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Actors and Asset Modification in Industrial Transformation: Evidence from Coking Industry in Shanxi, China

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SUMMARY: *Due to a reduction in carbon emissions, a carbon-intensive area has entered a restricted industrial economy based on coke and experienced a decline in downstream demand. Using Shanxi's coking industry as an example, this paper develops a Core–Intermediary–Affected actors (CIA) framework based on asset modification to explore how different kinds of actors affect the feasible forms of path adjustment under constraints. Based on the above results, the modifications currently being carried out in Shanxi are mainly extensions of the existing high-carbon industrial pathway and do not constitute deep-seated structural adjustments; thus, they should be classified as pathway extension and optimisation rather than profound transformation. Shrinking demand, strengthened regulations, and the lock-in effect of existing assets have jointly restricted the transition space; as a result, asset modification is taking the form of compliance-oriented upgrading, functional reorganization and limited reallocation, rather than a fundamental substitution for the dominant industrial path.*

KEYWORDS: *Asset modification, carbon-intensive regions, regional innovation system, climate change, reproductive agency*

1 Introduction

In recent years, over the past ten years, economic geography has focused more and more on how industrial transformation takes place and how assets are altered and deployed to support the new development pattern. With the evolution of evolutionary economic geography and regional innovation system (RIS) studies, research has increasingly focused on transition mechanisms and an agency perspective, and thus, approaches that view place-based structures and assets as static endowments have been criticised [1]. Research has focused on how actors adjust the development path within the constraints of multi-level governance and institutions through specific practices instead [2, 3]. In addition, assets are no longer limited to material and technological domains but have also extended to include cultural and institutional assets. Industrial culture has been designated as a primary local resource, and its joint formation with collective and individual agency has also been promoted [4, 5]. Changes in assets are now often used to explain the reasons for changes in the region. Actors reuse, modify, add or remove existing assets, change their functions and availability, and enable different types of path construction [6, 7]. More recently, the focus of discussion has moved to how assets are recombined in a working-level industrial structure and whether alignment can be achieved among firm-level and system-level assets [8].

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At the same time, there have been numerous discussions on climate change and environmental governance. Most of this discussion has focused on stories of new industries developing in areas due to structural advantages and policy support [9]. Regions with high carbon content, such as carbon-intensive areas, have received relatively little attention. At this time, the key assets are generally linked to high-carbon systems [10]. They have stricter compliance requirements, a higher exit cost, and a smaller strategic scope.

This study shows how the assets have been changing. I consider a change to be the modification and rearrangement of an existing asset system by actors. I will build an actor system and divide it into primary, subordinate and dependent actors. The above structure shows why there is an agency problem. This paper proposes that in carbon-intensive areas, the assets and institutions driving change are jointly determined. Firms and governments often choose forms of asset modification that can be accommodated by existing regulations, and as a result, the transition path is mainly incremental restructuring.

Shanxi's coking industry serves as the research object in this paper. According to the idea of asset modification, it is known that under strict regulatory and contract requirements, the industry will be changed, and consequently, regional economic activities will also be affected. Shanxi is a typical case of the transition of a carbon-intensive area. Coking has been the focus of the local economy and employment for a long time. The Environmental Protection standards have gradually been strengthened in recent years. Strengthen policies for emission control, market access and production capacity. At the same time, the downstream steel decarbonisation has reduced expectations for future coke demand. Coking enterprises have been investing in infrastructure and expanding value chains for by-products in response. Some have also launched trial investments in the new area of hydrogen. Analyze these processes of asset modification and reconfiguration in this study to explore their impact on the existing coking industry and the local industrial structure. Based on the above data, the construction of the new industrial cluster does not need to boost the whole region's economy or move large-scale old industrial bases. It is relatively less severe in practice. At this time, the distribution of transition benefits and adjustment costs is unevenly spread among leading enterprises, small and medium-sized enterprises, and affected communities.

2 Asset and Asset modification in Carbon Intensive Regions

Carbon-intensive regions (CIRs) generally refer to resource-based industrial areas whose economies are heavily dependent on fossil-fuel extraction (e.g., coal) and the downstream high-carbon production system built around it (e.g., coking, steel, power generation and heavy chemical industries) [11]. These areas often have a strong concentration of industries such as coal, coke, steel and power. Their growth models are based on a local constellation of material and institutional conditions, such as the spatial arrangement of mining districts and industrial parks, transport and energy infrastructure, including railways and power grids, industry-specific technological and skills bases, and governance routines focused on employment and fiscal revenue. Together, these arrangements produce strong regional path dependence and lock-in [12]. As a result, the decarbonisation of CIRs will be a change in technology that also involves multiple shifts in employment and energy security, as well as global competitiveness of these sectors. These pressures, in turn, will alter the structure of the local political alliance and cultural identity, thereby affecting the speed and social acceptance of the reform [13].

Carbon-intensive areas are new fields for the energy transition. In 2024, the world's CO_2 emissions from energy reached 37.8 billion tonnes, and the increase in these emissions in recent years has been led by coal [14]. Coal is still used to generate about one-third of the electricity in the world and has maintained a relatively large proportion in heavy industries, such as steel [15]. Therefore, in the face of the global environmental crisis, carbon-intensive areas and other regions with high emissions need to be treated as top priority targets for policy intervention and also as a fundamental regional type and a focus of research in studies of regional transitions.

2.1 Assets in CIRs

Regional assets are often covered by organisational and institutional regulations, and thus are included in the existing industrial structure. Therefore, they are likely to support the existing development model and general institutional arrangement [16]. Yet assets cannot be effectively utilised in path construction unless actors know of them, put them to use, and attribute value to them; that is to say, if they are unknown, unused, and undervalued [17]. Therefore, the appearance of new paths is often associated with a rearrangement of the regional asset base. This can be done by creating new assets through an additional investment; at the same time, existing assets and other facilities can be reused and recombined, and the older ones gradually phased out, as well as changes in institutional arrangements and organisational support structures [18, 19].

Transformation process is relatively less prone to CIRs. This resistance stems from the regional asset base and the institutionalised mode of asset operation and governance [20, 21]. First, the key assets in carbon-intensive areas are generally an asset system dominated by natural resources and infrastructure and materials, such as mines, coking plants, coal-fired power plants, transmission and distribution networks, dedicated railways and ports, and related chemical and metallurgical facilities [22]. These assets are fixed infrastructures in the local production system that lock in modes of production organisation and spatial arrangements. Therefore, one must determine how to reuse the infrastructure and materials for new purposes, and whether exnovation is necessary. At the same time, some studies have also put forward the idea that such fixed facilities can serve as carriers for mobilisation and resource coordination capacity to offer support for and enable collective action in times of crisis. Secondly, the regulated industries are more carbon-intensive and have been under stricter environmental supervision for a longer time. Rules for operating safety, environmental pollution and energy use have been built into the production organisation, process selection and management systems as institutions. Relatively stable permit and approval procedures, as well as emission and safety standards, set the basic rules for using the assets. Capacity and project management regimes, together with the relevant system of evaluation and accountability, have further defined the limits of asset modification [23]. Therefore, at the level of regional structural reform, a corresponding readjustment of the RIS needs to be carried out, covering production processes, equipment functions and industrial composition, and providing institutional support for regulatory compliance, infrastructure compatibility and market viability [24].

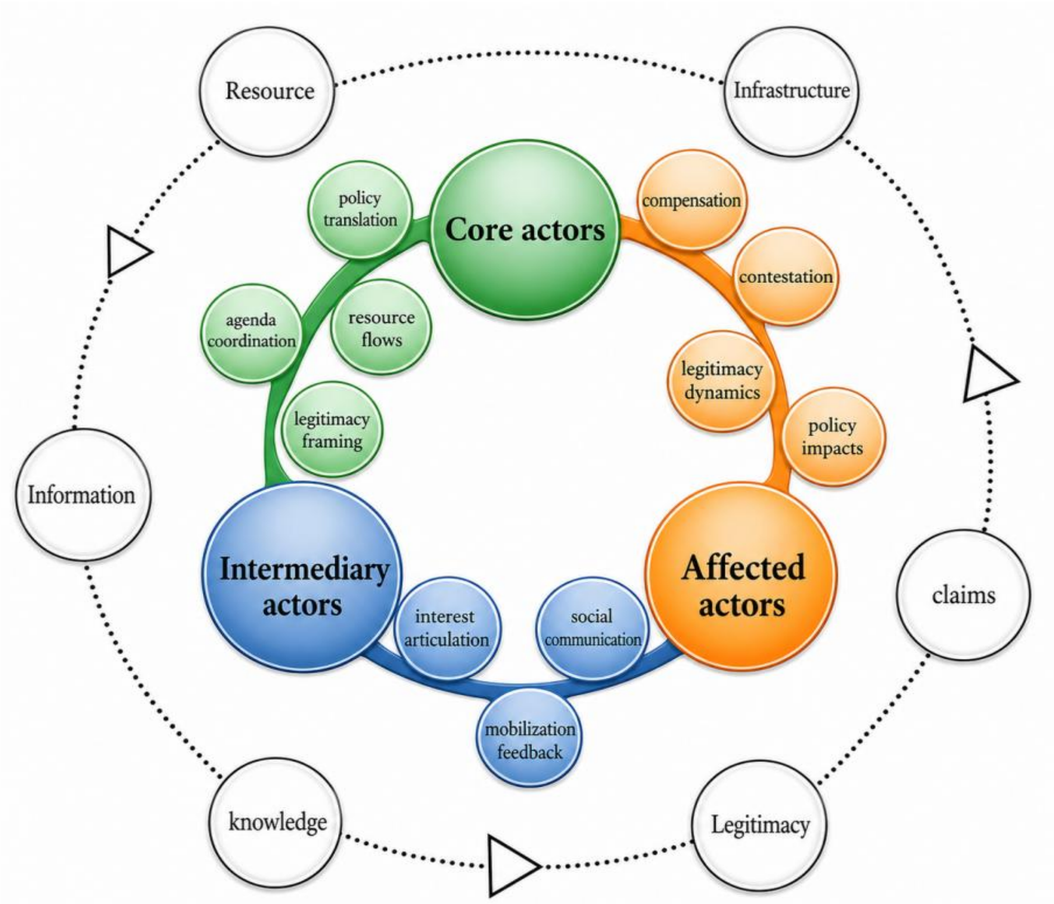
2.2 Agency and asset modification in CIRs

Transformation of assets is a typical way to decarbonize high-carbon areas. By altering how the existing assets are used and by combining or rearranging them, actors hope to expand the set of feasible choices under the current circumstances and modify the development path of the region. Asset Modification does not refer to technical or managerial adjustments. It is a PathShaping process for governance rules and asset configuration systems. Translating the feasible changes into actionable measures that are within the limits of compliance with regulatory requirements, infrastructure interdependencies and the market.

Asset modification operates as a dynamic system in which the three processes of re-use, creation/transplantation, and destruction advance in a coordinated manner. The re- use process is rooted in the regional specific asset base, reducing transition costs and providing transitional mechanisms through the recombination and upgrading of existing assets. Creation/transplantation supplements critical gaps and expands feasible transformation options** through local R&D or the introduction of external knowledge, technology, capital, and talent. And destruction alleviates path dependency and reconfigures the RIS by phasing out obsolete capacity, diminishing carbon-intensive technologies, and updating outdated institutions. Path development is the outcome of interaction between RIS and agency. Therefore, the three processes of asset modification are not merely technological substitutions, but more fundamentally RIS reconfiguration [25]. Studies indicate that technological upgrading typically requires simultaneous institutional adjustments and the phase-out of outdated production capacity.Moreover, the implementation of such modifications depends on the interaction and coordination of multi-level actors, including enterprises, governments, and intermediary organizations. Enterprises often lead the re-use of assets and the exploration of new models, whereas governments drive asset creation and dismantle obsolete rules through policy tools, public investment, and regulatory reforms [26].

2.3 Core–Intermediary–Affected actors in CIRs

This paper establishes a Core–Intermediary–Affected actors (CIA) framework (Figure 1). CIA divides the primary subjects, intermediary subjects and end-users in a regional transition network. Based on this classification, we will operationalise actor heterogeneity in terms of asset control and systemic position, and examine the uneven access to resources and differentiated forms of agency (Table 1). It does not confine itself to organisations of specific types, such as enterprises, governments, universities and NGOs, and the function they serve is not strictly defined; rather, it studies the reasons for and modes of operation of all these organisations as primary actors, intermediaries or subjects that are directly or indirectly affected. On the other hand, the well-known actor framework of the Triple Helix can be used to map institutional areas and functional division of labour; however, it usually starts from the premise of certain organisational forms and assumes relatively fixed roles for universities, enterprises and governments. As a result, they are less likely to focus on the structural constraints and power imbalances caused by high-carbon asset lock-in, institutional dependence and distributional conflict in carbon-intensive areas.



Source: Author's own work

Figure 1: The framework of Core-Intermediary-Affected.

3 Core actors

Core actors refer to those at the centre of a region's mobilisation and restructuring of the asset base. The "core" functions will be responsible for making changes to assets. Core actors have the following features. First, they operate or instruct essential facilities. Such control can be performed by possessing and operating firm-level assets; at the same time, it can also refer to governing system-level assets through the establishment of standards and their monitoring. The key people can change how the assets are used and arranged. Second, via compliance standards, project entry rules and accountability mechanisms, institutionalise selection for asset modification at the core level. Therefore, asset modification will be implemented in a project form that requires authorisation, inspection and accountability. The above arrangements will affect the cost and risk of asset modification. Therefore, those who control the key institutional assets have altered the assets and can change both the direction and strength of this alteration. Third, the main subjects have the ability to scale up asset modification initiatives into system-level actions. They can organise resources, arrange projects and ensure the complementary nature of infrastructure; local modifications will thus evolve from isolated projects into inter-organisations and scalable processes of asset reconfiguration to reshape the regional asset configuration. Fourth, in carbon-intensive areas, asset modification for key subjects generally serves the purpose of risk governance and system governance. Therefore, compliance-driven incremental upgrades and compatibility adjustments are more likely to be carried out. However, their autonomy does not have to reproduce the existing system. The main problem is whether asset modification includes wider asset reconfiguration and institutional change, thus transitioning from path extension to path creation.

4 Intermediary actors

Changes in assets refer to the deployment by the intervening party of connective and transferable resources, such as relational networks, knowledge resources, and regulatory-facing capabilities, for appraisal, certification, and interpretation of conformity obligations. Based on the regional asset base, intermediaries can connect enterprises and institutions or other kinds of assets that are not close to each other. Thus, the regional assets are more convenient to combine for asset modification.

Generally speaking, the two forms of asset modification by intermediaries are as follows. First, we will translate. Intermediary actors will translate policy goals and compliance requirements into practical project design plans, coordinate all key factors among the parties involved in the project, such as objectives, technological routes, schedules and responsibilities, etc. Typical actors are technology transfer offices, engineering consultancies, industrial park service centres and operators of public innovation platforms. The second is the agency model. Intermediary parties connect enterprises, government departments and financial institutions and other knowledge centres to help them form collaborative networks for the development and wider dissemination of pilot projects. The typical actors are universities and research institutions, industrial park administrations, business incubators, investment promotion offices and banks.

5 Affected actors

The affected parties have weak positions in terms of asset control and resource access, and bear more concentrated risks and costs in the transition period. Limited by existing asset arrangements and institutional boundaries, they generally have restricted access to material, financial and knowledge assets, as well as weaker institutional and legitimacy resources. Therefore, they are less likely to directly guide asset reorganisation and are more frequently involved in the implementation and adaptation of the current system.

However, the affected parties are not just passive objects of change. Through social acceptance, distributive claims and local experiments have set the boundaries for asset modification. Research on coal-dependent areas in Appalachia shows that civil-society actors can raise the transition issue in public awareness, increase the political costs of high-carbon projects through lawsuits, organisation and advocacy, and pressure main players to address problems such as equity, jobs and quality of life.

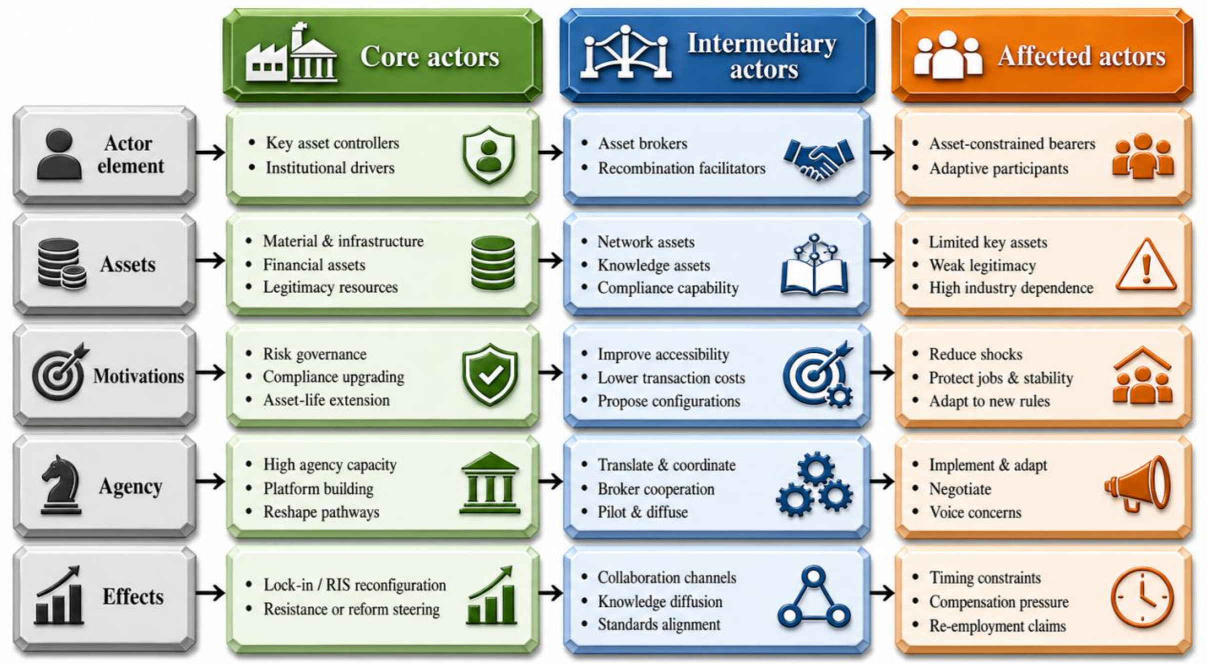


Figure 2: The Framework of Core-Intermediary-Affected

Based on the CIA framework and distinguishing between agency of change and agency of reproduction, conduct in-depth analysis of regional transformation. The CIA framework determines the structural positions of actors in the regional transition network, and change agency and reproductive agency describe the action orientation associated with these positions and their impact on the path of change. The central subjects among them have more power to decide on the path of regional development as they control essential resources, institutions and the flow of public opinion. Intermediary actors, on the other hand, can help a particular form of agency go beyond local initiatives and develop into an institutionalized, scalable system through translation, coordination, connection and diffusion. Affected parties affect the circumstances of project implementation and the scope of legitimacy through social acceptance, distributive demands, and forms of support or resistance.

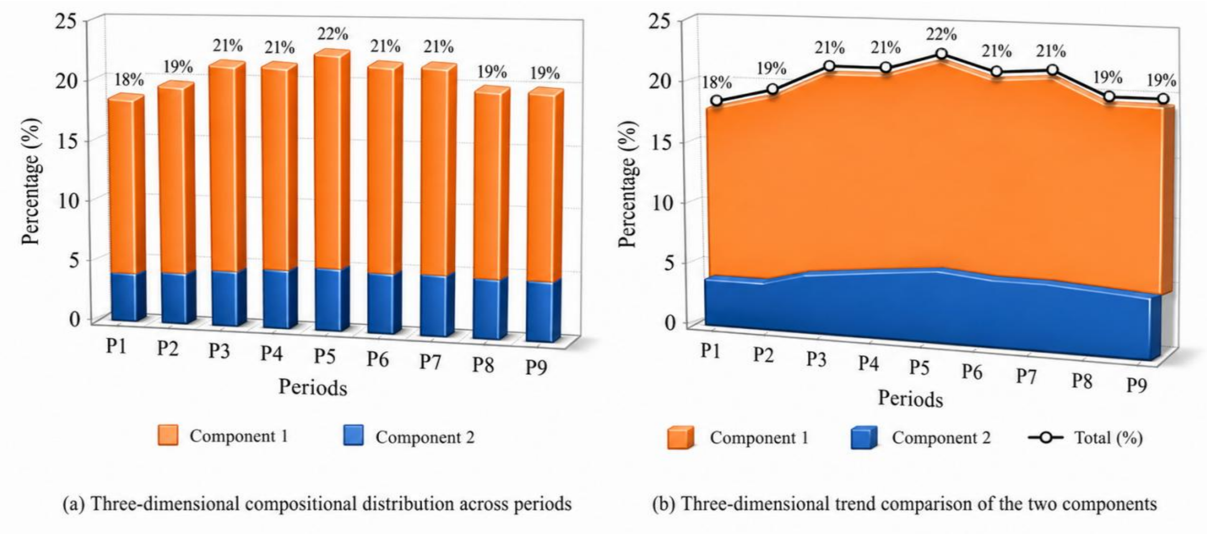
Therefore, the main problem of regional transition is not whether a certain type of agency exists for the key actors, but rather whether it can build a stable support system for all three positions of these actors. When change agency is embedded in the core actors and is supported by the organisational work of intermediary actors as well as the basic acceptance of affected parties, it is more likely to spread as a systemic change. On the other hand, if reproductive agency is carried out by central actors, it is more likely to strengthen the existing path of resource allocation and institutional rules, thus restricting the ability of other actors to create alternative paths. At the same time, change agency and reproductive agency should not be treated as two strictly opposed categories but rather as a continuum. Some behaviours that seem to be change-oriented may actually serve to reproduce the current situation; others are reproductive acts to maintain the stability of the system and thus provide the foundation for the next stage of transition. Therefore, for carbon-intensive areas, the analysis should not only determine whether there is an increase but also determine the direction and magnitude of this increase in light of the development process thus far and its cumulative impact.

6 Methodology

Data from a site visit and some interviews with coking enterprises in Shanxi were collected in 2017. According to the above data, in 2017, there were a total of 86 coking plants in Shanxi, including 16 state-owned and 70 privately-owned enterprises [27]. Based on the above, I carried out field visits to six enterprises, which included one state-owned enterprise (T) and five privately-owned enterprises (J, D, P, M, and H). A total of 52 people were interviewed, and among them, five focus group discussions were held in a meeting with over seven participants each. Most of the interviews were about 60-90 minutes long and conducted at the scene. In addition to the above interviews, I have also collected supporting materials from official channels of the company and related policy, report and media documents (such as policy texts, reports, and news articles) to triangulate the content of the interviews and gain a deeper understanding of the surrounding environment. The fieldwork was carried out in March-April 2025 and again in October 2025.

7 Results

Shanxi has good coal reserves of 270.901 billion tons, which make up about 17.3% of China's total and are the third-largest in the country [28]. The area will serve as a material base for a coal-coking system and is expected to be a strong point in Shanxi Province's heavy chemical industry. Shanxi has been a leading supplier of coke for the whole country for a long time. By as early as 2008, its coke production had reached 83.7644 million tons and accounted for 25.57% of the nation's total, showing that it was a large part of the country's steel-energy system. Around 2020, the peak of coke production in Shanxi was about 105 million tons, and since then, it has been in a steady decline (Figure 3).



Source: Based on the National Bureau of Statistics of China

Figure 3: Coke Output

7.1 Infrastructural asset modification in the coal–coke system

Shanxi has constructed a structural system for "shifting from road to rail/multimodal transport" for the outbound shipment of coal and coke in terms of transportation infrastructure.

The freight volume of the Watang-Rizhao Railway was 103 million tons in 2022, and the capacity of channels for bulk energy product transport has been expanded [29]. In practice, these infrastructural assets support the development of the coke-to-steel value chain and strengthen the existing development path of the area. Shanxi has built large-scale coke-production bases and a powerful heavy-duty logistics system.

The scale of production and the technological level of coking enterprises can be generally classified according to the height of the coke oven's carbonisation chamber (CC). CC height can be used as a device index that is simple to operate and record in statistics. High-capacity ovens generally have larger chambers and higher per-oven output, and they are also more likely to be equipped with advanced energy-saving and environmental-control or automated systems. In this sense, infrastructure is both a physical base for production and an objective of policy control and expansion of the production-capacity base. According to the 2017 Opinions on the Layout of Shanxi's Coking Industry, the installed coke-making capacity of the province was approximately 144.87 million tonnes, and of this amount, only 37.17 million tonnes (about 26%) were in large mechanised coke ovens with a CC height of 5.5 metres or more; most of the remaining 95.16 million tonnes (about 66%) were produced in conventional CC ovens with a height of 4.3 metres or less [27]. Subsequently, in 2018, Shanxi encouraged the early phase-out of older 4.3-metre ovens that had degraded in performance and smaller scales, and promoted the construction of new, large-scale coke ovens through a production-capacity replacement mechanism [30].

Many companies were merged through mergers and acquisitions during this round of capacity upgrading and structural adjustment, and some had to close down and leave. In 2018, a provincial policy stipulated that 4.3-metre coke ovens without complete procedures and failing to meet industry entry requirements had to be closed by the end of 2018. Capacity retirement is also linked to new capacity by the "capacity replacement with net reduction and build large and close small" policy. Therefore, in practice, no new capacity quotas could be added; replacement was only permitted after outdated capacity had been phased out, and earlier phase-out received a more favourable replacement ratio. At the same time, policies have raised equipment and environmental requirements for new projects substantially by establishing higher minimum standards for new coke ovens and demanding complementary dry quenching; they have also set clear plans for the comprehensive use and upgrading of coke oven gas, as well as zero liquid discharge measures for wastewater. Therefore, competition in this area has moved away from the expansion of output to the strengthening of regulatory compliance and system-wide governance. Firms that fail to upgrade the infrastructure of their 4.3-metre ovens to high-specification units and, at the same time, complete full-process ultra-low-emission control will gradually lose the regulatory basis for continued operation (INT 7, 8).

This trend has been further institutionalised in the provincial opinion on high-quality development.

2022. According to the document, by the end of 2021, Shanxi's total capacity of 4.3-metre coke ovens had reached

36.66 million tonnes. Among them, 32.21 million tonnes had been included in the registered quantities of the build-large-and-close-small replacement program. Fix a particular time for submission. By the end of 2023, coking enterprises were to have fully implemented coke dry quenching, completed ultra-low-emission retrofitting and shut down.

2 "Capacity replacement with net reduction": new capacity is connected to the phase-out of existing capacity, and generally requires retiring more capacity than adding new capacity. "Build large and close small" refers to replacing small, outdated or non-compliant units.

With large, new, and compliant ones.

All four 4.3-metre ovens and other non-compliant ovens. A full-featured assessment system has also been added to the policy for life-extension and development areas. Link the results of evaluation to output regulation, factor allocation and fiscal and financial support [31].

The Ministry of Ecology and Environment issued the Opinions on Promoting the Implementation of Ultra-Low Emissions in the Coking Industry at the national level in 2024. The document transforms the survival line into testable requirements. Set hourly-average concentration limits for organised emissions from coke-oven stacks. It also requires the company to meet these emission caps for 95% of the time each month if it claims to have extremely low emissions. Clean transport will also be necessary, and the minimum proportion for materials and product shipments will be 80 per cent. Under the above regulatory chain, small enterprises that use old oven equipment, are capital-poor and organisationally weak, and cannot access key system-level resources in industrial parks face an elevated exit risk. The above assets are wastewater treatment plants, utility corridors, rail access and clean-transport conditions, online monitoring and leak detection and repair systems. Due to the high cost of compliance, funds are now less abundant in the market, and a sale needs to be organised. The Capital Intensity of the upgrade is relatively high at the project level. The upgrading project of Shanxi Jinxin Energy Co., Ltd. will build a 6.73-metre coke oven equipped with all-around supporting facilities for coal preparation, coking, quenching, by-product recovery and environmental protection. The whole is 8 billion yuan [32]. The investment threshold will exclude performers with a weaker foundation.

7.2 Environmental regulators as core actors: gatekeeping and institutional asset modification

At the same time, there has been an increase in environmental regulation and the power of the relevant government departments. For a long time now, coke production has had some environmental issues, and locally, the management of these risks has been relatively weak. Shanxi's coking industry transition is changing; now, environmental authorities and the inspection system use entrance requirements to directly affect project feasibility (INT 13,39). They control some major institutional assets, such as the compliance status of environmental impact assessment, plans for reducing coal consumption or achieving one-to-one substitution, and emission permits. Securing funds does not mean that the project can be realised. If the institutional requirements are not met, the project will have to be suspended, revised or redrafted (INT 13,20).

In July 2021, the First Central Ecological and Environmental Protection Inspection Group reported in its feedback that some new projects in cities such as Lüliang and Yangquan, as well as in the Qingxu Fine Chemical Circular Industrial Park, involved falsification in coal-reduction plans and were required to be rectified [33]. This shows that the requirements for coal reduction have now become institutionalised verifiable hard constraints rather than being merely formal documents attached to project proposals. Therefore, the institution-building work of enterprises and local governments should be reinforced. Fill the coal-consumption gap, revise the substitution plan, coordinate environmental impact assessments with the approval chain, and thus restore institutional legitimacy.

Reduce energy and environmental constraints, and thus the project's technical and engineering designs need to be adjusted. Commonly, equipment specifications are increased; a strong end-to-end pollution control system is constructed; and, to reduce unit compliance costs, industrial park sitting and shared system provisions are used (INT 9,26). As a result, environmental conditions will determine whether a project can be realised, and at the same time, they will also affect the type of asset configuration for such a project. Therefore, gatekeeping functions as an auditable process for project selection and asset restructuring in the coking industry, continuing to promote asset upgrading and spatial rearrangement.

7.3 Industrial asset creation for path diversification

Given the profound changes in Shanxi's coking industry, some companies have started to explore and invest in renewable energy recently. The first is an adjustment in response to the changes in the environment and a way to keep up with the production capacity; the second is an internal wish to promote long-term industrial upgrading and build a good reputation. For a long time, the enterprises in Shanxi have been generally referred to as "large, cumbersome and dirty", and closely associated with the high-polluting, high-energy-consumption coking industry. Some leading enterprises are no longer in this situation and have established models for renewable energy chains, reformed their industrial systems, and improved their corporate images.

Fieldwork shows that all the visited companies have invested in renewable energy businesses. J, P and M are all focused on building a new-energy vehicle-friendly green hydrogen economy and have been leading the way in Shanxi. Among them, P has not only brought the hydrogen business to break-even but has also actively extended upstream and downstream operations. It is in collaboration with a Shanghai-based company to build a hydrogen fuel cell plant and has shown good foresight and execution capabilities. On the other hand, D is also developing related industries, such as aluminium and power generation, through by-products of coal and coke to improve resource utilisation and advance the value chain. H continues to focus on its coking core business and, at the same time, gradually expands into other areas such as tourism, real estate and so on to reduce reliance on a single industry. As a state-owned enterprise, T is cautious about the outlook of the industry and acknowledges the need for transition, but its operating revenue is still highly reliant on traditional coking business; thus, there is a persistence of path dependency and practical constraints on the transition process.

Although these enterprises have entered the renewable energy sector, the corporate group is still mainly concentrated in assets related to the coking core business. New activities, such as hydrogen, have already reached the break-even point and are now in an incubation stage; they cannot yet be considered main-source revenue for the group. Coking-related physical and infrastructural assets (coke ovens, auxiliary facilities and logistics networks), industrial assets (process capabilities, customer connections and supply-chain position), and institutional assets (permits, performance evaluation systems and targets, local government arrangements) collectively lock in the group's main cash-flow base. Therefore, the renewable energy industry will not be the main income source for the company in the near future.

8 Discussion

Shanxi's coking industry has entered a period of adjustment and cannot be avoided. Reduced demand for the market. Regulations and policies of the government are becoming stricter. At the same time, the prices of raw materials have also been rising continuously, and the industrial capacity remains excessively high. Thus, coke production has been less stable; profit margins have declined due to reduced revenue; and funds for emissions-compliance retrofitting, energy-saving and efficiency improvements have been reallocated. Firms are expanding into upstream and downstream links or related enterprises to reduce risk.

Shanxi's first coke market has long been focused on the steel industry in Hebei. A change in the amount of crude steel and the operating rate in Hebei directly impacts the orders and prices for Shanxi coke, thus affecting Shanxi's coke production. Hebei is a large-scale crude steel area in China. In 2023, the company produced approximately 210.5 million tonnes of crude steel and accounted for about 20.7 per cent of the national total [34]. Hebei's blast furnace-basic oxygen furnace route is heavily dependent on coke, and Shanxi is a primary area for obtaining this coke. Shanxi exports a relatively large proportion of its coke outside of the province, and Hebei is one of the first markets for these exports. Hebei is actively promoting the low-carbon transition of steel production and has increased the proportion of electric-arc-furnace (EAF) production and advanced low-carbon metallurgy. The Proportion of EAF shares will reach 20% by 2030. Therefore, Shanxi may lose about 17.75-22.64 million tonnes of its coke market [34].

The driving force for change in the Shanxi Coking Industry does not originate from a failure in will. External Constraints have reduced their choices. Hebei Steel is going to be net-zero, so coke demand will not increase. Environmental Regulations are Stricter. Strictly enforced low-emission requirements and market-entry regulations have raised the cost of new-production. The Price of Raw Materials is also unstable. The industry's capacity is still relatively high. No longer will the firm grow by expanding production capacity. At the same time, the funds for new projects will not be obtained from the coke-core business during this economic downturn.

Therefore, the two main forms of asset changes for the company are as follows. Both are based on the existing coking assets. They do not involve a large-scale shutdown of the coke oven complex or exiting the main business. The first type is compliance-driven asset upgrading. Firms carry out ultra-low-emission retrofitting. They will use cleaner transportation. They build the online monitoring system. They improve shared facilities of the industrial park. The Targets are infrastructure assets and institutional assets. Continuously meet the required specifications, obtain the relevant permits and pass inspections, and keep the plant operating normally. The second is the type of asset reallocation by-product-oriented. Firms develop projects for coke oven gas, coal tar and crude benzene. Modify equipment arrangement. Expand the range of products. They are extended to the upstream/downstream sections or related industries. The first two are industrial facilities and market links. Reduce the reliance on coke profit and reduce the risk of extended fluctuations in demand and profit margins. The two are of different difficulties to implement. Compliance upgrades meet the current regulatory requirements and will thus be approved and funded. By-product-driven reconfiguration is likely to have conflicts among interested parties and regulatory uncertainties; therefore, it will be slower to implement and more difficult to expand.

Local governments (at the municipal/county/district level) are not only implementers. They work more as intermediary institutions. Modify the asset to alter the operating environment of local industries and turn high-level constraints into feasible projects and implementation plans.

The local government reduces institutional assets at the same time. They operationalize the ultra-low-emission requirements, industry-entry rules and output caps through local rules, procedures and performance-assessment indicators. Based on the above arrangements, they set project thresholds, organise inspections and performance evaluations, and prioritise approvals, funds and quota/indicator allocations. The institutions are in a position to judge whether a company or plant should continue to operate, be upgraded, closed or moved.

Locally, governments have frequently concentrated industry parks to change the land-use mode and other infrastructure in the area. They direct the companies to the industrial park for centralised production. Park Platforms organize land supply, pipelines and networks, shared utilities, logistics support and environmental facilities, and coordinate corporate restructuring and capacity replacement. Park-based concentration alters the firm's location choice and production organisation. Expand the coverage of regulations and enhance their effectiveness.

The local government needs to implement the compliance target and protect local tax revenue and employment at the same time. Shanxi's fiscal structure is also so-so. Based on research of tax data, mining-related taxes have accounted for about 40% of the total tax revenue in Shanxi from 2010 to 2022 and increased to 63.7% in 2022 [35]. The leading coking-producing areas have an even higher fiscal and employment dependence on coal and coke. Therefore, the local government will select a solution that meets the requirements of compliance and keeps the industry and employment.

Therefore, local governments are more likely to choose a path that is regulated and continuously compliant. They generally reduce the space available for small-scale, dispersed, weak and non-compliant capacity. At the same time, they are given priority in terms of approvals, funding and factors of production for large enterprises with strong financial, technological and organisational capabilities to carry out upgrading retrofits and absorb capacity replacement. This, in turn, makes industrial restructuring more likely to take the form of a triadic structure: a small number of leading enterprises (core actors), local governments/industrial park platforms (intermediary actors), and displaced enterprises and affected communities (affected actors).

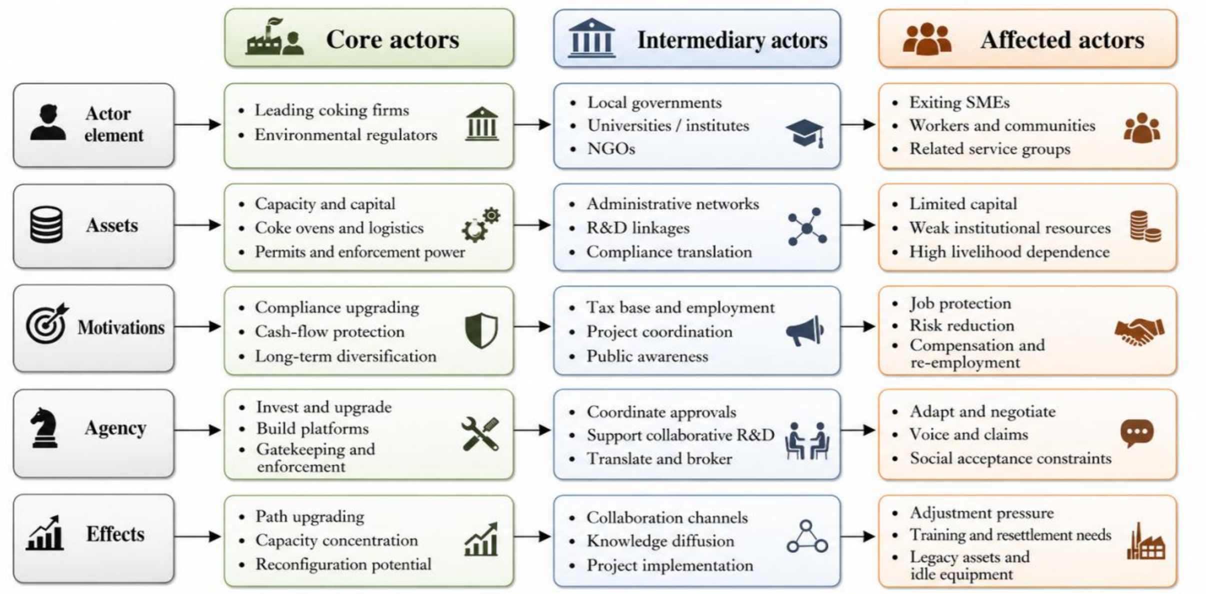


Figure 4: Core-Intermediary-Affected Actors of the Coke Industry in Shanxi

9 Conclusion

Drivers and Action Pathways of the Coking Industry Transition in Shanxi Province: A Study. Therefore, although they are forced to change, the companies have only carried out limited restructuring. Expanding on the view of asset modification, a new actor-analytical system is constructed to distinguish between core, intermediary and affected actors, and their boundaries of agency are defined by their asset endowment and asset dependence. Shanxi's coking transition is not due to a lack of the will to change. It is thus formed by a feasible set of strategies that are jointly produced through reduced demand, tightened regulations and lock-in effects of existing assets. Most transitions in this group are modifications and reallocations of the existing asset system, rather than changes to the dominant industry.

Shanxi is not without change, but the changes that are currently taking place are mostly within the existing high-carbon industrial pathway, and their main logic remains that of reproductive agency rather than change agency. Although some intermediate links have made adjustments, these adjustments have not been extensive enough to modify the overall trend of regional development, given the lack of substantial resources and weak institutional support compared with those at the level of key actors, as well as inferior agenda-setting abilities. Therefore, the current energy transition in Shanxi is closer to path extension and path upgrading rather than deep transformation.

Coking is still the main support for the local economy. New-energy businesses, such as hydrogen, are in their infancy at present. Even if some projects are operationally self-sufficient, they will not change the group's revenue structure and investment focus at the group level in the short run. In addition, enhancements to the coke-burning equipment have extended the operational life of the coke-burning system and enabled the main business to continue under tighter constraints. Therefore, it can be expected that the change in Shanxi's power sector will be a slow process of optimisation rather than a quick, radical transformation.

The different parties involved in the change are shown in the paper, and their levels of initiative vary due to differences in assets and dependencies. The main enterprises control the essential material resources and industrial bases. They aim to extend the life of assets through upgrades and retrofitting, and they compete for quotas and resources during policy windows. Environmental Protection Authorities should also be designated as the corresponding departments. Set emission standards, approve or deny applications, regulate online monitoring, and impose penalties. They determine whether the company will be allowed to operate and set a schedule and technical requirements for remediation. Local governments are the connecting links. They set the rules for and reorder the approval of asset use and combination. They employ the above mechanisms for firm and capacity screening and promote concentrated restructuring. Affected enterprises and communities bear exit and adjustment costs. Therefore, the demand for stability in society and the project's viability will affect the speed of policy implementation. Carbon-intensive areas have a high proportion of fixed assets and strong fiscal and employment dependency, thus exhibiting path dependence; therefore, their transformation requires upgrades to key assets and restructuring.

Future research will use a finer-grained view of asset changes to specify the types, sizes and governance conditions of such alterations. For example, by comparing cities and counties, it can be known which institutional arrangements are more likely to support reproductive upgrading and under what circumstances substitution-oriented reallocation is likely to occur. Future work can also track the actual economic returns of by-product-based path upgrading and determine whether scalable new asset configurations have been formed.

Author's Profile

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