

Trade Openness and Nutritional Security in India: Analyses at Sub-National Level

Poornima Varma, Vidya Vemireddy and Drishti Sharma

(International Agricultural Trade Research Consortium's Annual Meeting)

December 15, 2025

- ① Introduction and Role of Trade Openness**
- ② Study Objectives
- ③ Model, Data, and Construction of Variables
- ④ Results of the study
- ④ Concluding Remarks

- Significant transformation in food consumption over the past 4 decades from cereals to nutri-rich commodities (Birthal *et al.*, 2025)
- Share of cereals declined from 44 per cent in 1983 to 10 percent in 2023, non cereals from 28 percent to 48 percent.
- Trade can play a critical role in influencing the domestic food consumption primarily through changes in domestic prices.
- Trade can reduce the domestic food price volatility and enhances food security (Smith and Glauber, 2018).
- International trade is argued to be a more effective pathway to achieving food security than domestic self-sufficiency alone(Otero *et al.*, 2013).

- Existing empirical studies on trade openness and dietary outcomes focus mainly on national-level analyses and on food security (e.g., Dithmer and Abdulai, 2017; e.g., Forgenie *et al.*, 2024).
- However, systematic analyses of domestic food consumption patterns at sub-national levels are largely absent, particularly for India.

Role of Trade Openness

- Trade liberalisation reshapes domestic markets by lowering prices through import competition or raising them when export demand increases (Thow, 2009).
- These relative price adjustments influence household food budgets and the allocation of expenditure across food groups, with implications for dietary composition and nutrition outcomes (Tian and Lin, 2023).
- Trade openness through expanded exports and imports can drive structural changes in the food system by shifting cropping patterns, altering relative prices and ultimately reshaping household food consumption.

Potential Pathways for Trade Openness and Dietary Patterns

Trade Liberalization Outcomes	Food System Effects	Likely Medial Effects	Associated Dietary Changes
Greater exports	Higher foreign demand	Decreased availability of food and higher domestic prices	Relative decrease in consumption of locally produced traditional staples
	Increase in domestic prices	Shift in cropping pattern and changes in relative prices	Consumption of high value market-oriented food.
	Higher foreign earnings		Increased preferences for non-cereal items
	Changes in cropping pattern		
	Technological advancement and productivity changes		
Greater imports	Increased competition and decrease in domestic prices	Increased availability of food and lower domestic prices	Increased variety of food items
	Exchange rate effects and higher import price	Decreased production of import competing food items	Increased consumption of processed/refined/pre-prepared foods.
	Exchange rate effects and lower import price	Increased awareness of food quality and preferences	Increased consumption of locally produced food and decreased preference for imported food
	Supply side shocks and higher price for imported good		
	Changes in cropping pattern		
	Technological advancement and productivity changes		

Source: Adapted from Thow, 2009

Table of Contents

- ① Introduction and Role of Trade Openness
- ② **Study Objectives**
- ③ Model, Data, and Construction of Variables
- ④ Results of the study
- ④ Concluding Remarks

Study Objectives

To examine the relationship between trade openness and food security in India at the sub-national level.

Does trade influence the consumption behavior by shifting the consumption away from cereal to non-cereal items and from food expenditure to non-food expenditure?

Do trade impact on consumption patterns vary at different income levels?

Table of Contents

- ① Introduction and Role of Trade Openness
- ② Study Objectives
- ③ Model, Data, Construction of Variables**
- ④ Results of the study
- ④ Concluding Remarks

The Panel Smooth Transition Regression (PSTR) model is a non-linear model useful in analysing the non-linear relationship between trade openness and consumption, considering income as a transition variable.

PSTR helps in analysing the regime-switching.

The Panel Smooth Transition Regression

$$C_{it} = \theta_{it} + \beta_1 Z_{it} + \beta_2 Z_{it} \cdot G(q_{it}, \gamma, \phi) + u_{it} \quad (1)$$

- β_1 and β_2 are the parameter vectors of the linear and nonlinear components, respectively.
- θ_1 is a fixed individual effect, and u_{it} is the error term which is independently and identically distributed.
- The transition function $G(q_t, \gamma, \phi)$ is bounded between 0 and 1 and is a continuous function of the observable variable q_{it} (González *et al.*, 2017; Cheikh and Zaied, 2020; Anderl and Maria Caporate, 2023).
- The value of the transition variable q_{it} determines $G(q_{it}, \gamma, \phi)$ and the regression coefficient for $\beta_1 + \beta_2 \cdot G(q_{it}, \gamma, \phi)$ (González *et al.*, 2017).
- γ is the slope parameter, and ϕ is the location or threshold parameter, which determines the threshold value.

- The transition function can be logistic, exponential, or additive. The exponential function changes symmetrically around the threshold parameter ϕ , whereas the logistic function changes monotonically (Anderl and Maria Caporate, 2023).
- GDP per capita is used as the key transition variable. The transition variable can either be an exogenous variable or the lagged values of independent variables.

Data and Construction of variables

- Household-level consumption expenditure data are employed to construct the shares of cereal and non-cereal expenditures within total food expenditure.
- These shares are then aggregated to the district level for the period 2014–2018, covering 193 districts.
- Expenditure shares are deflated using disaggregated Consumer Price Index measures. The CPI for cereals is applied to cereal expenditure, while the CPI for food and beverages is applied to non-cereal expenditure.
- The non-cereal expenditure aggregate is derived by summing expenditures on pulses, edible oils, fruits, vegetables, meat, fish and eggs.
- Retail prices data provides item-level prices across major food groups, including cereals, fruits, vegetables, meat, fish and edible oils.
- Non-cereal prices are constructed as weighted averages using expenditure shares as category-specific weights.

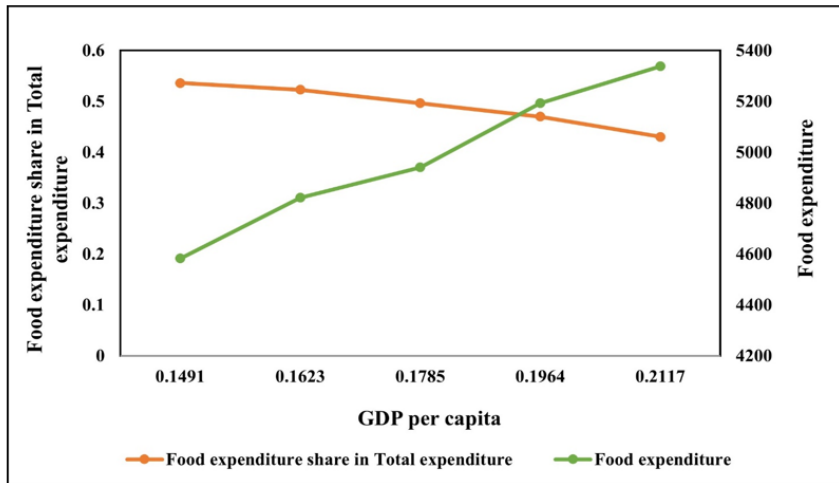
Data Sources

Variables	Data source
Deflated Proportion of Expenditures in Total Food Expenditure	Consumer Pyramids Survey by Centre for Monitoring Indian Economy (CMIE)
GDP – (Constant Prices)	Indicus Analytics
Trade Openness	Directorate General of Commercial Intelligence and Statistics (DGCIS)
Population	2011 Census of India
Retail Prices	Directorate of Economics and Statistics (DES)
Crop Area	International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)
Crop Yield	International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)
CPI	Ministry of Statistics and Programme Implementation (MOSPI)

Table of Contents

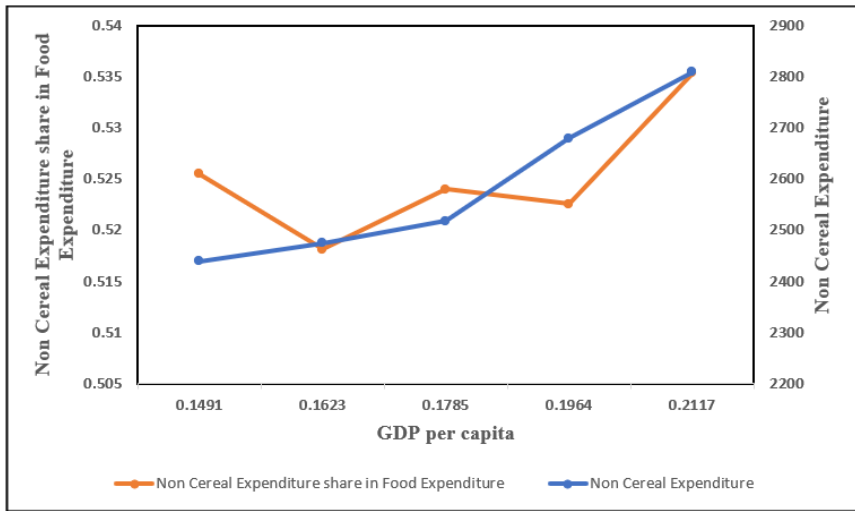
- ① Introduction and Role of Trade Openness
- ② Study Objectives
- ③ Model, Data, and Construction of Variables
- ④ **Results of the study**
- ④ Concluding Remarks

Graphical representation of Engel's law



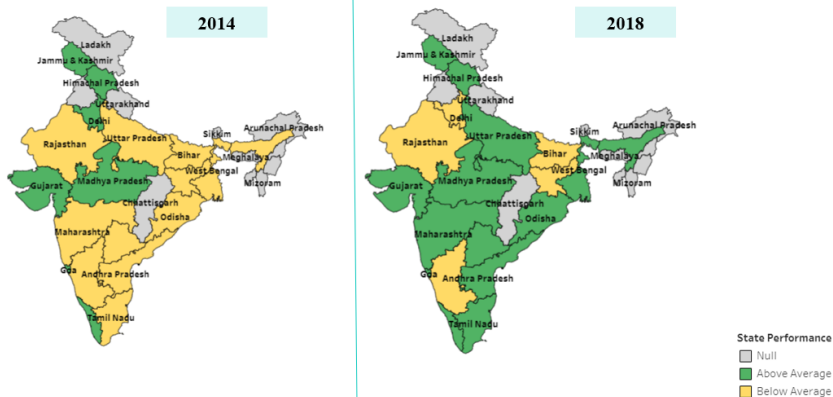
Source: CMIE

Graphical representation of Non-cereal expenditure



Source: CMIE

Non-Cereal expenditure share in Food expenditure



Descriptive statistics I

Variables	Mean (SD)	Description of variables
Food expenditure	0.511 (0.075)	Food expenditure share in total expenditure deflated by CPI of food and beverages
Cereal expenditure	0.228 (0.053)	Cereal expenditure share in food expenditure deflated by CPI of cereals
Non-cereal expenditure	0.525 (0.044)	Non-cereal expenditure share in food expenditure deflated by CPI of food and beverages
Fruits expenditure	0.025 (0.01)	Fruits expenditure share in food expenditure deflated by CPI of fruits
Edible oils expenditure	0.066 (0.018)	Edible oils expenditure share in food expenditure deflated by CPI of Oils and fats
Processed food expenditure	0.434 (0.098)	Processed food expenditure share in food expenditure deflated by CPI of food and beverages
Meat and fish expenditure	0.082 (0.057)	Meat and fish expenditure share in food expenditure deflated by CPI of meat and fish

Descriptive statistics II

Variables	Mean (SD)	Description of variables
Rice yield	2374.0269 (1113.0525)	Rice yield per kg hectare
Wheat yield	1702.8409 (1498.8480)	Wheat yield per kg hectare
Cereal Yield	2805.0391 (959.1951)	Weighted average of rice and wheat yield.
Oilseeds Yield	613.9165 (1467.3847)	Oilseeds yield per kg hectares
Retail prices of cereals	28.3481 (5.1985)	Average prices paid by consumers for cereal food items at district level.
Retail prices of non-cereals	97.3836 (46.7453)	Weighted average prices paid by consumers for non-cereal food items at district level
Retail prices of fruits	68.9297 (23.2462)	Average prices paid by consumers for fruits at district level.
Retail prices of meat and fish	269.7542 (63.9328)	Average prices paid by consumers for meat and fish at district level.
Retail prices of edible oils	146.4876 (26.5716)	Average prices paid by consumers for edible oils at district level.
Trade openness	0.0129 (0.0385)	District level real exports plus imports divided by real GDP
GDP per capita	0.2541 (0.8388)	District level GDP divided by district population.

PSTR Results: Deflated Food Expenditure

Variables	Deflated food expenditure
<i>First regime</i>	
GDP per capita	-23.298*** (0.755)
Trade openness	2.626** (1.284)
<i>Second regime</i>	
GDP per capita	23.266*** (0.755)
Trade openness	-2.643** (1.290)
Threshold	-1.518*** (0.108)
Ingamma	0.779*** (0.132)
Constant	0.016*** (0.0003)
Controls	Yes
<i>Linearity (homogeneity) test</i>	
$b_1=0$	89.89***
$b_1=b_2=0$	87.94***
$b_1=b_2=b_3=0$	84.56***
$b_1=b_2=b_3=b_4=0$	70.75***

Notes: The linearity test is conducted under the null hypothesis that the relationship is linear and the coefficients are homogeneous across all cross-sectional units and over time (chi-square values are reported).

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

PSTR Results: Deflated Cereal Expenditure

Variables	Deflated cereal expenditure	
	<i>First regime</i>	
GDP per capita	0.067*	(0.035)
Trade openness	0.009*	(0.005)
	<i>Second regime</i>	
GDP per capita	-0.066**	(0.033)
Trade openness	-0.013*	(0.007)
Threshold	0.047***	(0.015)
Ingamma	3.796***	(0.221)
Constant	0.001***	(0.00004)
Controls	Yes	
	<i>Linearity (homogeneity) test</i>	
$b_1=0$	8.32***	
$b_1=b_2=0$	6.61***	
$b_1=b_2=b_3=0$	4.73***	
$b_1=b_2=b_3=b_4=0$	5.34***	

Notes: The linearity test is conducted under the null hypothesis that the relationship is linear and the coefficients are homogeneous across all cross-sectional units and over time (chi-square values are reported).

*** p < 0.01, ** p < 0.05, * p < 0.10.

PSTR Results: Deflated Non-cereal Expenditure

Variables	Deflated non-cereal expenditure	
	<i>First regime</i>	
GDP per capita	-5.672***	(0.542)
Trade openness	-1.488**	(0.636)
	<i>Second regime</i>	
GDP per capita	5.653***	(0.542)
Trade openness	1.505**	(0.643)
Threshold	-0.569***	(0.078)
lngamma	1.984***	(0.110)
Constant	0.009***	(0.0002)
Controls	Yes	
	<i>Linearity (homogeneity) test</i>	
$b_1=0$	37.84***	
$b_1=b_2=0$	33.08***	
$b_1=b_2=b_3=0$	27.38***	
$b_1=b_2=b_3=b_4=0$	21.99***	

Notes: The linearity test is conducted under the null hypothesis that the relationship is linear and the coefficients are homogeneous across all cross-sectional units and over time (chi-square values are reported).

*** p < 0.01, ** p < 0.05, * p < 0.10.

PSTR Results: Deflated Edible Oil Expenditure

Variables	Deflated edible oil expenditure	
	<i>First regime</i>	
GDP per capita	-0.011***	(0.004)
Trade openness	-0.005	(0.005)
	<i>Second regime</i>	
GDP per capita	0.009**	(0.004)
Trade openness	0.033**	(0.014)
Threshold	-0.050	(0.110)
Ingamma	2.339***	(0.567)
Constant	0.002***	(0.0001)
Controls	Yes	
	<i>Linearity (homogeneity) test</i>	
$b_1=0$	8.64***	
$b_1=b_2=0$	9.61***	
$b_1=b_2=b_3=0$	7.23***	
$b_1=b_2=b_3=b_4=0$	5.79***	

Notes: The linearity test is conducted under the null hypothesis that the relationship is linear and the coefficients are homogeneous across all cross-sectional units and over time (chi-square values are reported).

** p < 0.01, ** p < 0.05, * p < 0.10.

PSTR Results: Deflated Fruits Expenditure

Variables	Deflated fruits expenditure
<i>First regime</i>	
GDP per capita	-0.001*** (0.000)
Trade openness	-0.009* (0.006)
<i>Second regime</i>	
GDP per capita	0.001*** (0.0002)
Trade openness	0.143 (0.106)
Threshold	0.428*** (0.125)
Ingamma	-0.720 (0.634)
Constant	0.001*** (0.00003)
Controls	Yes
<i>Linearity (homogeneity) test</i>	
$b_1=0$	20.13***
$b_1=b_2=0$	13.55***
$b_1=b_2=b_3=0$	10.66***
$b_1=b_2=b_3=b_4=0$	8.80***

Notes: The linearity test is conducted under the null hypothesis that the relationship is linear and the coefficients are homogeneous across all cross-sectional units and over time (chi-square values are reported).

*** p < 0.01, ** p < 0.05, * p < 0.10.

PSTR Results: Deflated Processed Food Expenditure

Variables	Deflated processed food expenditure	
	<i>First regime</i>	
GDP per capita	-8.2682***	(0.4990)
Trade openness	-1.9333*	(0.8689)
	<i>Second regime</i>	
GDP per capita	8.2443***	(0.4990)
Trade openness	1.9620**	(0.8772)
Threshold	-0.6615***	(0.0901)
Ingamma	1.8832**	(0.1145)
Constant	0.0062***	(0.0001)
Controls	Yes	
	<i>Linearity (homogeneity) test</i>	
$b_1=0$	84.83***	
$b_1=b_2=0$	65.34***	
$b_1=b_2=b_3=0$	54.92***	
$b_1=b_2=b_3=b_4=0$	45.31***	

Notes: The linearity test is conducted under the null hypothesis that the relationship is linear and the coefficients are homogeneous across all cross-sectional units and over time (chi-square values are reported).

*** p < 0.01, ** p < 0.05, * p < 0.10.

PSTR Results: Deflated Meat and Fish Expenditure

Variables	Deflated meat and fish expenditure	
	<i>First regime</i>	
GDP per capita		-0.0015 (0.0027)
Trade openness		-0.0542*** (0.0141)
	<i>Second regime</i>	
GDP per capita		0.0057** (0.0026)
Trade openness		0.0501*** (0.0143)
Threshold		0.0417*** (0.0011)
Ingamma		6.0989*** (0.2392)
Constant		0.0027*** (0.0002)
Controls		Yes
	<i>Linearity (homogeneity) test</i>	
$b_1=0$		10.39***
$b_1=b_2=0$		6.41***
$b_1=b_2=b_3=0$		4.99***
$b_1=b_2=b_3=b_4=0$		4.30***

Notes: The linearity test is conducted under the null hypothesis that the relationship is linear and the coefficients are homogeneous across all cross-sectional units and over time (chi-square values are reported).

*** p < 0.01, ** p < 0.05, * p < 0.10.

Key Findings

- Dependent Variable: Analysing consumption expenditure shares for various food categories, including non-cereal, cereal, total food, edible oil, meat, fish, fruits and processed food.
- Linearity (homogeneity) tests strongly reject the null hypothesis of a linear and homogeneous specification, confirming the presence of statistically significant nonlinearities and justifying the use of the Panel Smooth Transition Regression (PSTR) framework.
- PSTR results reveal threshold effects, with consumption patterns differing systematically across income regimes.
- Rising income levels are associated with a shift from starchy staples to animal-based and other high-value foods, providing strong support for the nutrition transition hypothesis.
- Relative food prices significantly influence consumption behaviour, with price changes driving reallocations in household food expenditure across food groups.

Key Findings

- Trade openness is positively associated with meat and fish consumption expenditure, while exerting a negative effect on cereal consumption, indicating substitution toward higher-value food items.
- Trade openness also increases expenditure on processed food products, reflecting greater availability, variety, and consumer preference for convenience-oriented, high-value items.
- Expenditure on edible oils rises with both income growth and trade openness, highlighting their role as key complementary inputs in preparing higher-value and animal-based foods.

Table of Contents

- ① Introduction and Role of Trade Openness
- ② Study Objectives
- ③ Model, Data, and Construction of Variables
- ④ Results of the study
- ④ **Concluding Remarks**

Conclusion

- Trade liberalization has increased competition in India's agricultural markets, deepening the integration with global markets.
- The study provides a detailed assessment of how trade openness shapes the consumption patterns of different food items.
- Trade openness raises consumption expenditure shares for non-cereals, edible oils, meat, fish, with cereals being the main exception.
- Per capita income and relative prices are the key drivers of changes in food consumption, alongside trade openness, as income growth and price shifts significantly alter consumption patterns.
- Rising incomes and trade openness are shifting diets away from starchy, plant-based staples to higher consumption of animal-based products and high-value foods.

Thank You