Original Research Article

A framework and preliminary findings for identifying cultural genes in iron and steel industrial heritage

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Abstract: This study distinguishes shared features of iron and steel industrial heritage from the culturally distinctive configurations of individual enterprises. Four cases—Hanyang Iron Works, Ansteel, Chongqing Iron and Steel, and Tangsteel—Are compared through technological genealogy, production networks, historical turning points, labour organization, and enterprise–city relations. The findings show that furnaces, converters, workshops, railways, and metallic materials are mainly sector-wide resources rather than cultural genes in themselves. Distinctiveness lies in historically formed relationships connecting technology, space, events, labour, and social memory. The four cases respectively represent technology introduction and resource integration, integrated production and national industrial-base construction, wartime relocation and reorganization, and converter development combined with post-earthquake recovery. A three-stage path—Common-dimension extraction, case-relationship comparison, and multi-source verification—Is proposed for traceable identification and subsequent heritage interpretation and design transformation.

Keywords: iron and steel industrial heritage; industrial cultural genes; multi-case comparison; technological genealogy; qualitative research

1. Introduction

Industrial restructuring and factory relocation have brought many steelworks into urban regeneration. Although blast furnaces, converters, workshops, railways, power facilities, and service buildings are increasingly reused as museums, parks, and public spaces, material retention alone does not preserve historical meaning. Without production processes, technical knowledge, labour cooperation, and enterprise communities, industrial sites become decontextualized scenery.

The Nizhny Tagil Charter defines industrial heritage through historical, technological, social, architectural, and scientific values [1], while the Dublin Principles emphasize relationships among sites, machinery, processes, knowledge, documents, and setting [2]. This relational view is especially relevant to steel production, whose units operated through flows of materials, energy, information, transport, and labour. Common visual devices—Rails, gears, steel beams, brick, warning colours, and rusted surfaces—May signal an industrial atmosphere but rarely explain why one enterprise differs from another.

The concept of industrial cultural genes is useful for organizing complex resources, but its application is often ambiguous. A workshop is a material remain, a technique is a process, an earthquake is an event, a work-team system is an organizational mechanism, and enterprise spirit is an interpretation. Treating all of them as equivalent genes obscures the difference between evidence, historical process, and analytical conclusion.

This study defines industrial cultural genes not as fixed symbols or lists of resources, but as historically formed relational structures that continued to influence technology, space, organization, or social life; remain distinguishable after sector-wide commonalities are excluded; and are supported by traceable evidence. It asks: which characteristics are shared across the steel industry, how did enterprises form distinctive cultural configurations, and what procedure is required to identify candidate cultural genes?

2. Literature review and analytical framework

2.1. Industrial heritage as a relational system

Industrial-heritage research has expanded from recording isolated buildings and machines to analysing production lines, industrial landscapes, enterprise communities, and regional networks. For steelworks, the historical meaning of a furnace, converter, or railway depends on its connections with fuel, power, transport, maintenance, scheduling, and downstream production. Material completeness is therefore less important than the ability to reconstruct essential relationships through surviving remains, maps, photographs, documents, and oral testimony.

Heritage is also produced through contemporary selection and interpretation [3-4]. Official narratives often stress technology and national development, whereas workers and residents remember risk, shift work, welfare, family life, pollution, closure, and relocation. Social value is relational and place-based [5], but memory is selective. Accordingly, this study distinguishes verifiable events and organizational practices from later value interpretations such as resilience or enterprise spirit. The gene metaphor is retained only in a relational sense: Continuity lies in the reproduction and reorganization of connections among knowledge, institutions, space, labour, and memory.

2.2. Five-dimensional comparative framework

A single case cannot determine whether a resource is unique, sector-wide, or common to large state-owned enterprises. Multi-case comparison supports analytical generalization by identifying repeated structures, contrasting mechanisms, and explanatory boundaries [6-7]. Five interdependent dimensions are used: (1) technological genealogy—Introduction, adaptation, modification, circulation, and replacement of technology; (2) production network—Relations among resources, energy, equipment, transport, maintenance, and logistics; (3) historical turning points—Events such as war, disaster, institutional change, closure, and relocation; (4) labour organization—Occupational divisions, work teams, training, repair, and coordination; and (5) enterprise–city relations—Employment, land, housing, services, environment, and urban identity.

The dimensions are analytical rather than independent. Technologies operate through production networks; turning points produce effects through labour organization; and production reshapes cities and communities. The task is not to locate one unique object, but to identify how common industrial components became persistently interconnected under particular historical conditions.

3. Research design

3.1. Case selection

Four Chinese cases were selected because they share the technological basis of steel production but represent different historical mechanisms. Hanyang Iron Works illustrates the introduction of modern technology and cross-regional resource integration; Ansteel provides a baseline of integrated production, national industrial-base construction, and enterprise-city development; Chongqing Iron and Steel represents wartime relocation and technological reassembly; and Tangsteel combines converter evolution, recovery after the 1976 Tangshan earthquake, urban-industrial integration, and coastal relocation.

Table 1. Historical position and comparative function of the four cases.

Case	Historical mechanism	Comparative function
Hanyang Iron Works	Technology introduction and regional resource integration	Explains formation of early modern industrial networks
Ansteel	Integrated production and national industrial-base construction	Identifies structures common to large steel enterprises
Chongqing Iron and Steel	Wartime relocation and production reorganization	Examines event-driven reassembly of technology and labour
Tangsteel	Converter evolution, earthquake recovery, and relocation	Examines a composite cultural configuration

3.2. Data sources and analytical procedure

Evidence includes surviving remains, official heritage records, corporate and local histories, archival publications, historical images, exhibition texts, and oral materials. Sources are assessed by independence, correspondence between claim and source type, consistency, and traceability rather than by unstandardized

counts. Field remains confirm spatial relations; official records verify dates and designated elements; histories reconstruct technical and organizational change; images document equipment and spatial transformation; and oral accounts add occupational knowledge and lived experience.

Analysis proceeds in three stages. First, resources are inventoried under technology, production space, events, labour, and city relations without being labelled as genes. Second, within-case coding and cross-case comparison distinguish recurrent elements from historically specific mechanisms. Descriptive codes identify objects and institutions, while process codes retain actions such as introducing, adapting, integrating, relocating, rebuilding, repairing, coordinating, withdrawing, and reusing. Third, candidate relationships are verified through multiple material, documentary, visual, or oral sources. A candidate must show temporal continuity, structural embeddedness, comparative distinctiveness, and evidential support.

4. Comparative findings

4.1. Shared industrial forms and distinctive configurations

All four cases contained furnaces, steelmaking and rolling equipment, railways, power systems, workshops, labour organizations, and service spaces. Their differences arise not primarily from object types but from the roles similar objects played in different historical processes. Hanyang's distinctiveness lies in assembling imported technology, ore, coal, transport, capital, and labour into an early cross-regional industrial network. Ansteel is characterized by the institutionalized coordination of integrated production and enterprise-city systems. Chongqing Iron and Steel is defined by dismantling, long-distance transport, reinstallation, emergency organization, and wartime production. Tangsteel combines converter experimentation, post-earthquake repair and restart, long-term urban relations, and later coastal relocation.

At Hanyang, machinery carried technological transfer through adaptation to local resources, transport, maintenance, and skills. At Ansteel, coordination of production, energy, repair, management, and services linked the steel chain to national planning and urban development. At Chongqing, equipment gained meaning through migration and wartime reassembly. At Tangsteel, converter genealogy and earthquake memory require evidence linking experiments, technical adjustment, repair, team coordination, and production restart.

4.2. Cross-dimensional comparison

Equipment type alone has limited discriminatory power; significance lies in how technology was introduced, adapted, moved, and transmitted. Production networks shift attention from railways or pipelines themselves to what they connected. Events become distinctive when they caused lasting technical, spatial, organizational, and social change. Shared labour systems gain specificity when tied to relocation, converter development, or earthquake recovery, while enterprise–city relations extend heritage to communities, services, environmental conflict, closure, and relocation.

Railways clarify the distinction between shared form and distinctive relationship. At Hanyang, transport enabled regional resource integration; at Ansteel, internal railways sustained an integrated production chain; at Chongqing, river and rail movement made wartime relocation possible; and at Tangsteel, the old railway network records urban production organization and contrasts with port-oriented coastal logistics. The analytical question is therefore not whether a plant possessed a railway, but what it connected and how those connections changed.

Table 2. Five-dimensional cross-case comparison.

Dimension	Hanyang	Ansteel	Chongqing Iron and Steel	Tangsteel
Technology	Introduction and local adaptation	Integrated-system reconstruction	Migration and reassembly	Converter iteration
Network	Ore–coal–transport integration	Complete production and service system	Wartime transport and reconstruction	Urban rail network to port logistics
Turning point	Establishment and westward movement	Recovery and national construction	Wartime relocation and continued production	Earthquake recovery and coastal relocation
Labour	Formation of industrial workers	Institutionalized teams and training	Emergency relocation and repair	Technical repair and production restart
City relation	Modern industrial origins in Wuhan	Enterprise city of Anshan	Formation of Dadukou district	Tangshan reconstruction and spatial transition
Configuration	Technology introduction and resource integration	Integrated production and enterprise-city development	Relocation, reorganization, and continuity	Converter development and post-disaster recovery

4.3. Identification results

The comparison supports four analytical levels. General industrial resources include structures, equipment, archives, and photographs. Industry-wide content includes production chains, logistics, power, training, safety, and enterprise services. Case-distinctive relationships arise when these shared elements are reorganized by particular historical conditions. A candidate industrial cultural gene is the further subset that demonstrates continuity, structural embeddedness, comparative distinctiveness, and multi-source verification.

Accordingly, Hanyang's candidate configuration connects modern technology introduction with cross-regional resource integration and industrial-labour formation. Ansteel links integrated production, national construction, institutionalized labour, and enterprise-city development. Chongqing Iron and Steel links wartime equipment migration, technological reassembly, emergency coordination, and production continuity. Tangsteel links converter experimentation and knowledge transmission with earthquake destruction, technical repair, organizational mobilization, production recovery, and urban reconstruction; coastal relocation represents a later reorganization of this identity. These genes may extend beyond current site boundaries because mines, transport corridors, ports, equipment routes, and workers' communities can be integral to the historical relationship.

Industrial cultural genes are therefore neither visually industrial objects nor abstract slogans. Their identification should follow "common-dimension extraction—Case-relationship comparison—Multi-source evidence verification," producing a traceable chain from resource and historical process to cultural interpretation and design transformation.

5. Conclusion

This multi-case comparison shows that furnaces, workshops, railways, chimneys, steel structures, and metallic materials are primarily common features of iron and steel heritage and should not be identified as cultural genes on visual form alone. Industrial cultural genes are historically formed relational structures jointly constituted by technological genealogies, production networks, turning points, labour organization, and enterprise–city relations. The four cases reveal distinctive configurations of technology introduction and resource integration, integrated production and national construction, wartime relocation and reorganization, and converter development combined with post-earthquake recovery. The proposed three-stage path reduces the risk of mistaking sector-wide forms for local distinctiveness and provides a traceable basis for classification, interpretation, conservation, and subsequent design practice.

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