of long-term resources	
Q152			Innovative financial instruments	
Q153			Development and strengthening of the securities exchange through improvement and expansion of the information network	
Q154		Revenue Policies	Government revenue policies	
Q155			Gradual elimination of tax exemptions	
Q156			Revision and completion of tax laws to establish indirect tax tariffs	
Q157			Examination of the introduction of new and unconventional methods into the national taxation system	
Q158			Revision of organizational structures and tax collection methods to modernize and improve the efficiency of the taxation system	
Q159			Continuation of policies involving tax incentives to encourage investment	
Q160			Expansion of revenue-generation opportunities	
Q161		Expenditure Policies	Establishment of a rational balance between revenues and expenditures	
Q162			Consolidation of budget lines and classifications	
Q163			Current expenditures	
Q164			Development expenditures	
Q165			Budget formulation within the framework of the objectives of the Second Development Plan	
Q166			Consideration of services and outputs resulting from increased utilization rates when approving new projects	

Through the separation, summarization, and classification of the indicators (subcategories), 166 indicators were identified, and these were consolidated into 41 components representing the principal indicators.

Table 2. Final Components Identified for Production Policies in the Steel Industry

No.	Component
1	Investment in the steel industry
2	Financial structure of the steel industry
3	Application of technological equipment
4	Competitive strategies of the steel industry
5	Knowledge management
6	Research and development cycles
7	Marketing capabilities for steel industry production
8	Achievement of competitive advantage
9	Government laws and regulations
10	Implementation of standards
11	Organizational strategies and policies

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12	Management policies
13	Risk management
14	Government interventions
15	Intellectual property management
16	Strategic production management
17	Research management
18	Development and commercialization management
19	Knowledge enhancement
20	Collaborative network management
21	Human resource management
22	Technology management
23	Systems engineering
24	Monthly steel price
25	Project management
26	Steel industry innovation
27	Steel industry vision
28	Steel industry development levers
29	Management systems
30	Nominal steel production capacities
31	Environment
32	Production of mineral products
33	Iron ore reserves
34	Higher value-added production
35	Production operational programs
36	Customer orientation
37	Workplace orderliness and organization
38	Money market
39	Capital market
40	Revenue policy
41	Expenditure policy

4. Discussion and Conclusion

The present study aimed to identify and classify the components affecting production policy scenarios in the steel industry through a futures studies approach. The findings showed that, from 166 initial indicators, 41 principal components could be extracted and organized within eight major policy domains: customer orientation, knowledge management, economic and financial policy, research and development, competition and marketing, technology, human resources, and institutional-environmental policy. The identified components included investment in the steel industry, financial structure, technological equipment, competitive strategies, knowledge management, research and development, marketing capabilities, competitive advantage, governmental laws and regulations, standards, organizational and managerial policies, risk management, government intervention, intellectual property management, strategic production management, research management, development and commercialization, knowledge enhancement, collaborative networks, human resource management, technology management, systems engineering, steel pricing, project management, innovation, industry vision, development levers, management systems, production capacity, environmental considerations, mineral-product production, iron ore reserves, higher value-added production, operational production programs, customer orientation, workplace organization, the money market, the capital market, revenue policy, and expenditure policy. Taken together, these results demonstrate that steel production policy is not a single-dimensional technical or economic issue but rather a complex policy system shaped by interactions among organizational, technological, financial, market, institutional, environmental, and human factors.

One of the most important findings was the prominent role of economic and financial components, particularly investment, financial structure, the money market, the capital market, revenue policy, expenditure policy, and steel pricing. This result is consistent with the capital-intensive character of the steel industry, in which production expansion, modernization, technological upgrading, mine development, energy infrastructure, and environmental compliance require substantial and continuous financial resources. Previous research has similarly emphasized that investment is a major determinant of industrial competitiveness and that insufficient capital formation can restrict productivity, technological renewal, and long-term growth

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(Bardazzi & Ghezzi, 2018; Berndt, 2016). In addition, financing conditions can shape firms' investment behavior through interest rates, liquidity, credit availability, and the broader monetary environment (Caraiani, 2022). In the Iranian steel sector specifically, the development of appropriate financing mechanisms has been identified as a critical requirement for sustaining large-scale investment and improving financial performance (Shafiei & Mirabi, 2020). Therefore, the present findings reinforce the argument that steel production policy should be developed in close coordination with financial, monetary, and fiscal policies rather than being treated as an isolated industrial-policy domain.

The identification of governmental laws and regulations, government intervention, organizational policies, revenue policy, and expenditure policy also highlights the central role of the institutional environment in production policymaking. Steel firms operate within regulatory structures that shape taxation, investment incentives, environmental obligations, foreign trade, pricing, access to raw materials, financing, and market behavior. From a public-policy perspective, such findings are expected because policy outcomes are influenced not only by the content of individual policies but also by institutional arrangements, implementation mechanisms, and the interaction of governmental and non-governmental actors (Asadifard et al., 2016; Soudagar et al., 2018). The significance of institutional factors is further reinforced by interpretive perspectives suggesting that policy design is affected by how problems are defined and represented by policymakers (Bacchi, 2015). Moreover, policymakers' cognitive maps and assumptions about causal relationships can influence how industrial problems are prioritized and which interventions are selected (Teymouri Naghadeh et al., 2023). Consequently, the effectiveness of steel production policies depends not only on the formal adoption of regulations but also on the coherence, stability, predictability, and coordination of the institutional framework within which production decisions are made.

The study also identified competitiveness-related components, including competitive strategies, marketing capabilities, competitive advantage, branding, international marketing, customer orientation, and production of higher value-added products. These findings indicate that production policy should not focus solely on increasing output volume. Rather, policy should support firms in developing differentiated products, improving quality, responding to customer needs, penetrating domestic and international markets, and sustaining long-term competitive positions. This interpretation is consistent with research showing that competitiveness is generated through combinations of organizational excellence, entrepreneurial competencies, strategic resources, and market capabilities (Biswas, 2022). International evidence also suggests that public policy can either facilitate or constrain firms' access to foreign markets through institutional support, trade policy, finance, and regulatory conditions (Cardoza et al., 2016). The present findings therefore imply that steel production scenarios should be designed around both production capacity and market absorption capacity. Expansion of output without corresponding improvements in product quality, export capability, branding, market intelligence, and customer responsiveness may lead to excess capacity and reduced profitability.

Quality and standardization emerged as additional important dimensions. The identification of standards, quality management systems, customer orientation, and workplace organization indicates that production performance depends substantially on internal process quality and organizational discipline. In industrial organizations, quality performance can serve as a mechanism through which organizational resources and managerial factors are translated into competitive advantage (Ferdousi et al., 2019). For the steel industry, where customers often require precise technical specifications, product certification, consistency, and compliance with national and international standards, quality systems are directly connected with market access and export competitiveness. Therefore, standardization should be viewed as a strategic component of production policy rather than a purely technical compliance issue.

Another major finding was the importance of research and development, innovation, knowledge management, knowledge enhancement, research management, development and commercialization, and intellectual property management. These components indicate that the future competitiveness of the steel industry depends heavily on its capacity to generate, acquire, share, absorb, and commercialize knowledge. This finding aligns with research showing that innovation performance is closely related to knowledge production and the institutional and organizational conditions that support learning (Ali, 2024). Likewise, investment in research and development has been found to strengthen competitiveness by enabling firms to improve products, processes, and technological capabilities (Bočková & Meluzín, 2016). The importance of knowledge-oriented leadership and human resource development in supporting organizational innovation and sustainable competitive advantage has also been

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demonstrated (Banmairuroy et al., 2021). The present results therefore suggest that steel production policy should incorporate mechanisms for research funding, collaboration between industry and universities, technology development, commercialization, protection of intellectual property, and systematic knowledge sharing.

The identification of human resource management, training, research personnel, employee competencies, education, collaborative networks, leadership style, and teamwork further indicates that technology and capital alone are insufficient for sustainable production development. Technological systems require skilled personnel capable of operating, adapting, maintaining, and improving advanced production systems. Human resource capabilities also affect organizational learning, problem-solving, innovation, and the implementation of strategic policies. This multidimensional interpretation is consistent with studies showing that organizational performance and competitive advantage depend on the interaction of human resource development, leadership, and innovation capability (Banmairuroy et al., 2021). The findings also support the broader view that industrial stagnation or weak performance may result from combinations of managerial, structural, financial, and organizational deficiencies rather than from a single isolated factor (Amiri et al., 2020). Accordingly, workforce development should be treated as a central production-policy instrument.

Technology management and the use of advanced technological equipment were among the most prominent components identified in the study. This finding is particularly important given the ongoing digital transformation of manufacturing. Contemporary industrial production increasingly relies on automation, intelligent systems, integrated information platforms, advanced sensors, data analytics, and digitally connected production environments. Recent studies show that Industry 4.0 practices can contribute to operational performance through production-system integration and greater supply-chain agility (Turan, 2026). Similarly, Sustainable Industry 4.0 transformation requires integration of technological, operational, supply-chain, and sustainability capabilities (Pervez et al., 2026). Intelligent production scheduling based on knowledge graphs and advanced optimization methods has also been proposed as a means of improving production efficiency and decision quality in process industries (Sun et al., 2026). Thus, the present findings support the inclusion of digital production, technological modernization, systems integration, and smart manufacturing within future steel production scenarios.

The importance assigned to systems engineering, project management, operational planning, and collaborative network management also reflects the systemic character of steel production. The steel industry comprises interdependent subsystems involving mining, concentrate production, pelletizing, direct reduction, steelmaking, rolling, transportation, energy supply, financing, sales, and environmental management. The identification of these components is compatible with systems-thinking approaches that emphasize feedback relationships, time delays, interdependence, and unintended consequences within complex industrial systems (Hamidizadeh, 2020). For example, policies promoting rapid capacity expansion may be ineffective if transportation infrastructure, energy supply, raw material availability, or downstream demand are not developed simultaneously. Therefore, scenario-based policymaking should account for interactions among production-chain components rather than optimizing individual elements in isolation.

The results also emphasized the significance of nominal production capacity, mineral-product production, iron ore reserves, raw material availability, and steel-industry development levers. These findings are particularly relevant to long-term production planning because steel capacity is constrained by the availability of upstream resources and infrastructure. National steel planning studies have emphasized the importance of coordinating steelmaking capacity with iron ore, concentrate, pellets, direct-reduced iron, infrastructure, transportation, and energy availability (Foolad Technic International Engineering et al., 2016). The present findings confirm that future-oriented production scenarios should be based on realistic assessments of resource availability and supply-chain balance. An expansion strategy that neglects raw material constraints may increase dependence on imports, raise costs, and undermine production continuity.

Energy availability is closely related to this issue. Steel production is highly energy-intensive, and energy supply shortages or price instability can directly affect capacity utilization, production costs, and export competitiveness. The identification of sustainable energy and energy-related development requirements is consistent with national energy assessments that demonstrate the importance of understanding energy production, allocation, and consumption across industrial sectors (Institute for International Energy, 2016). Energy policy and industrial production policy should therefore be coordinated, particularly under conditions of rising domestic demand, changing energy prices, and increasing environmental constraints.

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Environmental considerations constituted another major category identified in the study. The components included reduction of pollutants, efficient use of resources and energy, environmental performance improvement, waste control, and prevention of environmental pollution. These findings are highly consistent with contemporary transformations in the global steel industry. Life-cycle analyses indicate that steel production generates substantial carbon emissions across multiple stages of the production chain and that cleaner-production strategies must address raw materials, energy consumption, production processes, and end-use pathways (Wu et al., 2026). Recent studies also suggest that major reductions in emissions may be achieved through combinations of low-carbon technologies, renewable energy, carbon capture, and process innovation (Andrade et al., 2024). Green hydrogen-based steel production has additionally been identified as an important emerging pathway, particularly where renewable energy and iron ore resources are available simultaneously (Devlin et al., 2023). Accordingly, environmental policy should not be treated merely as a regulatory constraint but as a strategic component of technological modernization and future competitiveness.

The identification of industry vision, development levers, and strategic production management further demonstrates that production policymaking requires a long-term orientation. Industrial-policy scholarship increasingly emphasizes that governments should support structural transformation, learning, technological upgrading, sustainability, and productive capability rather than relying solely on short-term market correction (Chang & Andreoni, 2020). The post-crisis industrial-policy literature also emphasizes resilience, sustainable human development, and coordinated state intervention in shaping future production systems (Ferrannini et al., 2021). These perspectives support the present finding that the steel industry requires a coherent vision capable of integrating investment, technology, environmental objectives, human capital, market development, and institutional reform.

The findings are also consistent with research emphasizing the need for multidimensional criteria when evaluating industrial policies. Models developed for evaluating production-oriented industrial policies have identified multiple dimensions that extend beyond output growth to include performance, competitiveness, institutional conditions, and development capacity (Shahsavari et al., 2022). Similarly, innovation-oriented policy models indicate that effective industrial development requires coordinated support across institutional, organizational, and innovation-related domains (Hosseini et al., 2018). These studies support the present conclusion that no single policy instrument can adequately address the complexity of steel production. Instead, integrated policy packages are required.

The business environment identified implicitly across the findings also reflects the importance of regulatory stability, taxation, investment conditions, and market confidence. Reports on Iran's business environment have repeatedly highlighted the importance of financial conditions, regulatory procedures, trade constraints, and investment climate for industrial firms (Tehran Chamber of Commerce & Agriculture, 2019). Therefore, the presence of components such as tax policy, revenue policy, capital markets, government regulations, and institutional intervention in the present study is theoretically and empirically justified. A fragmented or unstable policy environment may increase uncertainty and discourage long-term investment, whereas coherent and predictable policies can support capital formation and industrial modernization.

Overall, the results of the present study suggest that future production-policy scenarios for the steel industry should be developed through an integrated framework rather than through isolated sectoral interventions. The interaction among finance, technology, human resources, innovation, environmental sustainability, markets, regulation, infrastructure, raw materials, and strategic management creates a complex policy ecosystem. This conclusion is also compatible with qualitative policy-analysis approaches that emphasize contextual interpretation, the identification of interconnected categories, and the systematic development of conceptual frameworks from multiple sources of evidence (Beigi, 2015; Khanifar & Moslemi, 2016). The identified 41 components therefore provide a structured basis for the subsequent development of future scenarios and for evaluating alternative production-policy pathways under different economic, technological, institutional, and environmental conditions.

One limitation of the present study is that the findings were derived primarily from documentary sources, official policy documents, organizational materials, and selected scientific literature. Although this approach made it possible to examine a broad range of formal and institutional evidence, some informal practices, tacit managerial knowledge, and operational realities may not be fully reflected in written documents. In addition, the study focused on identifying and classifying influential

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components and did not quantitatively assess their relative importance, causal strength, or interactions. The findings are also influenced by the temporal and institutional context in which the reviewed documents were produced, and changes in economic conditions, regulatory frameworks, energy markets, technologies, or international trade may alter the significance of some components over time.

Future studies are recommended to evaluate the identified components quantitatively using methods such as the Delphi technique, structural equation modeling, interpretive structural modeling, DEMATEL, cross-impact analysis, MICMAC, or fuzzy multi-criteria decision-making. Researchers may also examine the causal relationships among the 41 components and determine which factors function as key drivers, dependent variables, or critical uncertainties. Scenario-building studies can use the present findings to construct alternative futures for the steel industry under different combinations of energy availability, environmental regulation, technological transformation, investment conditions, export opportunities, and governmental intervention. Comparative research across major steel-producing countries may also help determine which components are context-specific and which have broader applicability.

For practice, policymakers and steel-industry managers should use the identified components as an integrated decision framework rather than as independent policy items. Government agencies should coordinate industrial, financial, energy, environmental, trade, and technological policies to reduce contradictions and improve investment predictability. Steel companies should simultaneously strengthen research and development, digital technologies, workforce capabilities, knowledge management, environmental performance, quality systems, customer orientation, and international marketing. Particular attention should be given to aligning production-capacity expansion with raw material reserves, energy availability, transportation infrastructure, market demand, and access to finance. Establishing a permanent interinstitutional mechanism involving government agencies, steel producers, financial institutions, technology providers, universities, and environmental authorities could improve coordination and support more resilient and future-oriented production policies.

Ethical Considerations

All procedures performed in this study were under the ethical standards.

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Conflict of Interest

The authors report no conflict of interest.

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