Regional Trade Agreements and India's Trade Efficiency: Evidence from a Stochastic Frontier Gravity Model

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Abstract: *This study examines the determinants and potential of India's exports using an augmented gravity model within a stochastic frontier framework. Using panel data for India's major trading partners and SAARC countries over 2000–2018, the study estimates conventional gravity and stochastic frontier models to analyze bilateral export performance and technical efficiency. The results show that partner-country GDP and population positively influence India's agricultural exports, while geographical distance acts as a major trade barrier. SAFTA and AFTA significantly enhance exports, whereas favorable exchange rate movements improve export competitiveness. The stochastic frontier estimates reveal significant export inefficiency, indicating considerable unrealized trade potential. Technical efficiency varies across trading partners, with higher efficiency observed in developed and ASEAN markets than in neighboring South Asian economies. Although export efficiency improved modestly after 2010, substantial untapped export potential remains. The findings highlight the need to strengthen trade facilitation, improve logistics infrastructure, reduce non-tariff barriers, and enhance the implementation of regional trade agreements to realize India's export potential.*

Keywords: Gravity Model, Stochastic Frontier Analysis, Export Efficiency, Trade Potential, Regional Trade Agreements.

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Introduction

International trade has become one of the principal drivers of economic growth in the modern global economy. Beyond the traditional notion of comparative advantage, contemporary trade increasingly reflects the influence of economic integration, global value chains, institutional quality, and regional cooperation (Krugman, 1994). By enabling countries to specialize, expand markets, exploit economies of scale, and facilitate technology transfer, international trade contributes significantly to productivity and economic development. Consequently, Regional Trade Agreements (RTAs) and Free Trade Agreements (FTAs) have emerged as important instruments for promoting trade liberalization and strengthening economic integration. Empirical evidence suggests that Economic Integration Agreements (EIAs) increase bilateral trade substantially, with trade among member countries rising by nearly 50 percent following their implementation (Kohl, 2014).

Following the economic reforms of 1991, India progressively integrated with the global economy through trade liberalization, leading to a significant expansion in its international trade. Despite this progress, India's share in global merchandise trade remains modest relative to the size of its economy, and considerable variation exists in its trade performance across partner countries, indicating that substantial export potential remains unrealized. To strengthen its integration into regional and global markets, India actively pursued a series of regional and bilateral trade agreements during the last two decades. Major initiatives include SAFTA, the ASEAN–India Free Trade Agreement, and comprehensive agreements with Singapore, Japan, South Korea and Malaysia, along with preferential trade agreements with Chile and MERCOSUR. These agreements reduced trade barriers, improved market access and deepened economic cooperation.

The implementation of the South Asian Free Trade Area (SAFTA) in 2006 marked a formal step toward strengthening regional trade integration within the SAARC framework through phased tariff reductions and differentiated commitments for least developed member states. The ASEAN–India Free Trade Agreement (2010 for goods; 2015 for services) significantly expanded India’s access to Southeast Asian markets and facilitated its integration into regional production networks. At the bilateral level, comprehensive agreements such as the India–Singapore CECA (2005)**,** India–South Korea CEPA (2010)**,** India–Japan CEPA (2011)**,** and India–Malaysia CECA (2011) broadened cooperation beyond goods to include services, investment, and professional mobility, thereby diversifying India’s export destinations and attracting foreign investment. Preferential agreements with Chile (2006) and MERCOSUR (2009) further extended India’s trade outreach to Latin America.

Collectively, these pacts strengthened India’s trade architecture, reduced tariff barriers, diversified export markets, and supported its gradual integration into regional and global trade frameworks. Although SAFTA aimed to stimulate intraregional trade by lowering formal trade barriers, South Asia continues to display relatively low levels of regional integration compared to other trade blocs. This suggests that structural bottlenecks, non-tariff barriers, and limited economic complementarities may constrain the full realization of trade potential. In this context, evaluating India’s trade performance with SAFTA members is crucial for understanding the extent to which regional trade agreements translate into effective export expansion.

Nevertheless, their effectiveness depends not only on tariff liberalization but also on trade facilitation, institutional quality, logistics, infrastructure and regulatory harmonization. Consequently, reductions in formal trade barriers do not necessarily translate into the full realization of trade potential. Despite sustained liberalization efforts, South Asia continues to exhibit one of the lowest levels of intra-regional trade among major regional blocs. Persistent non-tariff barriers, weak transport connectivity, institutional bottlenecks and limited economic complementarities continue to constrain regional trade.

Although the gravity model has been widely employed to analyze bilateral trade flows, relatively few studies have examined India's trade potential by explicitly incorporating FTAs within a stochastic frontier gravity framework. Existing studies primarily estimate the average trade effects of FTAs, with limited attention to measuring unrealized trade potential and export efficiency.

Against this backdrop, the present study estimates India's trade potential using an augmented stochastic frontier gravity model that explicitly incorporates FTAs as a key determinant of bilateral trade.

Literature Review

Trade openness has been widely recognized as an important determinant of economic growth and convergence. Earlier studies demonstrate that greater openness accelerates income convergence by promoting specialization, efficient resource allocation, and technology diffusion (Dowrick & Golley, 2004; Giles & Stroomer, 2006). Similarly, Keho (2017) argues that trade openness stimulates long-run economic growth through improvements in productivity and market efficiency. These findings have encouraged countries to adopt regional and bilateral trade agreements as instruments for deepening economic integration. In the Indian context, bilateral Free Trade Agreements (FTAs) and the ASEAN–India agreement have been found to improve export and import efficiency (Kumar & Prabhakar, 2017), although Ganesh-Kumar and Chatterjee (2016) emphasize that preferential agreements should complement broader multilateral trade liberalization.

The literature on South Asian integration presents mixed evidence regarding the effectiveness of regional trade agreements. Rahman et al. (2006) report that SAFTA increased intra-regional exports but generated uneven benefits across member countries. Taneja et al. (2013) identify India as the principal driver of regional integration while noting that institutional weaknesses and trade barriers continue to constrain regional trade.

The gravity model has become the standard empirical framework for analyzing bilateral trade flows and estimating trade potential. Stack and Pentecost (2011) identify substantial unrealized trade opportunities, while Ravishankar and Stack (2014) show that incorporating institutional quality and non-tariff barriers significantly improves gravity model performance.

Karemera et al. (1999) demonstrate that the gains from regional integration vary across commodities, emphasizing the importance of sector-specific trade policies. A major methodological advancement was introduced by Kalirajan (2007), who integrated stochastic frontier analysis with the gravity model to distinguish trade inefficiency from random shocks. Applying this framework, Kalirajan and Singh (2008) show that China's export success is largely attributable to institutional reforms, whereas India's export performance continues to be constrained by persistent structural inefficiencies.

Several studies have applied gravity-based models to South Asian trade. Akhter and Ghani (2010) find evidence of both trade creation and trade diversion within SAARC, while Ekanayake et al. (2010) conclude that the effectiveness of Asian regional trade agreements depends on complementary domestic policy reforms. Using a stochastic frontier gravity model, Bhattacharya and Das (2014) estimate significant unrealized trade potential within SAARC and emphasize the importance of improving infrastructure, reducing bureaucratic inefficiencies, and strengthening trade facilitation. Earlier work by Nath Bhattacharya (2011) similarly identifies structural and institutional constraints as major impediments to regional integration.

Overall, the literature establishes that trade agreements generally promote bilateral trade and regional integration; however, their effectiveness depends critically on institutional quality and trade facilitation. While gravity models have been extensively employed to analyse bilateral trade flows, relatively few studies have used the stochastic frontier gravity framework to examine India's trade potential while explicitly incorporating the role of FTAs. The present study addresses this gap by employing an augmented stochastic frontier gravity model to estimate India's trade potential and evaluate the contribution of FTAs to export efficiency and trade potential.

Data sources

The data used for this study has been extracted from the UNCOMTRADE database from the year 2002 to 2018 for SAARC countries and other 25 major trading partners of India. Data on GDP, exchange rate and population has been taken from the WDI, world bank database. The data on other gravity variables like Language, border and distance has been extracted from CEPPI data base. The complete description and expected sign of variable is listed in table 1.

Table 1: Data Description

Variable	Symbol	Description	Expected Sign	Source
Exports		Total Exports of country *i* to country *j*		WITS
GDP partner	LnGDPj	Gross domestic product of importing Country (j)	+	WDI
Population	Lnpop	Population of a partner country	+	WDI

Distance	LnDis	Distance between country *i* and *j*; measured using the great circle method which takes into account the distance between the most populated cities of each country	_	CEPII
Common language	comlang_off	Common ethnic language between the trading countries; Dummy Variable takes value 1 if the countries have a common ethnic language otherwise zero	+	CEPII
Common border	Contig	Common Border highlights the contiguity or adjacency between the trading countries; Dummy Variable takes value 1 if the countries share a common border otherwise zero	+	CEPII
Exchange rate	Lnbechr	Bilateral nominal exchange rate between two countries expressed as domestic per dollar	+	IMF
ASEAN free trade agreement	Aftaij	Free Trade Agreement among ASEAN countries (AFTA); Dummy Variable takes value 1 if the two nations are signatories of ASEAN FTA otherwise zero.	+/-	WTO
South Asian free trade agreement	SAFTAij	Free Trade Agreement among South Asian countries (SAFTA); Dummy Variable takes value 1 if the two nations are signatories of South Asian FTA otherwise zero	+/-	WTO

Source: Author’s own compilation.

Empirical Framework

The gravity model has emerged as the most widely applied framework for analyzing bilateral trade flows because of its strong theoretical foundations and robust empirical performance. Inspired by Newton's law of gravitation, Tinbergen proposed that trade between two countries is positively related to their economic size and negatively related to the distance separating them. Larger economies possess greater production capacity and market demand, while geographical distance captures transportation, communication and other transaction costs. Subsequent contributions by Anderson (1979), Bergstrand (1985), Eaton and Kortum (2002), and Anderson and Van Wincoop (2003) established the gravity model as a theoretically consistent general equilibrium framework. In addition to GDP and distance, modern gravity models incorporate multilateral resistance terms and other bilateral characteristics such as common language, common borders and regional trade agreements.

Although the conventional gravity model successfully explains average trade flows, it assumes that deviations between observed and predicted trade arise solely from random disturbances. Such an assumption is restrictive because countries often export below their potential owing to institutional weaknesses, inadequate infrastructure, customs inefficiencies, policy rigidities and governance-related constraints. These behind-the-border barriers are systematic rather than random and therefore cannot be adequately isolated within the conventional gravity framework. Consequently, ordinary least squares estimation cannot distinguish between random shocks and persistent trade inefficiency, limiting its usefulness for estimating unrealized export potential.

To overcome these limitations, the present study employs the Stochastic Frontier Gravity Model (SFGM), which combines the traditional gravity model with the stochastic frontier approach developed by Aigner, Lovell and Schmidt (1977) and Meeusen and Van den Broeck (1977). Unlike the conventional gravity model, the stochastic frontier approach estimates the maximum attainable level of bilateral trade (the trade frontier) and measures the gap between observed and potential exports. This gap represents inefficiency attributable to domestic structural and institutional constraints.

In the stochastic frontier model, the composite error term is decomposed into a symmetric random component (v) and a one-sided inefficiency component (u). The random error captures measurement errors and exogenous shocks beyond policy control, whereas the non-negative inefficiency term captures domestic trade barriers that prevent exports from reaching their potential. This decomposition enables the separation of pure statistical noise from systematic trade inefficiency.

Accordingly, the empirical specification augments the conventional gravity equation by incorporating the stochastic frontier error structure. Bilateral exports are modelled as a function of GDP, population, geographical distance and a vector of additional gravity variables including common language, regional trade agreements, exchange rates, trade freedom and other bilateral characteristics. GDP is expected to influence exports positively, while distance is expected to reduce trade because of higher transport and transaction costs. Variables facilitating economic integration are expected to exert positive effects on bilateral exports.

An important advantage of the stochastic frontier approach is that it permits estimation of export efficiency. Technical efficiency is measured as the ratio of observed exports to the stochastic frontier and ranges between zero and one. A value of one indicates that exports have fully realized their potential, whereas lower values indicate unrealized trade opportunities arising from behind-the-border constraints. Potential exports can therefore be obtained by comparing observed exports with the estimated efficiency scores.

The stochastic frontier framework also provides important diagnostic measures. The gamma parameter indicates the proportion of total variation attributable to inefficiency rather than random shocks. Higher values of gamma imply that deviations from potential exports are primarily due to domestic institutional constraints.

The panel version of the empirical model is therefore as follows:

$$LnX_{ijt} = \beta_0 + \beta_1 LnY_{it} + \beta_2 LnY_{jt} + \beta_3 Lnd_{ij} + \beta_4 Z_{it} + \beta_5 CP_{ij} + \beta_6 Y_{rt} + \beta_7 \pi_{it} + \beta_8 P_{jt} + V_{ijt} - U_{ijt} \quad (1)$$

where U_{ijt} is a single sided error for combined effects of economic distance or 'behind-the-border' constraints and, $U_{ijt} \sim i.i.d\ N^{+}(0, \sigma_u^2)$ with a half normal distribution truncated at 0, or, $U_{ijt} \sim i.i.d\ N^{+}(\mu_{ij}, \sigma_u^2)$ a truncated normal distribution. V_{ijt} is a double-sided error term capturing measurement errors and omitted implicit 'beyond the border' variables randomly distributed across observations and, $V_{ijt} \sim i.i.d\ N^{+}(0, \sigma_v^2)$.

$$TE_{X_{ij}} = \frac{actual\ X_{ij}}{potential\ X_{ij}} = \text{export performance (achieved export efficiency)} \quad (2)$$

$$TE_{X_{ij}} = \frac{f(\beta X_{it}).\exp(V_{ijt} - U_{ijt})}{f(\beta X_{it}).\exp(V_{ijt})} = \exp(-U_{ijt}) \quad (3)$$

[Following the Jondrow (1982) specifications].

$$Ln(X_{ijt}) = \beta_0 + \beta_1 Ln(GDP_{jt}) + \beta_2 Ln(pop_{jt}) - \beta_3 Ln(Dist_{ij}) + \beta_4 comlang_{ij} + \beta_5 contig_{ij} + \beta_6 Ln(RER_{ijt}) + ASEAN_{ij} + SAFTA_{ij} + V_{ijt} - U_{ijt} \quad (4)$$

The dependent variable X_{ijt} represents India's export flows to partner country j, expressed in million US dollars. The model excludes the domestic GDP due to the exclusive focus on India's export performance. The explanatory variables include importer-specific economic size indicators, namely partner country (GDP_{jt}) and population (pop_{jt}), to capture demand-side effects. In addition, standard bilateral controls such as common official language ($comlang_{ij}$), shared borders ($contig_{ij}$), and geographical distance ($Dist_{ij}$) are incorporated. while bilateral time-varying variables such as the real exchange rate (RER_{ijt}) and participation in regional trade agreements ($ASEAN_{ij}\ and\ SAFTA_{ij}$) capture evolving country-pair dynamics. The population variable serves as an additional proxy for market size effects in the importing economy.

The panel stochastic frontier literature provides several approaches for estimating equation (4), which differ primarily in whether inefficiency is assumed to be time-invariant or time-varying. The earliest panel stochastic frontier models assume time-invariant inefficiency, including the fixed-effects model of Pitt and Lee (1981) and the specification of Battese and Coelli (1988). Prominent time-varying stochastic frontier models include the time-decay model (bc92) of Battese and Coelli (1992) and the neutral technical inefficiency effects model (bc95) developed by Battese and Coelli (1995) and Greene's (2005) 'true random effects' (TRE) approach. In these models, the stochastic frontier structure of equation (5) is retained, while inefficiency is specified as an individual-specific component that remains constant or varying over time as per equation listed from equation (5) to (8) .

$$y_{it} = \propto + \beta X_{it} + V_{ijt} - U_i \quad (5)$$

$$y_{it} = \propto + \beta_i X_{it} + V_{ijt} - U_i \quad (6)$$
$$U_{it} = u_i \beta(t) \quad (7)$$
$$\beta(t) = \exp(-\eta(\tau - T) \quad (8)$$

Identification of the inefficiency component requires a distributional assumption; therefore, these models are estimated using maximum likelihood estimation (MLE). In the log-linear specification, the coefficients of the log-transformed variables are interpreted as trade elasticities with respect to the corresponding explanatory variables. The estimated parameters β_i, λ, θ and the various variance measures σ_u , σ_v , σ^2 where $\sigma^2 = \sigma_v^2 + \sigma_u^2$, $\lambda = \sigma_u^2 / \sigma_v^2$ and η, captures the time path of efficiency. A statistically significant λ indicates the presence of a stochastic frontier, implying that the one-sided error term u_i dominates the symmetric error v_i, and that deviations from the frontier primarily reflect technical inefficiency. In the TRE model, θ measures the standard deviation of the random effects; if $\theta > \sigma_u$, random effects dominate the inefficiency component. Model performance is evaluated using multiple criteria to assess the strengths and limitations of each specification.

Consistent with standard stochastic frontier practice, the presence of inefficiency effects is first examined using the generalized likelihood-ratio (LR) test. The test compares the conventional OLS model with the Battese and Coelli (1992) stochastic frontier specification to assess the suitability of the stochastic frontier approach. The rejection of the null hypothesis confirms that the stochastic frontier model is preferred over the conventional regression model, supporting the inclusion of a one-sided inefficiency term alongside the random error component. Moreover, the estimated lambda (λ), which measures the relative contribution of inefficiency to the composite error term, is positive and statistically significant, providing further evidence of technical inefficiency in the data. Following confirmation of inefficiency effects, the most appropriate stochastic frontier specification among the vaious models is selected using the generalized likelihood-ratio (LR) test.

Results and Discussion

Table 2 reports the estimates of the log-linear gravity model using the conventional OLS estimator and five stochastic frontier specifications (PL81, BC88, BC92, BC95, and TRE). The frontier-specific parameters strongly support the use of the stochastic frontier approach. The likelihood ratio (LR) test rejects the null hypothesis of no trade inefficiency, confirming that the frontier models provide a better representation of India's agricultural exports than the conventional gravity model. Consistent with this finding, the estimated values of λ are positive and statistically significant across all specifications, indicating that a substantial share of the unexplained variation in bilateral exports is attributable to trade inefficiency rather than random shocks. Moreover, the positive and significant estimate of η in the BC92 model suggests a gradual decline in inefficiency over the sample period, implying that India's agricultural exports have moved closer to their potential frontier over time.

The estimated gravity coefficients are broadly consistent across alternative specifications. Partner-country GDP and population exert positive effects on India's agricultural exports, highlighting the importance of market size in driving export demand. By contrast, distance remains a significant impediment to trade, reflecting the persistent influence of transport costs and other trade-related frictions. The negative coefficient on contiguity is negative and significant in most specifications, indicating that sharing a common border does not promote exports. The bilateral exchange rate contributes positively to export performance in the frontier models, indicating improved export competitiveness after controlling for inefficiency. In contrast, a common official language has only a limited influence, becoming significant only in the TRE specification after accounting for unobserved country-specific heterogeneity. The coefficients of the regional trade agreement dummies further indicate that both SAFTA and AFTA have enhanced India's agricultural exports by improving market access and facilitating regional integration.

a. Technical Efficiency Estimates: bc95 and tre Models (2000–2018)

Table 3 reports the technical efficiency (TE) estimates of India's exports obtained from the BC95 and True Random Effects (TRE) stochastic frontier models. Before interpreting the efficiency scores, the preferred model specification is evaluated using a sequence of likelihood ratio (LR) tests. The LR test rejects the null hypothesis of no trade inefficiency, confirming the suitability of the stochastic frontier framework over the conventional OLS model. These results justify the use of frontier-based efficiency measures for assessing India's export performance.

Table 2: Estimation Results

	(ols)	(pl81)	(bc88)	(bc92)	(bc95)	(tre)
LnGDP	1.018*	1.087*	1.103*	0.540*	0.547*	1.130*
	(0.04)	(0.05)	(0.05)	(0.06)	(0.07)	(0.03)
LnPop	0.741*	1.028*	0.994*	0.444*	0.395*	0.642*
	(0.05)	(0.10)	(0.09)	(0.06)	(0.05)	(0.02)
Contig	-3.099*	-4.214*	-3.713*	-0.772	-1.594*	-3.540*
	(0.75)	(0.60)	(1.64)	(0.94)	(0.58)	(0.19)
comlang_off	-0.443	-0.530	-0.812	-0.192	-0.125	0.317*
	(0.48)	(0.71)	(1.01)	(0.49)	(0.47)	(0.12)
LnDis	-3.107*	-5.848*	-3.887*	-1.101**	-1.310*	-3.570*
	(0.42)	(0.57)	(0.82)	(0.56)	(0.47)	(0.15)
Aftaij	0.372**	0.291**	0.281**	0.146**	0.620**	0.242*
	(0.08)	(0.08)	(0.08)	(0.07)	(0.25)	(0.07)
Saftaij	0.524*	0.386*	0.368*	0.273*	1.407*	0.266*
	(0.10)	(0.10)	(0.10)	(0.09)	(0.28)	(0.09)
Lnbechr	0.206*	0.095	0.106	0.051	0.213*	0.239*
	(0.06)	(0.09)	(0.08)	(0.06)	(0.06)	(0.02)
Constant	-6.328*	13.947*	-0.284	15.122	-3.303	-2.753*
	(3.36)	(4.15)	(6.81)	(24.58)	(3.14)	(0.88)
Lambda(λ)	-	11.56*	-		6.92*	2.01*
		(0.805)			(.901)	(0.781)

Sigma U	-	5.07*	-		3.3*	.67*
		(0.807)			(0.60)	(0.53)
Sigma V	-	0.439*	-		.129*	0.412*
		(0.013)			(0.28)	(0.32)
Theta(Θ)	-					1.903*
Eta(η)				0.031		
				(0.00)		
LR test of inefficiency				1039.03	342.05	360.21
LR test of Model comparison					696***	18.1***
Observations	627	627	627	627	627	627

Standard errors in parentheses
*** p<.10, ** p<.05, * p<.01
Source: Author’s own calculations.

The efficiency estimates reveal considerable differences between the BC95 and TRE specifications. Under the BC95 model, technical efficiency remains constant at 0.82 across all trading partners, implying that India's agricultural exports operate, on average, at 82% of the estimated export frontier, leaving an inefficiency gap of approximately 18%. The absence of cross-country variation reflects the restrictive assumption of a common time-varying inefficiency process and therefore provides only an aggregate measure of export performance.

By contrast, the TRE model uncovers substantial heterogeneity in bilateral export efficiency. Average technical efficiency declines to 0.62, indicating that India realizes only 62% of its potential agricultural exports, while approximately 38% remains unrealized. The wider dispersion of efficiency scores suggests that controlling for unobserved country-specific heterogeneity yields a more realistic assessment of export performance than the BC95 specification.

The country-level estimates further demonstrate pronounced differences in India's export performance across destination markets. Export efficiency is highest for Brunei Darussalam, Australia, Japan, Thailand, Germany, Canada, Italy, the United Arab Emirates, and the United States, where exports operate relatively close to the estimated frontier. In contrast, Bhutan, Nepal, Bangladesh and China record persistently low efficiency scores, indicating substantial unrealized export potential despite geographical proximity. These findings suggest that institutional constraints, non-tariff barriers, inadequate trade facilitation, and infrastructure bottlenecks continue to limit India's export performance with neighboring economies.

b. Pre- and Post-FTA Analysis

To assess the impact of regional trade agreements, the sample was divided into the pre-FTA (2000–2009) and post-FTA (2010–2018) periods. The TRE estimates indicate a modest improvement in average technical efficiency from 0.59 to 0.64, suggesting that India’s exports moved closer to their potential frontier following the implementation of FTAs. The improvement was more pronounced for developed and ASEAN partners, whereas several SAFTA members, including Bangladesh, Nepal, Bhutan, and Pakistan, continued to exhibit relatively low efficiency levels.

These findings suggest that while regional trade agreements have enhanced market access and contributed to export growth, their benefits have been uneven across partner countries. The persistently low efficiency within South Asia indicates that tariff liberalization alone is insufficient to realize the full gains from regional integration. Addressing non-tariff barriers, inadequate border infrastructure, weak trade facilitation, and logistical constraints remains essential for improving India's export efficiency and fully exploiting the potential of SAFTA.

Conclusion

This study employed a stochastic frontier gravity model to examine the determinants and export potential of India's exports. The findings show that partner-country market size is the principal driver of exports, while geographical distance remains a significant barrier to trade. Regional trade agreements, particularly SAFTA and AFTA, have contributed positively to export performance by improving market access, whereas exchange rate movements enhance export competitiveness.

The stochastic frontier estimates confirm the presence of significant export inefficiency, indicating considerable unrealized export potential. Technical efficiency varies substantially across trading partners, with relatively high efficiency observed in developed and ASEAN markets, but persistently low efficiency in several neighboring South Asian economies. The pre- and post-FTA analysis further suggests a modest improvement in export efficiency after 2010, although significant inefficiencies continue to constrain India's exports.

Overall, the results suggest that while regional trade agreements have strengthened India's export performance, realizing its full export potential requires more effective implementation of these agreements alongside improvements in trade facilitation, logistics, customs procedures, and the reduction of non-tariff barriers. Addressing these structural constraints will be crucial for narrowing the gap between actual and potential exports and sustaining long-term growth in India's agricultural exports.

Table 3: Efficiency Scores

	2000-2018		**2000-2009**		**2010-2018**	
	bc95	**tre**	**bc95**	**tre**	**bc95**	**tre**
Australia	0.82	0.77	0.82	0.74	0.82	0.79
Bangladesh	0.82	0.10	0.82	0.10	0.82	0.09
Bhutan	0.82	0.00	0.82	0.00	0.82	0.00
Brazil	0.82	0.65	0.82	0.55	0.82	0.75
Brunei Darussalam	0.82	0.93	0.82	0.90	0.82	0.95
Cambodia	0.82	0.67	0.82	0.66	0.82	0.68

Canada	0.82	0.73	0.82	0.72	0.82	0.75
China	0.82	0.21	0.82	0.26	0.82	0.14
France	0.82	0.69	0.82	0.60	0.82	0.78
Germany	0.82	0.73	0.82	0.66	0.82	0.79
Indonesia	0.82	0.68	0.82	0.72	0.82	0.62
Iran	0.82	0.67	0.82	0.59	0.82	0.76
Italy	0.82	0.73	0.82	0.67	0.82	0.79
Japan	0.82	0.75	0.82	0.70	0.82	0.81
Lao People's Dem. Rep.	0.82	0.64	0.82	0.62	0.82	0.65
Malaysia	0.82	0.72	0.82	0.72	0.82	0.71
Maldives	0.82	0.59	0.82	0.67	0.82	0.49
Mexico	0.82	0.49	0.82	0.28	0.82	0.73
Nepal	0.82	0.04	0.82	0.02	0.82	0.06
Netherlands	0.82	0.58	0.82	0.45	0.82	0.73
Pakistan	0.82	0.58	0.82	0.55	0.82	0.62
Philippines	0.82	0.76	0.82	0.80	0.82	0.72
Qatar	0.82	0.62	0.82	0.78	0.82	0.44
Russian Federation	0.82	0.71	0.82	0.70	0.82	0.71
Saudi Arabia	0.82	0.71	0.82	0.69	0.82	0.73
Singapore	0.82	0.66	0.82	0.69	0.82	0.63
South Africa	0.82	0.69	0.82	0.57	0.82	0.82
Sri Lanka	0.82	0.67	0.82	0.70	0.82	0.63
Thailand	0.82	0.74	0.82	0.75	0.82	0.73
United Arab Emirates	0.82	0.73	0.82	0.66	0.82	0.80
United Kingdom	0.82	0.68	0.82	0.69	0.82	0.67
USA	0.82	0.71	0.82	0.65	0.82	0.78
Viet Nam	0.82	0.69	0.82	0.62	0.82	0.77
Average	**0.82**	**0.62**	**0.82**	**0.59**	**0.82**	**0.64**

Source: Author’s own calculations.

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