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Determinants of Merchandise Exports in Madhya Pradesh: Short- and Long-Run Elasticities from an ARDL Bounds Analysis (2002–2025)

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Abstract - This research paper analyses the determinants of merchandise exports in Madhya Pradesh, a landlocked and largely agrarian state. The paper takes into consideration data over 2002–03 to 2024–25 using annual time-series. Applying the ARDL bounds testing approach, the paper uncovers cointegration (F-statistic = 10.57, exceeding the upper critical bound) and estimate short- and long-run elasticities for gross state domestic product (GSDP), scheduled commercial bank credit, road infrastructure, and industrial capital. Bank credit and road length exert significant positive long-run effects (elasticities of 0.76 and 1.03, respectively; $p<0.05$), while GSDP and industrial capital effects prove insignificant owing to multicollinearity (VIF>20). The error correction term (-1.00; $p=0.003$) signals full adjustment to equilibrium within one year. Findings underscore targeted credit expansion and road investments to elevate state exports toward India's US$ 1 trillion national target.

Key Words: Exports, ARDL, Cointegration, Infrastructure, Bank Credit, Madhya Pradesh

1. INTRODUCTION

India's merchandise exports attained INR 37 trillion in 2024–25, propelled by engineering goods and pharmaceuticals, yet pronounced sub-national disparities endure: coastal states such as Gujarat predominate, whereas landlocked Madhya Pradesh (MP), India's second-largest state by area, registers modest contributions notwithstanding a twenty-fold escalation from INR 33 billion (2002–03) to INR 662 billion (2024–25). MP's export portfolio, dominated by medicaments (17.6%), soy oil-cake (7.4%), and unwrought aluminium (6.6%), ostensibly depends on enabling macroeconomic and structural factors, including gross state domestic product (GSDP), scheduled commercial bank credit, road infrastructure, and industrial capital formation.

This research paper redresses a lacuna in sub-national econometric inquiry by quantifying these determinants via the Autoregressive Distributed Lag (ARDL) framework, thereby subjecting the export-led growth (ELG) hypothesis to empirical scrutiny within a landlocked, agrarian context. Contra prevalent national- or firm-level analyses, it explains state-specific dynamics amid India's Viksit Bharat @2047 ambitions and the 2025–26 Export Promotion Mission (₹2,250 crore allocation), furnishing actionable insights for federal trade policy calibration.

Guiding analyses include: (1) Whether GSDP, credit, roads, and industrial capital Granger-cause exports; and (2) the magnitude of short- and long-run elasticities. Null hypotheses posit insignificant positive associations. The empirical strategy leverages 23 annual observations (2002–03 to 2024–25), operationalized through ARDL-ECM estimation with bounds testing for cointegration.

2. LITERATURE REVIEW

Classical theories provide the foundation for understanding exports' role in economic growth. Adam Smith's (1776/2003) absolute advantage and David Ricardo's (1817/2004) comparative advantage principles suggest nations benefit by specializing in goods they produce relatively more efficiently. New trade theory builds on this foundation, Krugman (2008) highlights how economies of scale, product differentiation, and transport costs drive trade patterns, with infrastructure playing a key enabling role.

Empirical evidence on export-led growth (ELG) remains mixed across contexts. Studies in emerging markets often find positive causal links from exports to GDP growth (Villanueva, 1993), attributing gains to productivity spillovers and foreign exchange earnings. However, evidence elsewhere reveals bi-directional causality or the reverse growth-led exports (GLE) pattern, where output expansion precedes export rises (Awokuse, 2008). These discrepancies underscore the influence of development stage, trade openness, and complementary factors like infrastructure and finance.

Transportation infrastructure lowers trade costs and expands market access, Limão and Venables (2001) estimate infrastructure accounts for over 50% of trade

cost variation across countries. For roads specifically, Banerjee, Duflo, & Qian (2012) document that a 1% increase in road density correlates with a 1% rise in district-level exports in India. Financial development complements this by easing credit constraints for exporters; Rajan and Zingales (1998) show industries reliant on external finance grow faster in market-based systems, while Levine (2005) links banking depth to total factor productivity gains.

India-specific research reinforces these channels. Post-1991 liberalization boosted firm productivity through tariff reductions, especially in FDI-exposed sectors (Topalova, 2004; Kandilov, Leblebicioğlu, & Manghnani, 2017). Yet sub-national disparities persist, coastal states outperform interiors due to logistics advantages (Veeramani & Dhir, 2016; Jha & Talathi, 2023). Madhya Pradesh lacks dedicated econometric treatment; this study addresses that gap using Pesaran, Shin, & Smith (2001) ARDL bounds approach, suitable for small samples with mixed I(0)/I(1) variables.

3. RESEARCH METHODOLOGY

This research paper utilizes annual time-series data spanning 2002–03 to 2024–25 (23 observations) for Madhya Pradesh, sourced from authentic Indian databases: Directorate General of Commercial Intelligence and Statistics (DGCIS) for merchandise exports; Ministry of Statistics and Programme Implementation (MOSPI) for gross state domestic product (GSDP); Centre for Monitoring Indian Economy (CMIE) for scheduled commercial bank credit, total road length, and industrial fixed capital investment. All variables enter in natural logarithms to interpret coefficients as elasticities and stabilize variance. Minor data gaps in recent years (e.g., 2024–25 industrial capital) were addressed via linear interpolation, cross-verified against RBI state handbooks; this ensures series continuity without trend distortion.

Table 1: Variable Definitions and Sources

Variable	Definition	Units	Source
Ln EXPORTS	Log of merchandise exports	INR million	DGCIS
Ln GSDP	Log of GSDP at factor cost (constant prices)	INR crore	MOSPI
Ln CREDIT	Log of scheduled commercial banks' total outstanding credit	INR crore	CMIE
Ln ROAD	Log of total road network length (national, state, district, rural roads)	Kilometers	CMIE
Ln INDUSTRY	Log of fixed capital invested in registered industries	INR crore	CMIE

The following null hypotheses (H_0) guide the empirical analysis, positing no significant relationships between merchandise exports (EXPORTS) and each explanatory variable in both short- and long-run dimensions:

- **H_1**: There is no significant relationship between gross state domestic product (GSDP) and exports of Madhya Pradesh.
- **H_2**: Scheduled commercial bank credit (CREDIT) extended has no significant impact on exports.
- **H_3**: Road infrastructure (ROAD) does not significantly influence export performance.
- **H_4**: Industrial capital investment (INDUSTRY) has no significant effect on exports.

Descriptive statistics reveal positive trends: exports grew twenty-fold (mean of ln EXPORTS = 11.72, SD=0.85); explanatory variables exhibit similar upward trajectories (e.g., mean of ln ROAD=10.21). Augmented Dickey-Fuller (ADF) tests confirm suitability for ARDL: ln EXPORTS is I (0) ($p=0.001$ at levels); others I (1) ($p>0.05$ levels, $p<0.05$ first differences).

Pesaran et al.'s (2001) ARDL bounds testing approach suits small samples with mixed integration orders. The F-statistic on lagged levels tests the null of no cointegration ($\theta_1 = \theta_{2k} = 0$) against existence of a level relationship. Critical bounds (e.g., I (0) =3.79, I (1) =5.23 at 5%, k=4, n=30 case) accommodate uncertainty; F > upper bound confirms cointegration.

Table 2: ADF Unit Root Test Results

Variable	Level (Intercept)	1st Difference	Order
Ln EXPORTS	-4.12 (0.001)*	-	I (0)
Ln GSDP	-1.89 (0.769)	-5.23 (0.003)**	I (1)
Ln CREDIT	-2.01 (0.724)	-6.78 (0.000)*	I (1)
Ln ROAD	-2.45 (0.287)	-3.89 (0.062)*	I (1)
Ln INDUSTRY	-1.76 (0.678)	-4.67 (0.010)**	I (1)

3. RESULTS AND FINDINGS

The ARDL bounds test unequivocally rejects the null hypothesis of no cointegration. The computed F-statistic of 10.57 exceeds the upper critical bound of 5.23 (5% significance, unrestricted intercept, k=4), confirming a stable long-run relationship among exports and the explanatory variables.

Optimal lag structure ARDL (1,0,0,0,0), selected via AIC, yields a high explanatory power (R^2=0.978, adjusted R^2=0.965). Short-run dynamics reveal significant positive impacts from bank credit (coefficient=0.72, t=2.42, p=0.028) and road infrastructure (0.97, t=2.26, p=0.038). GSDP and industrial capital effects remain insignificant in the full specification (p>0.20), likely reflecting multicollinearity among trending aggregates (VIF GSDP=24.3; INDUSTRY=21.8)

Table 3: Short-run ARDL Estimates

Variable	Coefficient	Std. Error	t-statistic	p-value
ΔlnGSDP	-0.98	0.82	-1.20	0.249
ΔlnCREDIT	0.72	0.30	2.42	0.028
ΔlnROAD	0.97	0.43	2.26	0.038
ΔlnINDUSTRY	0.09	0.15	0.61	0.552
Constant	0.15	0.08	1.88	0.082

Long-run elasticities, derived as $-\theta_2 k/\theta_1$, confirm bank credit's 0.76% export response per 1% credit expansion (t=2.34, p=0.032) and roads' elastic 1.03% effect (t=2.41, p=0.029). GSDP appears perversely signed but insignificant (-1.03, p=0.231); industrial capital negligible (0.10, p=0.612).

The error correction model exhibits a highly significant ECT coefficient of -1.00 (t=-4.12, p=0.003), implying full convergence to long-run equilibrium within one year, exceptionally rapid adjustment for annual data.

Post-estimation diagnostics validate model adequacy. No serial correlation (Breusch-Godfrey LM F=1.89, p=0.158); homoskedasticity (ARCH F=1.62, p=0.219); normal residuals (Jarque-Bera χ^2=0.89, p=0.375, visually confirmed); parameter stability (CUSUM/CUSUMSQ plots remain within 5% bounds).

Table 4: Diagnostic Test Summary

Test Statistic	Value	p-value	Decision
Breusch-Godfrey LM (2 lags)	1.89	0.158	No autocorrelation
ARCH (1 lag)	1.62	0.219	Homoskedastic
Jarque-Bera normality	0.89	0.375	Normal
VIF (max: GSDP)	24.3	-	Multicollinearity
CUSUM/CUSUMSQ	Within bounds	-	Stable

Robustness checks reinforce core findings: (1) Alternative criteria (HQIC selects ARDL(1,0,0,0,1), F=9.84>upper bound, CREDIT/ROAD remain significant); (2) HAC-Newey-West standard errors unchanged (CREDIT p=0.045); (3) Bivariate ARDLs yield GSDP elasticity 1.13 (p<0.001), confirming suppression by collinearity; (4) Reduced model excluding INDUSTRY elevates GSDP significance (0.67, p=0.087).

These results substantiate hypotheses H2 (credit) and H3 (roads) while rejecting H1 (GSDP, full model) and H4

(industry), highlighting complementary infrastructure-finance channels over aggregate scale in Madhya Pradesh's export dynamics.

4. POLICY IMPLICATIONS

Bank credit and road infrastructure emerge as primary export determinants in Madhya Pradesh, with long-run elasticities of 0.76 and 1.03 (both $p<0.05$). A 10% credit increase thus boosts exports by 7.6% over time, while equivalent road expansion yields 10.3%, effects robust for a landlocked state, aligning with finance constraints theory (Rajan & Zingales, 1998; Levine, 2005) and logistics evidence (Limão & Venables, 2001; Banerjee et al., 2012). These channels support MP's pharma (17.6% share) and agro-processing sectors (soy oil-cake 7.4%).

GSDP and industrial capital insignificance reflects multicollinearity (VIF>20); bivariate checks confirm GSDP's positive role (1.13, $p<0.001$), indicating indirect transmission via credit/roads rather than direct scale effects (Manova, 2013). The ECT (-1.00, $p=0.003$) implies full annual adjustment, underscoring exports' sensitivity to policy signals.

Findings nuance export-led growth in non-coastal settings, favouring complementary factors over unidirectional causality (Awokuse, 2008; Veeramani & Dhir, 2016), consistent with MP's twentyfold export rise despite modest national share.

Policymakers should prioritize credit and infrastructure to amplify MP's export contributions toward India's US$ 1 trillion merchandise target and Viksit Bharat 2047 vision. Targeted interventions coild include:

Export-linked Credit Enhancement: Expand priority sector lending under NABARD's RIDF and RBI's export credit schemes, allocating 20–30% of bank's credit (currently INR crores scale) to MSMEs. Cross-border factoring (per 2025–26 Export Promotion Mission's ₹2,250 crore outlay) could mitigate working capital gaps for landlocked exporters.

Road Infrastructure Corridors: Accelerate PM GatiShakti investments in export-focused highways (e.g., Indore-Mumbai, Bhopal-Delhi), targeting 10% annual road length growth. Integrate inland waterways and rail for last-mile connectivity, potentially lifting exports 10% per infrastructure elasticity.

Sectoral Synergies: Link credit/roads to MP's strengths, pharma clusters (e.g., Indore), agro-parks (soy in Malwa), and mineral processing, via state export policy 2.0, including GST rebates and RoDTEP extensions.

Monitoring Framework: Deploy MSME export readiness analytics (e.g., ARDL-based dashboards) to track elasticities quarterly, adjusting allocations dynamically amid global shocks (Russia-Ukraine, Red Sea disruptions).

5. CONCLUSIONS

This research paper confirms bank credit and road infrastructure as key long-run drivers of Madhya Pradesh's merchandise exports, with elasticities of 0.76 and 1.03 ($p<0.05$), validated by ARDL cointegration ($F=10.57$) and full annual ECM adjustment (-1.00, $p=0.003$) over 2002–25. GSDP and industrial capital effects, suppressed by multicollinearity, operate indirectly through these channels, addressing a critical gap in subnational trade empirics.

The findings advocate prioritizing credit allocation and logistics corridors to elevate MP's contribution toward India's US$ 1 trillion export target and Viksit Bharat 2047. Future work should explore quarterly data, sectoral analyses, threshold effects, or district panels to enhance granularity and generalizability.

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