Research on the Mechanisms and Pathways for Industrial Transfer in Northwest China: An Integrated Ecological Perspective

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Abstract. Industrial transfer in Northwest China faces a persistent dilemma between ecological conservation and economic development. Moving beyond traditional economic geography, this study integrates ecological theories of "community succession" and "expansive adaptation" to construct a unified analytical framework explaining both industrial cluster dynamics and agent adaptive behaviors. Using a Logistic coupling model, we quantitatively demonstrate a significant S-shaped growth relationship (R^2=0.68) between industrial transfer ecological level and expansive adaptation capacity, revealing two critical carrying capacity thresholds at 0.3 and 0.7. This research uncovers mechanisms underlying industrial succession outcomes and provides a systematic decision-support framework—from "ecological diagnosis to stage assessment to pathway adaptation"—offering novel theoretical and practical solutions for green industrial transformation in ecologically fragile regions.

Keywords: industrial transfer; community succession; expansive adaptation; ecological thresholds; coupling mechanism; Northwest China

1 Introduction

Industrial relocation in Northwest China faces dual pressures from ecological conservation and economic development [1]. With "dual carbon" goals advancing, industrial transfer from Eastern China accelerates, but traditional resource-intensive models conflict with regional vulnerabilities—water scarcity and land desertification—risking ecosystem degradation [3]. Resolving this dilemma is theoretically urgent and practically significant.

Existing research offers economic geography perspectives [4] but lacks systematic analysis of underlying ecological transformation mechanisms. A critical gap is the failure to integrate "community succession" theory (macro-system evolution) with "expansive adaptation" theory (micro-agent adjustments). Their combination can

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interpret the bidirectional interaction between environmental selection and industrial adaptation.

This study addresses three questions: (1) What are the systemic dynamic patterns ("community succession") of industrial transfer under ecological constraints? (2) How does the core behavioral mechanism ("expansive adaptation") operate for transferring entities? (3) Can their synergistic relationship be quantified for policy interventions? Answers will advance industrial succession from passive "scale expansion" to proactive "ecological adaptation."

2 Analytical Framework, Methods, and Data

2.1 Core Concepts and Theoretical Integration

Industrial undertaking is the process whereby a region, under ecological constraints, attracts and integrates external industrial elements for sustainable development. The industrial ecosystem is the organic whole formed by industrial communities and their environment through material and energy flows [2].

Theoretical innovation lies in integrating "community succession" and "pre-adaptation" theories. Community succession analogizes industrial undertaking to natural community formation: "pioneer species" (external enterprises) invasion, competition and symbiosis (industrial chain construction), and "climax community" (stable industrial ecosystem) in three stages: introduction, growth, maturity. Pre-adaptation suggests agents achieve environmental matching through resource adaptation (intensive development), technological adaptation (process innovation), and structural adaptation (industrial chain reorganization). Coupling logic: succession stages set adaptation priorities; adaptation effectiveness affects succession speed, driving the system toward higher ecological levels under carrying capacity constraints.

2.2 Research Methods and Data

This study employs mixed methods. Qualitative research uses case studies of national industrial undertaking demonstration zones in Yinchuan-Shizuishan (Ningxia) and Lanzhou-Baiyin (Gansu). Quantitative research constructs indicator systems and econometric models.

Table 1 presents the evaluation indicator system for ecological level of industrial undertaking.

Table 1. Evaluation Indicator System for Ecological Level of Industrial Undertaking

Dimension	Indicator	Unit	Data Source
Resource Adaptation	Water consumption per 10k RMB GDP	m^3/10k RMB	Provincial Water Resources Bulletins

Dimension	Indicator	Unit	Data Source
	Energy consumption per unit industrial value added	tce/10k RMB	Provincial Statistical Yearbooks
	Local raw material procurement rate	%	Key park surveys
	Land use intensity	100 million RMB/km²	Development Zone Catalog
Technological Adaptation	R&D intensity of above-scale industrial enterprises	%	Science & Technology Yearbooks
	Share of green patents granted	%	National Intellectual Property Admin
	Cleaner production tech transformation coverage	%	Dept. of Ecology & Environment surveys
	Industrial water reuse rate	%	Ecological & Environmental Bulletins
Structural Adaptation	Industrial chain correlation	Input-output coefficient	Inter-regional Input-Output Tables
	Industrial diversification index	Inverse Herfindahl	Provincial Statistical Yearbooks
	Park circular economy coupling degree	Proportion of linked enterprises	Park management surveys
	Share of producer services	%	Provincial Statistical Yearbooks
Community	Industrial agglom-	Location	Provincial Statistical

Dimension	Indicator	Unit	Data Source
Succession	eration degree	quotient	Yearbooks
	Industrial chain completeness	Local supporting rate %	Key enterprise surveys
	Ecological compatibility	Environmental performance index	Ecological & Environmental Bulletins
	Enterprise survival rate	%	Business registration database
	Employment contribution rate	Employment elasticity	Provincial Statistical Yearbooks

Table 2 reports descriptive statistics and the correlation matrix for the main variables.

Table 2. Descriptive Statistics and Correlation Matrix

Statistic	Resource Adapt	Tech Adapt	Structural Adapt	Community Succession
Mean	0.482	0.397	0.351	0.468
Std. Dev.	0.176	0.203	0.158	0.192
Correlation				
Resource Adaptation	1.000			
Technological Adaptation	0.427***	1.000		
Structural Adaptation	0.316**	0.562***	1.000	
Community	0.583***	0.671***	0.604***	1.000

Statistic	Resource Adapt	Tech Adapt	Structural Adapt	Community Succession
Succession				

Note: ***p<0.01, **p<0.05. Maximum VIF=3.82, indicating no severe multicollinearity.

Panel data from 30 prefecture-level cities in five Northwest provinces (2013-2023) from yearbooks, bulletins, surveys, and business databases. Missing values interpolated.

2.3 Model Specification

Based on the assumption that industrial ecosystem growth follows an S-shaped curve, we specify a Logistic model:

$$Y_{it} = \frac{1}{1 + e^{-(\beta X_{it} + \alpha_i + \gamma_t + \varepsilon_{it})}}$$

where Yit is the industrial community succession index, Xit is the pre-adaptation capacity index, and αi and γt represent region and time fixed effects. Nonlinear least squares estimation is used with cluster-robust standard errors.

Robustness checks include alternative model specifications, nonlinearity tests, sample split regressions, and leave-one-out cross-validation.

Instrumental variable approach: Construct a Bartik instrument IVit=∑kShareik,2013×Gkt,

where Shareik,2013 is the base-year employment share of industry k in region i, and Gkt is the national growth rate of green patent applications in industry k.

3 Empirical Findings

3.1 Ecological Constraints and Structural Contradictions

Industrial undertaking in Northwest China exhibits duality: extreme ecological fragility (per capita water 32.8% of national average) alongside expanding scale and emerging green trends [1]. The deep contradiction is the "upgrade gap" between urgent green transformation and weak innovation capacity, leaving many projects as "isolated points" without local integration..

3.2 Three-Stage Succession of Industrial Undertaking

Introduction: "Pioneer" enterprises enter, facing niche barriers (water quotas, arid adaptation). Governments provide infrastructure.

Growth: Competition and symbiosis; efficient segments survive, form clusters; high-pollution capacity phased out; technology and chain extension drive growth.

Maturity: Stable material-energy-information networks with environment; circular economy of "resource—manufacturing—by-product—waste utilization" achieved.

3.3 Coupling Relationship between Succession and Adaptation

3.3.1 Logistic Model Estimation.

Table 3 reports the Logistic model estimation results.

Table 3. Logistic Model Estimation Results

Variable	**(1) Baseline**	**(2) Two-Way FE**	**(3) IV**
Pre-adaptation (X)	0.653***(0.127)	0.739***(0.151)	0.801**(0.337)
Constant	0.284***(0.061)	0.238**(0.079)	0.197(0.142)
Fixed Effects	No	Yes	Yes
Observations	330	330	330
R^2	0.68	0.74	-
Cragg-Donald Wald F	-	-	18.37

Note: ***p<0.01, **p<0.05; cluster-robust standard errors in parentheses.

Pre-adaptation significantly impacts succession; coefficients robust. IV larger than OLS, suggesting attenuation bias. MAPE=12.7%, good predictive accuracy.

3.3.2 Threshold Identification.

Inflection analysis yields thresholds at Y=0.28 and 0.72 (rounded to 0.3, 0.7). Hansen's panel threshold regression [5] confirms single threshold at 0.31 (p=0.023) and double thresholds at 0.31 and 0.69. Sensitivity analysis (trimming, bootstrap, alternative weighting) confirms robustness.

3.3.3 Stage Heterogeneity Analysis.

Table 4 presents the stage-wise regression results.

Table 4. Stage-wise Regression Results

Variable	Y<0.3	0.3≤Y≤0.7	Y>0.7
Resource Adaptation	0.487***(0.142)	0.263*(0.135)	0.089(0.098)
Technological Adaptation	0.156(0.113)	0.514***(0.126)	0.232**(0.117)
Structural Adaptation	0.073(0.089)	0.297**(0.138)	0.526***(0.151)
Observations	86	178	66

Dominant mechanisms shift: resource in low stage, technology in medium, structure in high stage, validating stage-fit logic..

3.3.4 Micro-Mechanism Evidence.

DID on 42 firms in Dingxi "enclave park" (2018-2023) shows technology adaptation subsidy policy increases three-year survival rate by 18.7 percentage points (t=2.83), confirming causal effect of pre-adaptation on succession quality.

4 Optimization Pathways

4.1 Dual-Threshold Spatial Governance

Develop ecological monitoring embedded in spatial planning with dual thresholds: red (<0.3) project circuit breaker; yellow (0.3-0.7) tech transformation support; green (>0.7) structural upgrades with priority land quotas. Annual system cost 3-5 million RMB; benefits: avoid sunk costs (200-300 million RMB/year) and reduce remediation (150 million RMB/year).

4.2 Niche-Based Industrial Cluster Design

Government as "niche designer": compile "Regional Industrial Niche Map" (GIS-based, triennial) identifying compatible directions (e.g., PV equipment, water-saving processing). Screen pioneer enterprises based on resource efficiency; establish "Industrial Chain Symbiosis Incubation Fund" to incentivize SME participation.

4.3 Linked Pre-adaptation Innovation Support

Resource: "Northwest Green Value Chain Fund" (200 million RMB, leveraging 600-800 million, IRR 12-15%) for integrated chains (Xinjiang forestry, Qinghai lithium battery). Technology: "Green Technology Adaptability Innovation Center" (Xi'an/Lanzhou, 20 million RMB/year) to shorten localization cycles from 3.2 to 1.8 years. Structure: "Compound ecological industrial land" for integrated formats (agri-voltaics, eco-restoration + industry); pre-arrange material exchange in parks.

4.4 Incentive-Compatible Coordination Mechanisms

Shift from penalty to incentive: "Ecological Performance Accounts" link water/energy saving, carbon reduction to land quotas, fiscal subsidies, green credit [6]. Shizuishan pilot: 0.8 ppt lower financing costs, 23% higher tax per mu. Promote water rights/emission trading; explore including industrial ecological performance in carbon trading.

5 Conclusion and Implications

T his study integrates community succession and pre-adaptation theories, constructing a dynamic analytical framework for ecological industrial undertaking. Logistic model verifies S-shaped coupling (R^2=0.68) and thresholds (0.3, 0.7). IV confirms causality. Core conclusion: industrial undertaking in Northwest China is a co-evolution process where communities transition from pioneer invasion to stable symbiosis through resource-technology-structure adaptation.

Policy implications: governments must become "industrial ecosystem designers." The proposed dual-threshold early warning, niche design, adaptation innovation, and ecological accounts provide actionable solutions.

The paradigm extends to global ecologically fragile regions, showing sustainable development can guide economic-natural co-evolution through ecosystem design.

Future research: (1) add "digital empowerment" as fourth adaptation dimension; (2) analyze governance in "R&D East + Manufacturing West" models.

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