STAGE-CONTINGENT FUNDAMENTALS OF STRUCTURAL TRANSFORMATION: EVIDENCE FROM UNIVARIATE LOGISTIC REGRESSIONS

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Abstract. This paper explores the fundamental factors influencing movement across five developmental stages within a global country classification as proposed by Aituar et al. We operationalize the staged frameworks of Rostow, Ohno, and Porter by estimating stage-specific univariate logistic regressions for each transition, utilizing a comprehensive set of institutional, policy, and capability variables while reporting odds ratios and ranking the leading predictors for each transition. In this framework of structural transformation, economies advance along a path of manufacturing led development, progressing from pre-industrial conditions to early manufacturing, followed by diversification through enhanced domestic linkages and integration into global value chains, increased complexity, and ultimately reaching an innovation frontier. Our findings support and refine this narrative: the take-off stage is most closely linked to investment capacity and basic appropriability; diversification is associated with administrative and legal predictability as well as external-risk management; maturity correlates with significant investment and appropriability effects alongside regulatory alignment and advanced factor conditions; and entry into the frontier and sustained presence there is tied to robust rule-of-law institutions and disciplined openness. Indicators tend to strengthen systematically across stages. Two refinements emerge from our analysis: appropriability (proxied by intellectual property as % of GDP) plays a more significant role earlier than the literature suggests, and the positive associations observed between inflation volatility (proxied by standard deviation of inflation) reflects temporary reform turbulence rather than causal growth and stage advancement.
Keywords: structural transformation; stage of development; industrialization; diversification; complexity; innovation; univariate logistic regression.

Аңдатпа. Бұл мақала ұсынылған жаһандық жіктеме аясында экономикалардың бес даму кезеңі бойынша ілгерілеуге ықпал ететін іргелі факторларды зерттейді. Біз Ростов, Охно және Портер ұсынған кезеңдік тұжырымдамаларды эмпирикалық түрде іске асырып, әрбір өтуді бір айнымалы логистикалық регрессиялармен бағалаймыз, институционалдық, саясаттық және қабілет айнымалыларының кең жиынтығын қолданамыз, сондай-ақ әр өтудегі жетекші болжағыштарды ранжирлейміз. Құрылымдық трансформация контекстінде экономикалар өндіріс пен өңдеуші өнеркәсіпке сүйенген траекториямен алға жылжиды: доиндустриялық жағдайдан бастап ерте өндірістік кезеңге өтеді, содан кейін ішкі байланыстарды күшейту және жаһандық құндылық тізбектеріне кірігу арқылы әртараптанады, күрделілігін арттырады және ақырында инновациялар шебіне жетеді. Нәтижелер осы баянды қолдап әрі нақтылайды: бастау кезеңі инвестициялық әлеуетке және құндылықты иелену қабілетіне (appropriability) ең тығыз байланысты; әртараптану әкімшілік және құқықтық болжамдылықпен әрі сыртқы тәуекелдерді басқарумен астасады; кемелдену ірі инвестициялық және appropriability әсерлерімен, реттеушілік үйлесіммен және озық факторлық шарттармен сабақтас; ал шекараға ену және онда тұрақтау құқық үстемдігі институттары мен реттелген ашықтыққа тәуелді. Көрсеткіштердің ықпалы кезеңдер бойынша жүйелі түрде күшейеді. Екі маңызды нақтылау байқалды: appropriability (ЖІӨ-дегі зияткерлік меншік үлесі арқылы өлшенген)

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әдебиеттегіге қарағанда ертерек мәнге ие болады, ал инфляция құбылмалылығымен байқалған оң байланыстар (инфляцияның стандартты ауытқуы арқылы өлшенген) реформаларға тән уақытша турбуленттілікті көрсетеді және өсім мен кезеңдер бойынша ілгерілеудің себептік факторы болып табылмайды.
Түйінді сөздер: құрылымдық трансформация; даму кезеңі; индустрияландыру; әртараптандыру; экономикалық күрделілік; инновация; бір айнымалы логистикалық регрессия.

Аннотация. В этой статье исследуются фундаментальные факторы, влияющие на движение по пяти стадиям развития в рамках глобальной классификации стран, предложенной Айтуаром и др. Подходы Ростоу, Охно и Портера операционализируются через оценку для каждого перехода с помощью однофакторных логистических регрессий на широком наборе институциональных, политических и компетентностных переменных; для каждого перехода отношения шансов сообщаются, а ведущие предикторы ранжируются. В логике структурной трансформации траектория развития характеризуется последовательным продвижением от доиндустриального состояния к ранней индустриализации, далее к диверсификации через укрепление внутренних связей и интеграцию в глобальные цепочки стоимости, затем к повышению экономической сложности и, наконец, к выходу на инновационный фронтир. Полученные результаты интерпретируются как подтверждающие и уточняющие этот нарратив: запуск роста связывается с инвестиционной ёмкостью и базовой защищённостью результатов; диверсификация - с административно-правовой предсказуемостью и управлением внешними рисками; зрелость - с крупными инвестициями, правовой защищённостью результатов и регуляторным выравниванием при улучшении факторных условий; вход и удержание на фронтире - с верховенством права и дисциплинированной открытостью. Отмечается, что влияние повторяющихся индикаторов систематически усиливается по мере смены стадий. Выявляются два уточнения: защищённость результатов (приближённо измеряемая долей поступлений по интеллектуальной собственности в ВВП) начинает играть существенную роль уже на ранних этапах; положительная связь между волатильностью инфляции (стандартным отклонением) и отдельными переходами, по-видимому, отражается краткосрочной турбулентностью реформ, а не причинным вкладом в рост и продвижение к следующей стадии.
Ключевые слова: структурная трансформация; стадия развития; индустриализация; диверсификация; экономическая сложность; инновации; однофакторная логистическая регрессия.

Introduction

The evolution of national economies is characterized not only by variations in income levels but also by significant structural transformations in production methods, institutional frameworks, and capabilities. These transformations occur neither automatically nor uniformly; rather, they manifest as distinct developmental transitions that nations experience at disparate rates, sequences, and degrees of success. A notable contribution to the understanding of these patterns is the structural classification articulated by Aituar et al. (in press), which categorizes countries on the basis of proximate variables, including export composition, manufacturing intensity, and the accumulation of human capital. While these proximate variables serve to illuminate comparative positions, they provide limited insight into the underlying mechanisms that facilitate a nation's transition from one structural stage to another. As explained by Acemoglu, Gallego, and Robinson (2014), development outcomes are optimally understood not merely by investigating proximate causes such as physical capital, levels of education, or income, but by exploring the fundamental variables that shape long-term trajectories, including institutional capacity, technological prowess, and sectoral policies. This paper endeavors to expand upon that insight by identifying specific, policy-relevant factors that enable economies to progress from one stage of structural transformation to another. Our analysis is framed around Rostow's (1971) historical model that delineates a staged take-off through mechanisms of investment, entrepreneurship, and sectoral modernization, Ohno's (2013) framework on industrial policy which underscores the importance of capability-building through sequential learning, management of foreign direct investment (FDI), and the development of domestic enterprises, and Porter's (1990) analysis on competitiveness and clustering, describing the evolutionary process of factor-driven economies as they transition from efficiency-based operations to innovation-centric growth. These authors converge on the notion that development encompasses distinct transitions, each necessitating targeted interventions in areas such as human capital, infrastructure, institutional frameworks, and industrial policy. We operationalize the theory with a five-stage development model in which each stage reflects a step-change in productive capacity and institutional complexity, from pre-industrial, resource-dependent systems to innovation-driven economies. The focus is a manufacturing-led pathway: countries initiate early industrialization via light manufacturing and export assembly, then diversify by building domestic linkages and absorbing more complex technologies. As capabilities deepen, export sophistication rises-often through global value chains-culminating in high-income, post-industrial structures anchored in services and knowledge-based growth. Our central inquiry focuses on the fundamental variables associated with progressing from one developmental stage to another. We approach this by employing a series of

univariate logistic regressions, estimated individually for each transition and predictor, and we report odds ratios for ease of interpretation. This design facilitates a transparent mapping from theory to evidence, reduces risks of overfitting and multicollinearity in a high-dimensional context, and allows for clear cross-stage comparisons of the association of the same indicator. The remainder of this paper is organized as follows. The literature review synthesizes the staged development frameworks. The data and methodology section outlines the construction of the fundamental variable dataset, describes the classification of countries used as the dependent variable, and details the univariate logistic regression models employed. The results section presents empirical findings, highlighting which fundamental variables exhibit the strongest associations with stage transitions along a manufacturing-led pathway. The discussion interprets the results and emphasizes policy-relevant insights related to structural transformation. Finally, the conclusion encapsulates the main contributions, acknowledges limitations, and suggests directions for future research and policy development. We draw on stage-based frameworks by Rostow (historical sequencing), Ohno (industrial policy), and Porter (competitiveness) to view development as a sequence of discontinuous transformations rather than a smooth path. What matters is not the number or labels of stages, but the structural upgrades in production, institutions, and capabilities they represent. These transitions are not automatic; they typically follow deliberate policy that strengthens fundamentals. In this perspective, growth serves to build the capabilities that enable further advancement. The review therefore synthesizes theory and evidence to identify the conditions that move economies from subsistence to industrialization, diversification, greater complexity, and ultimately the innovation frontier.The first phase is defined by resource dependence, fragile institutions, and low human capital, with subsistence production, weak bureaucracies, and poor infrastructure. Rostow (1971) calls this the Traditional Society, Ohno (2013) the Pre-Industrial Stage, and Porter (1990) the Factor-Driven Stage, all stressing reliance on basic inputs rather than productivity or innovation. The consensus is that economies must industrialize by building foundations for manufacturing: Rostow highlights social overhead capital and entrepreneurship, Ohno emphasizes policy capacity, education, and early FDI awareness, and Porter points to improved factor conditions and initial clusters. Building on Rodrik (2013), early productivity gains are driven by labor reallocation from agriculture into manufacturing, but-consistent with Rodrik (2016)-these gains materialize only when investment is paired with institutional basics. Secure property rights and a functioning legal order protect capital and lower transaction costs (Acemoglu, Johnson, & Robinson, 2001), while rising investment, savings, and urban infrastructure accompany the first expansion of manufacturing (Szirmai, 2012). Connectivity and openness are likewise pivotal: weak infrastructure and high transport costs dampen trade and diffusion (Haraguchi, Cheng, & Smeets, 2017). Finally, appropriability enters earlier than classical sequencing implies: stronger intellectual property rights accelerate international technology transfer via royalties, affiliate R&D, and patenting, allowing even rudimentary IP regimes to serve as “contract technology” at take-off (Branstetter, Fisman, & Foley, 2006). Once these foundations are in place, industrialization can proceed. In Rostow’s “preconditions for take-off,” savings and investment are mobilized to reallocate resources from subsistence agriculture toward modern industry and to finance social-overhead capital (Rostow, 1971). Ohno’s “early industrial stage” stresses that this phase requires a capable state and coordination mechanisms that enable firm-level learning rather than the mere appearance of factories (Ohno, 2013). Porter’s “factor-driven stage” adds the early creation of specialized factors and supplier networks as proto-clusters take shape (Porter, 1990). The objective is not only to start manufacturing but to lay the institutional and capability base for the subsequent transition to diversification. Diversification requires strengthening institutions and productive capabilities. Rostow highlights sustained investment across infrastructure and manufacturing, Ohno stresses policy coherence, quality systems, and public–private coordination, and Porter emphasizes supplier development and specialized factors to support competitive clusters. Empirical work confirms these points: producer-friendly institutions channel resources into growth (Mehlum, Moene, Torvik, 2006); economies diversify predictably at middle-income levels (Imbs, Wacziarg, 2003); and capability accumulation with certification systems underpins expansion (Hausmann, Hidalgo, 2011). Excessive concentration hinders growth (Lederman, Maloney, 2003), while resource rents risk underinvestment in education (Gylfason, 2001). Transitional instability, such as inflation during liberalization, is common but temporary. After an initial industrial base is established, economies must expand their productive structures through diversification. Rostow (1971) situates diversification within the later Take-Off and Drive to Maturity stages, when investment expands beyond a narrow set of industries and growth

spreads across multiple sectors. For him, the hallmark of this phase is sustained capital accumulation and the diffusion of infrastructure that enables the benefits of industrialization to reach a broader set of industries. Ohno (2013) similarly emphasizes that diversification requires policy coherence across sectors, strengthening domestic linkages between industries, and institutionalizing systems of quality control that allow firms to expand into new products and export markets. Porter (1990) highlights diversification as the expansion of clusters: rather than being confined to one or two industries, a country must nurture multiple interconnected supplier networks and develop specialized factor conditions such as skilled labor, capital markets, and logistics that serve a wide array of industries. Empirical studies underscore diversification as a key transition stage. Strong institutions prevent rent-seeking and channel resources into broad-based growth (Mehlum, Moene, Torvik, 2006). Diversification typically peaks at middle-income levels before re-specialization (Imbs, Wacziarg, 2003) and requires dense productive capabilities with certification systems (Hausmann, Hidalgo, 2011). Excessive export concentration hampers growth (Lederman, Maloney, 2003), while weak fiscal discipline can erode education and human capital investment (Gylfason, 2001). Short-term volatility during liberalization is common but temporary. Ultimately, diversification builds resilience by reducing sectoral dependence and preparing for Stage 4: Complexity. At the next stage, economies become more complex, producing sophisticated goods and managing advanced supply chains, while still relying on foreign sources of innovation. Rostow (1971) describes this as the Drive to Maturity, when growth becomes sustained across a wide range of advanced sectors. Ohno (2013) emphasizes that complexity represents engineering mastery and the ability to adapt imported technology, but not yet original innovation. Porter (1990) similarly views this stage as one characterized by performance-driven competition, advanced clusters, supplier networks, and demand sophistication, all of which prompt firms to focus on high-quality production but fall short of invention. The purpose of this stage is to prepare for the leap into innovation and to cross into high-income prosperity. The stage theory authors agree that advancing to complexity requires sustained investment in knowledge systems and institutions. Rostow stressed higher education and research, Ohno emphasized R&D promotion and university–industry collaboration, and Porter highlighted sophisticated demand and support industries that drive originality. Empirical studies confirm these requirements: export sophistication predicts growth (Hausmann, Hwang, Rodrik, 2007); innovation networks enhance complexity (Balland, Boschma, and Rigby, 2022). Acemoglu et al. (Acemoglu, Johnson, Robinson, 2001) argue that inclusive institutions, such as secure property rights, the rule of law, and broad access to opportunities, are the fundamental basis of long-run innovation-driven growth. Collectively, these studies confirm that complexity is not an endpoint, but rather the road to high income. Without institutional credibility and sustained investment in innovation capacity, countries risk stalling in a middle-income trap; with them, they can cross into the innovation frontier. The final transformation occurs when economies reach the innovation frontier, which is defined by their ability to generate, absorb, and diffuse knowledge domestically. Rostow (1971) describes this as the Age of High Mass Consumption, characterized by sustained prosperity through technological advancements and social investment. Ohno (2013) emphasizes that innovation cannot be imported but must be domesticated through national systems of research, advanced human capital, and refined institutions. Porter (1990) similarly stresses that competition at the frontier is no longer efficiency-based but driven by originality, branding, and design, with demand sophistication pushing firms to innovate continuously. At this stage, the priority is to consolidate innovation capacity so it reliably sustains high income. This requires continued investment in education and social overhead (Rostow, 1971), refined policies that strengthen R&D systems, clusters, and university–industry links (Ohno, 2013), and advanced clusters connected to global knowledge networks (Porter, 1990). Empirical work shows that innovation pays only when backed by strong institutions (Rodrik, 2016) and inclusive governance (Acemoglu, Johnson, & Robinson, 2001). Reaching the frontier is therefore not an endpoint but the start of a self-reinforcing cycle of innovation that underwrites long-run prosperity. Contemporary empirical research demonstrates that progression through these stages is not guaranteed and depends critically on complementary conditions: secure and inclusive institutions (Acemoglu, Johnson, and Robinson, 2001; Acemoglu, 2025), human-capital development (Rodrik, 2013), openness and connectivity (Limão, Venables, 2001; Wacziarg, Welch, 2008). The literature collectively shows that what separates countries that advance from those that stagnate is not the existence of stages per se, but the ability to meet the institutional, infrastructural, and policy thresholds that make transitions possible. Development, in this light, is best understood not as linear growth but as a sequence of capability upgrades.

Materials and Methods

We have created a balanced panel annual dataset encompassing 120 economies over a span of 35 years (1984-2019). Each year, countries are categorized into structural clusters using the dynamic factor model developed by Aituar et al. (in press). A notable contribution to the understanding of these patterns is the structural classification articulated by Aituar et al. (in press), which categorizes countries using proximate variables such as export composition, manufacturing intensity, and human capital. The categorization was established through the application of k-means clustering, utilizing the specified structural variables.

Our analysis centers on five contiguous cluster-transition events. The dataset consists of **152 structural indicators** drawn from publicly available sources, including World Development Indicators, World Governance Indicators, UNESCO, IMF, etc. All the variables were standardized (min-max from 0 to1) to facilitate coefficient comparability.

Let $j \in \{1, 2, 3, 4, 5\}$ index the five upward transitions in the Aituar et al. (in press) typology. For each transition j, define a binary outcome

$$Y_{i,t}^{(j)} = \begin{cases} 1 & \text{if country } i \text{ moves from the origin cluster to the destination cluster in } t \\ 0 & \text{otherwise} \end{cases}$$

and consider a single structural covariate $X_{i,t}^{(k)}$. We estimate separate **univariate** logits,

$$\log\left(\frac{P(Y_{i,t}^{(j)} = 1)}{1 - P(Y_{i,t}^{(j)} = 1)}\right) = \alpha_k^{(j)} + \beta_k^{(j)} X_{i,t}^{(k)},$$

by maximum likelihood. Huber–White (heteroskedasticity-robust) standard errors are reported; sensitivity checks with country-clustered errors yield the same rankings. For each stage–indicator pair, we present odds ratios (OR) and average marginal effects (AME) along with 95% confidence intervals. The AME represents the average derivative of the predicted transition probability concerning the predictor (dy/dx) and is expressed in percentage points. Our inference utilizes country-clustered standard errors; results that are robust to heteroskedasticity are comparable and do not influence the screening rankings. This screening design is deliberate. Given the numerous correlated institutional and policy indicators in relation to the number of transitions, univariate models mitigate the risk of coefficient instability caused by multicollinearity, (ii) provide a clear and transparent connection from theory to a singular margin at each stage, and (iii) facilitate straightforward cross-stage comparisons of the associations linked to the same indicator. The estimates are interpreted as marginal associations rather than causal effects.All continuous predictors are standardized within the pooled sample; for such variables, $\beta_k^{(j)}$ is the log-odds change for a one–standard-deviation increase in X_k. Main-text effects are reported as odds ratios $OR_k^{(j)} = exp\left(\beta_k^{(j)}\right)$ for readability. Min-max scaling is employed to normalize all variables to a range of 0 to 1, thereby facilitating direct comparability without the imposition of arbitrary units. For each transition j, we retain covariates with $p < 0.05$ (two-sided) and rank them by $\left|\beta_k^{(j)}\right|$. Tables 1–5 report the top twenty indicators with highest coefficients. Since we screen many predictors, we present Benjamini–Hochberg false-discovery-rate (FDR) q-values as a robustness check; headline rankings are stable under reasonable FDR thresholds. To aid policy interpretation across differently scaled variables, we additionally report standardized odds ratios.To study recurrent mechanisms, we trace the same indicator's β and OR across j, documenting coefficient escalations or attenuations as economies move from take-off to the innovation frontier. This cross-stage profiling underpins the discussion's sequencing of policy priorities.

Results

We conducted univariate logistic regressions for each of the five successive development transitions using a common set of 150 structural covariates. In each case, Table 1 through Table 5 report the twenty predictors with the largest statistically significant coefficients ($p < .05$), sorted by descending log-odds (β) alongside their odds ratios, and marginal effects with confidence intervals.

Table 1. 20 indicators with highest coefficients in the transition from Pre-Industrial to Early Industrialization

Rank	**Variable**	**Coef.**	**Odds Ratio**	**Δp (p.p.), AME**	**95% CI (low, p.p.)**	**95% CI (high, p.p.)**
1	Return on capital	3.02	20.45	72.61	49.27	95.95
2	IP % of GDP	2.15	8.59	51.02	35.24	66.8
3	Bureaucracy quality	0.71	2.04	16.82	12.46	21.19
4	Physicians (per 1,000 people)	0.48	1.61	11.44	7.75	15.12
5	Air departures per 1000	0.38	1.47	9.3	5.92	12.68
6	Socioeconomic conditions	0.26	1.29	6.09	4.43	7.75
7	Regulatory trade barriers	0.24	1.27	5.78	4.12	7.45
8	Adjusted savings: education expenditure (% of GNI)	0.24	1.27	5.62	4.16	7.09
9	Hospital beds (per 1,000 people)	0.21	1.24	5.05	3.61	6.5
10	Ethnic tensions	0.18	1.20	4.46	1.94	6.99
11	Financial openness	0.16	1.18	3.94	2.8	5.07
12	Standard deviation of inflation	0.14	1.15	3.43	2.2	4.65
13	Risk for inflation	0.14	1.15	3.36	2.19	4.53
14	Market openness	0.13	1.14	3.26	1.5	5.03
15	Freedom to enter markets and compete	0.13	1.14	3.22	1.52	4.91
16	Taxes on goods and services (% value added of industry and services)	0.13	1.14	3.11	2.37	3.85
17	State ownership of assets	0.13	1.14	3.1	1.57	4.62
18	Legal system & property rights -- without gender adjustment	0.13	1.13	3.1	0.5	5.7
19	Other taxes (% of revenue)	0.13	1.13	3.06	1.9	4.21
20	Freedom to trade internationally	0.12	1.13	2.89	1.28	4.5

Source: Author's own compilation

Moving from resource-dependent to an early-industrializing cluster is dominated by investment (Return on capital) and basic appropriability (IP % of GDP). Return on capital is the largest effect, followed by IP % of GDP. AMEs confirm that these two variables deliver the largest probability gains among significant predictors, with narrow 95% CIs that exclude zero, underscoring both substantive and statistical importance. Administrative capability and legal baselines are already material-bureaucracy quality and the legal system & property-rights composite—and their AMEs indicate smaller but still probability increases relative to investment and IP. Human-capital and connectivity proxies are positive-physicians, hospital beds, air departures-and their AMEs show modest, policy-relevant gains. Trade/financial-openness variables carry moderate ORs and correspondingly modest AMEs. Notably, the standard deviation of inflation shows OR > 1, but its AME is small with CIs close to zero, suggesting limited practical impact and supporting the "reform-turbulence" reading rather than a growth mechanism.

Table 2. 20 indicators with highest coefficients in the transition from Early Industrialization to Diversification

Rank	**Variable**	**Coefficient**	**Odds Ratio**	**AME (probability)**	**AME 95% CI low**	**AME 95% CI high**
1	Bureaucracy quality	0.83	2.28	0.16	0.12	0.21
2	Standard deviation of inflation	0.46	1.59	0.09	0.07	0.12
3	Regulatory trade barriers	0.46	1.59	0.09	0.07	0.11
4	Size of government	0.41	1.51	0.08	0.06	0.10
5	Protection of property rights	0.40	1.49	0.08	0.05	0.12

6	Top marginal income and payroll tax rate	0.38	1.47	0.07	0.06	0.08
7	Democratic accountability	0.37	1.45	0.07	0.05	0.10
8	Legal system & property rights -- without gender adjustment	0.34	1.41	0.07	0.04	0.10
9	State ownership of assets	0.33	1.38	0.06	0.05	0.09
10	Impartial courts	0.32	1.38	0.06	0.05	0.09
11	Risk for debt service	0.32	1.38	0.06	0.05	0.09
12	Non-tariff trade barriers	0.31	1.37	0.06	0.04	0.09
13	Risk for international liquidity	0.28	1.32	0.05	0.03	0.09
14	Risk for foreign debt	0.26	1.30	0.05	0.04	0.07
15	Top marginal income tax rate	0.24	1.27	0.04	0.04	0.06
16	Law & order	0.22	1.24	0.04	0.02	0.08
17	Risk for current account as % of GDP	0.21	1.23	0.04	0.03	0.06
18	Reliability of police	0.21	1.23	0.04	0.02	0.07
19	Protection of foreign assets	0.19	1.21	0.04	0.02	0.06
20	Money growth	0.14	1.15	0.03	0.01	0.05

Source: Author's own compilation

The shift brings stronger administrative and legal predictability alongside risk management and calibrated fiscal capacity. Bureaucracy quality remains the leading predictor (β = 0.83, OR = 2.28). AMEs again show a clear positive, non-trivial probability gain with tight CIs. Private-law institutions (property rights, legal composite, impartial courts) and border/process quality (regulatory and non-tariff barriers) display moderate ORs and mid-sized AMEs, consistent with moving from threshold capacity to process discipline. External-finance risk ratings and money growth are directionally prudent; their AMEs are positive but comparatively small. Inflation variability retains a positive OR; here too the AME is limited, reinforcing the interpretation of transitional noise rather than a substantive lever.

Table 3. 20 indicators with highest coefficients in the transition from Diversification to Maturity

Rank	Variable	Coefficient	Odds Ratio	AME (probability)	AME 95% CI low	AME 95% CI high
1	Return on capital	6.27	529.60	1.44	0.99	1.90
2	IP % of GDP	3.45	31.49	0.80	0.46	1.14
3	Physicians (per 1,000 people)	2.63	13.89	0.39	0.36	0.41
4	Protection of property rights	2.09	8.12	0.27	0.26	0.28
5	Air departures per 1000	1.40	4.08	0.19	0.18	0.21
6	Regulatory trade barriers	1.38	3.97	0.22	0.20	0.23
7	Legal system & property rights -- without gender adjustment	1.34	3.81	0.22	0.21	0.24
8	Market openness	1.33	3.79	0.18	0.17	0.19
9	Freedom to enter markets and compete	1.17	3.22	0.18	0.16	0.19
10	Non-tariff trade barriers	1.11	3.05	0.18	0.17	0.20
11	Hospital beds (per 1,000 people)	0.88	2.41	0.16	0.14	0.19
12	Business regulations	0.87	2.39	0.17	0.15	0.20
13	Military in politics	0.83	2.30	0.16	0.14	0.18
14	Legal enforcement of contracts	0.74	2.09	0.14	0.12	0.16
15	State ownership of assets	0.69	2.00	0.15	0.12	0.18

16	Impartial public administration	0.66	1.93	0.13	0.11	0.14
17	Business permits	0.64	1.89	0.12	0.11	0.13
18	Integrity of the legal system	0.62	1.86	0.13	0.11	0.15
19	Protection of foreign assets	0.60	1.83	0.12	0.10	0.14
20	Impartial courts	0.59	1.80	0.13	0.10	0.15

Source: Author's own compilation

The transition is investment- and capability-intensive. Return on capital and IP % of GDP remain dominant. AMEs translate these into large probability increases with tight 95% CIs, showing that their very high ORs correspond to real movement in predicted transition probabilities, not just log-odds arithmetic. Legal deepening (property rights; legal composite; enforcement; integrity; impartial courts) shows mid-to-high AMEs, indicating that procedural predictability and enforceability have substantive bite at maturity. Advanced factor and connectivity proxies (physicians, air departures, hospital beds) also display non-trivial AMEs, consistent with capacity scaling.

Table 4. 20 indicators with highest coefficients in the transition from Maturity to the Innovation Frontier

Rank	Variable	Coefficient	Odds Ratio	AME (probability)	AME 95% CI low	AME 95% CI high
1	IP % of GDP	7.01	1 104.81	1.21	1.07	1.35
2	Bureaucracy quality	1.72	5.60	0.33	0.30	0.37
3	Protection of property rights	0.91	2.47	0.18	0.16	0.21
4	Socioeconomic conditions	0.83	2.30	0.15	0.14	0.17
5	Legal system & property rights -- without gender adjustment	0.67	1.96	0.15	0.12	0.19
6	Revenue from trade taxes (% of trade sector)	0.58	1.79	0.13	0.10	0.16
7	Legal enforcement of contracts	0.55	1.73	0.12	0.10	0.15
8	Life expectancy at birth, total (years)	0.45	1.57	0.08	0.07	0.09
9	Risk for current account as % of GDP	0.40	1.49	0.09	0.07	0.10
10	Tariffs	0.39	1.48	0.09	0.06	0.12
11	Risk for international liquidity	0.36	1.44	0.09	0.06	0.12
12	Impartial courts	0.36	1.43	0.08	0.05	0.12
13	Risk for debt service	0.34	1.41	0.08	0.05	0.11
14	Freedom to trade internationally	0.32	1.38	0.08	0.05	0.11
15	Standard deviation of inflation	0.31	1.37	0.07	0.05	0.10
16	Regulatory trade barriers	0.31	1.36	0.07	0.04	0.11
17	Law & order	0.30	1.35	0.07	0.04	0.11
18	Risk for inflation	0.30	1.35	0.07	0.05	0.09
19	Integrity of the legal system	0.29	1.34	0.07	0.04	0.10
20	Business regulations	0.26	1.30	0.06	0.04	0.09

Source: Author's own compilation

Innovation take-off hinges on domestic knowledge generation and high-reliability administration. IP % of GDP shows the single largest association. Its AME indicates a very large probability gain with narrow CIs, confirming substantive importance. Bureaucracy quality and the legal stack (property rights; legal composite; contract enforcement; impartial courts; integrity) post mid-sized, precise AMEs, showing that administrative reliability and enforceability remain critical. Socioeconomic conditions and life expectancy carry positive, smaller AMEs, consistent with demand sophistication and human capital as complementary enablers. A calibrated fiscal-trade pattern

(trade-tax revenue, tariffs, and openness) yields small-to-moderate AMEs, indicating compatibility with high-quality openness rather than causal primacy. Ratings for current-account, liquidity, debt service, and inflation risk deliver positive but limited AMEs, reflecting macro-prudential credibility without overshadowing innovation capacity.

Table 5. 20 indicators with highest coefficients in the transition from Innovation Frontier to Deepening Innovation Capabilities

Rank	Variable	Coefficient	Odds Ratio	AME (probability)	AME 95% CI low	AME 95% CI high
1	Legal system & property rights -- without gender adjustment	3.54	34.35	0.24	0.23	0.24
2	Bureaucracy quality	3.24	25.41	0.35	0.33	0.37
3	Integrity of the legal system	2.54	12.74	0.19	0.17	0.20
4	Law & order	2.39	10.89	0.24	0.23	0.25
5	Freedom to trade internationally	2.27	9.70	0.29	0.27	0.30
6	Protection of property rights	2.19	8.94	0.16	0.15	0.16
7	Impartial courts	2.03	7.65	0.16	0.15	0.16
8	Standard deviation of inflation	1.97	7.16	0.33	0.29	0.38
9	Regulatory trade barriers	1.96	7.08	0.24	0.23	0.25
10	Reliability of police	1.90	6.69	0.16	0.15	0.17
11	Market openness	1.80	6.07	0.21	0.20	0.22
12	Freedom to enter markets and compete	1.70	5.47	0.22	0.21	0.24
13	Revenue from trade taxes (% of trade sector)	1.62	5.03	0.29	0.24	0.34
14	Impartial public administration	1.31	3.72	0.13	0.12	0.14
15	Legal enforcement of contracts	1.20	3.33	0.14	0.14	0.14
16	Protection of foreign assets	1.13	3.09	0.16	0.15	0.18
17	Business regulations	1.12	3.06	0.15	0.14	0.16
18	Tariffs	1.05	2.86	0.18	0.16	0.21
19	Religious tensions	1.01	2.75	0.18	0.16	0.20
20	Non-tariff trade barriers	0.98	2.65	0.15	0.14	0.16

Source: Author's own compilation

At the frontier, institutional depth and openness quality dominate. The legal system & property rights composite and bureaucracy quality yield large, precise AMEs, consistent with their very high ORs. Law & order, integrity, protection of property rights, and impartial courts show mid-to-high AMEs, confirming the premium on predictability, impartiality, and administrative efficiency. High-quality openness (freedom to trade, regulatory discipline, market openness) delivers moderate AMEs, while trade-tax revenue and tariffs show small-to-moderate AMEs, consistent with rules-based co-financing of innovative public goods. Additional supports—impartial administration, police reliability, contract enforcement, business regulation quality, and protection of foreign assets—register positive AMEs that, while smaller than the legal core, remain economically meaningful. Social cohesion (fewer religious tensions) likewise shows a positive AME.

Discussion and Conclusion

Take-off from pre-industrial to early industry is investment-led: returns to capital and backbone infrastructure anchor the transition (Rostow, 1971; Ohno, 2013; Chenery & Syrquin, 1975; Wacziarg & Welch, 2008). Appropriability appears earlier than classic sequencing, with IP receipts acting as "contract technology" for licensing and transfer (Branstetter, Fisman, & Foley, 2006; Lee, 2013). Core institutions-bureaucratic quality and secure property rights—lower transaction costs and support investment (Acemoglu, Johnson, & Robinson, 2001; Rodrik, 2016). A mixed state–market

configuration and eased trade/finance barriers raise connectivity and absorptive capacity (Ohno, 2013; Porter, 1990; Limão & Venables, 2001; Wacziarg & Welch, 2008). Social-overhead capacity in health and international links supports early productivity, while inflation-volatility correlations likely reflect reform turbulence rather than gains from instability (Rodrik, 2016). Broad fiscal capacity plausibly finances these foundational public goods (Gylfason, 2001). As economies shift from early industrialization to diversification, the decisive levers are administrative capability and legal predictability—higher bureaucratic quality, secure property rights, impartial courts, and accountable governance enable “producer-friendly” coordination (Ohno, 2013; Porter, 1990; Acemoglu, Johnson, & Robinson, 2001; Mehlum, Moene, & Torvik, 2006). Trade facilitation at the border-standards, customs, certification-reducing regulatory and non-tariff barriers broadens export baskets at middle income (Imbs & Wacziarg, 2003; Hausmann & Hidalgo, 2011). Macro-prudence also matters: better external-risk management and restrained money growth, supported by a predictably financed state using broad tax bases, sustain diversification (Rodrik, 2016; Mehlum, Moene, & Torvik, 2006). Any remaining positive link between inflation variability and diversification is best interpreted as transition noise, not a policy tool.The transition from diversification to maturity is investment- and capability-intensive. The return on capital rises sharply (OR 529.60) and IP receipts increase steeply (OR 31.49), consistent with competitive production under appropriability and with export sophistication as a predictor of growth (Ohno, 2013; Porter, 1990; Hausmann, Hidalgo, 2011). Institutional depth becomes granular, with property-rights protection peaking (OR 8.12) alongside more vigorous contract enforcement and legal integrity, mirroring the rising returns to inclusive institutions at higher development levels (Acemoglu, Johnson, Robinson, 2001). Advanced factor conditions scale with maturity, as evidenced by significant effects on health capacity and international connectivity, which are consistent with knowledge-network and absorptive-capacity channels. Broader governance, characterized by impartial public administration and limited military involvement, supports long-horizon investment and lowers the risk of slowdown.Moving from maturity to the innovation frontier, domestic knowledge generation and high-reliability administration become decisive. IP receipts post the most significant single effect (OR 1,104.81), consistent with a pivot from adaptation to invention under strong appropriability (Porter, 1990). Bureaucratic quality and property rights regain prominence, while the broader legal architecture, such as contract enforcement, judicial impartiality, and system integrity, remains foundational for innovation-driven growth (Acemoglu, Johnson, Robinson, 2001). Demand-side and welfare fundamentals align with the role of sophisticated demand and human capital in avoiding slowdowns (Porter, 1990). Rules-based border revenues coexist with openness when facilitation and regulatory quality, rather than tariff levels alone, support complex integration.At the stage of deepening innovation capabilities, institutional depth and the quality of openness dominate. Substantial effects on the composite legal system and property rights, together with law and order, property rights protection, and impartial courts, confirm the premium on predictability and impartiality at the frontier (Acemoglu, Johnson, Robinson, 2001). High-quality openness, including freedom to trade, disciplined regulatory barriers, and market openness, aligns with global-network competition and standards leadership (Porter, 1990). Investment and appropriability emerge as the strongest and most precisely estimated drivers in the take-off and maturity phases, translating theory-consistent odds ratios into substantial gains in transition probabilities. Institutional deepening-through stronger bureaucracy, property rights, contract enforcement, and legal integrity-shows mid-to-high AMEs that rise with development, underscoring the role of predictable rules for complex production. Overall, the AMEs confirm that OR rankings reflect meaningful probability shifts, not anomalies. They also clarify sequencing: high AMEs for capital returns and intellectual property early and at maturity, mid-range for legal and administrative depth near the frontier, and smaller but supportive effects for openness and macro-prudential stability. This stage-contingent profile aligns with the literature while quantifying its policy relevance. Across stages, recurrent indicators follow consistent patterns (Appendix A). Bureaucracy quality evolves from minor effects at take-off to dominance at the frontier, reflecting the move to a meritocratic, digital state. Property rights show a similar trajectory, becoming critical as production turns contract- and intangible-intensive. Appropriability rises most steeply: intellectual property matters at take-off, strengthens toward maturity, and becomes decisive at innovation. Three systematic divergences from standard narratives are noteworthy. First, intellectual property intensity matters earlier than expected, suggesting that minimal appropriability facilitates technology inflows at takeoff. Second, positive associations for inflation variability at several transitions likely reflect reform-era turbulence in a univariate design rather than gains from volatility. Third, the coexistence

of trade-tax revenues and tariffs with high-quality openness at advanced stages is consistent with calibrated, rules-based revenue systems that help finance non-rival innovation infrastructure (Porter, 1990).Taken together, the evidence refines rather than overturns staged development theory. Investment capacity and core institutions initiate take-off (Rostow, 1971; Acemoglu, Johnson, and Robinson, 2001; Acemoglu, 2025). Policy coherence, legal predictability, and risk management support diversification (Ohno, 2013; Mehlum, Moene, and Torvik, 2006). Appropriability, procedural streamlining, and regulatory alignment drive maturity (Porter, 1990; Hausmann, Hidalgo, 2011). At the frontier, deep rule of law, high-reliability administration, calibrated openness, and social cohesion dominate (Acemoglu, Johnson, Robinson, 2001). The escalating role of bureaucratic quality, property rights, and the legal composite, as well as IP, across stages provides a stage-contingent guide to sequencing reforms (Hausmann, Hwang, Rodrik, 2007).This paper extends the staged development literature by integrating the structural classification of Aituar et al. (in press) with the frameworks of Rostow (1971), Ohno (2013), and Porter (1990). Using data from 120 countries between 1984 and 2019, the analysis shows that the drivers of transformation shift systematically across stages. Early transitions depend on demographic change, education, and infrastructure; mid-stage advancement is facilitated by diversification, digital connectivity, and tertiary skills; and reaching the innovation frontier is primarily determined by institutional quality, bureaucratic capacity, and the rule of law. These findings confirm that development is not automatic but the result of stage-specific and cumulative policy efforts.The study also carries limitations. Reliance on univariate logistic regressions provides functional associations but cannot capture non-linearities or interactions among variables. Extremely large odds ratios suggest that results should be interpreted as indicative patterns rather than precise effects. Future research will therefore prioritize the use of random forest classifiers and related machine learning approaches, which can detect complex relationships, manage high-dimensional data, and generate robust rankings of variable importance. These tools, combined with the classification allows a deeper analysis of how binding constraints evolve across stages. In the explicitly predictive extensions, we will develop cross-validated forecasting specifications and report discrimination and calibration metrics (ROC, PR, Brier, calibration plots) alongside stability checks across time and regions, complementing the transparent stage-comparative maps provided here. Our research objective is explanatory, not predictive: identifying stage-contingent fundamental drivers of structural transformation. ROC/PR curves are appropriate for forecasting models, not for estimating marginal associations in a theory-testing framework. The univariate design prioritizes interpretability and cross-stage comparison over prediction accuracy, consistent with the growth diagnostics tradition (Hausmann, Hidalgo, 2011).

Our results underscore that growth strategies must be tailored to the specific constraints countries encounter at various stages of their development trajectory. For policymakers, the implication is not to implement every possible reform simultaneously but to recognize where their country stands and to sequence interventions accordingly. Early investments in human capital and infrastructure provide the foundations. Mid-stage strategies should consolidate diversification and digital adoption. At the frontier, institutional quality and openness sustain innovation-led growth. This study should therefore be read less as a definitive roadmap than as a flashlight shedding light on the direction of inquiry and policy sequencing that can guide countries along the demanding but achievable path of structural transformation.

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Code Availability

All analysis code is available publicly on GitHub: https://omar-bolatbay/Stage-Contingent-Fundamentals-of-Structural-Transformation. It includes pinned packages, fixed random seeds, a minimally reproducible dataset, and scripts to regenerate all tables and figures.

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ҚҰРЫЛЫМДЫҚ ТРАНСФОРМАЦИЯНЫҢ КЕЗЕҢГЕ ТӘУЕЛДІ НЕГІЗГІ ФАКТОРЛАРЫ: БІР АЙНЫМАЛЫ ЛОГИСТИКАЛЫҚ РЕГРЕССИЯЛАР НЕГІЗІНДЕГІ ЭМПИРИЯЛЫҚ ДӘЛЕЛДЕР

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ФУНДАМЕНТАЛЬНЫЕ ФАКТОРЫ СТРУКТУРНОЙ ТРАНСФОРМАЦИИ, ЗАВИСЯЩИЕ ОТ СТАДИИ РАЗВИТИЯ: ЭМПИРИЧЕСКИЕ СВИДЕТЕЛЬСТВА НА ОСНОВЕ ОДНОФАКТОРНЫХ ЛОГИСТИЧЕСКИХ РЕГРЕССИЙ

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