Research Article:

ESTIMATION OF MAIZE IMPORT DEMAND FUNCTION IN NEPAL: AN ARDL-ECM APPROACH

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ABSTRACT

This study examined the long-run and short-run determinants of maize import behavior in Nepal, where maize is the second most imported cereal after rice. An error correction version of Autoregressive Distributed Lag (ARDL) model was employed using 28 years of time series data (1997-2024) collected from secondary sources. The stationarity of variables was tested using Augmented Dickey-Fuller (ADF) test, Phillips-Perron (PP) and Kwiatkoski-Phillips-Schmidt-Shin (KPSS) tests, confirming integration at either I (0) or I (1). The Bounds test verified the existence of long-run relationships among the variables (F=11.18, p<0.01). The error correction term (ECT_{t-1}=-1.038) was negative and significant (p=0.0012), indicating rapid adjustment toward long-run equilibrium. The results revealed that remittance inflow (p<0.1), import price of substitute commodity rice (p<0.05) and consumer price inflation (p<0.01) significantly influenced maize imports in long-run, all exhibiting positive relationships. In the short-run, remittance inflow (p<0.01), price of substitute goods (p<0.1) and consumer price inflation (p<0.05) affected maize imports. However, unlike the long-run effect, increased remittance inflows were associated with a decrease in maize imports in the short-run, suggesting a temporary shift in consumer preference towards other commodities. Diagnostic tests confirm normality (Jerque-Bera Statistic X^2=0.346, p>0.05 & Shapiro-wilk statistic w=0.975, p>0.05), absence of autocorrelation (Breusch-Godfrey LM=3.378, p>0.05) and heteroskedasticity (Studentized Bruesch-pagan BP= 17.198, p>0.05), and no model misspecification (D'Agostino skewness test statistic=2.267, z=0.658, p>0.05); thereby validating the robustness and reliability of model. The findings emphasize strengthening domestic maize production, promoting productive use of remittances, and maintaining stable inflation to reduce maize import dependency for policy implications.

Keywords: Error correction term, import demand and policy, integration, maize, normality

INTRODUCTION

Maize is the second most important cereal crop in Nepal after rice in terms of both area and production (MoALD, 2025). It is also the second most imported cereal crops after rice in Nepal (DoC, 2025). Nepal imported 383,109 mt of maize worth of 19.27 billion Nepalese rupees during 2024/25, nearly 87% of which was from India while Argentina and Brazil ranked second and third that constituted approximately 3.93% and 3.45% of maize import volume respectively (DoC, 2025). Despite consistent rise of maize production during last 28 years, there are huge maize imports and are projected to remain high for years to come (Bhattarai et al., 2026). Increase in import despite increase in production during past 28 years suggest many factors are responsible for maize import demand in Nepal.

Maize stands first among cereal commodities globally in terms of production and second in terms of cultivated area (FAO, 2024). Maize is cultivated on an estimated 209 million hectare of land worldwide, making it the second most widely grown crop in the world after wheat, with an estimated production of 1236 million tons globally is distinctly higher than both rice and wheat (FAO, 2024). On a global perspective, maize is primarily used as feed with more than fifty percent of production, a fifth used for non-food item, and 13% for food; making it most versatile multipurpose crop compared to rice and wheat (Erenstein et al., 2022).

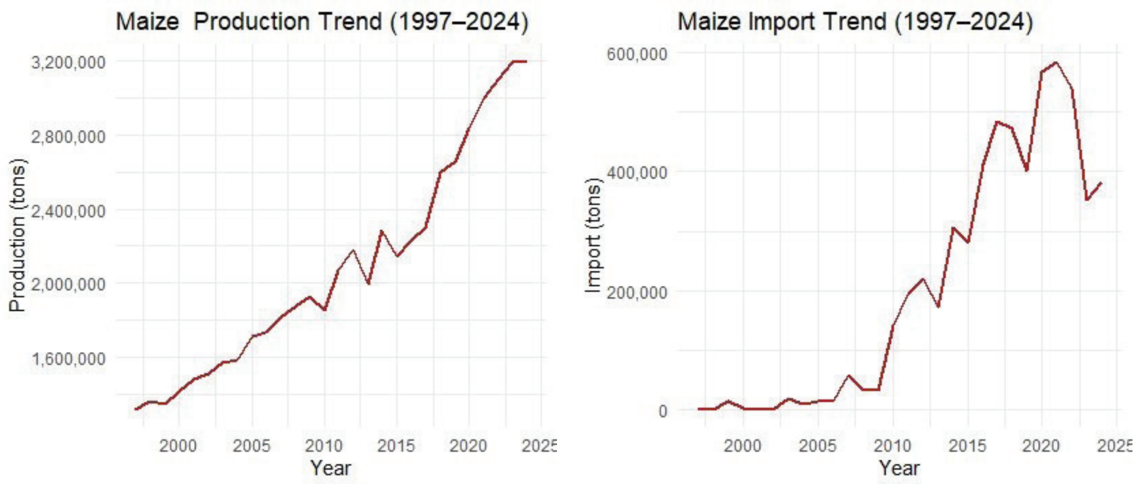
The production of maize is rising consistently in Nepal during last decade reaching 3.19 million metric tons in 2024 from 2.28 million metric tons (MoALD, 2025). Khanal et al. (2022) reported that poultry feed which constitute 65% of maize, almost half of which are imported from India. It is believed to be a major food crop of hilly people and source of animal feed for different feed industries in terai region of Nepal (KC et al., 2015). The production of poultry meat in Nepal increased form 4315 mt in 1971 to 65,387 mt in 2022 (Adhikari et al., 2023); which is mainly because of increased protein demand due to increased income. Timsina et al. (2016) projected 1.5 million metric tons of maize required for feed industries, large portion of which are imported.

The increase in production of maize is not sufficient to meet the growing demand in Nepal (Bhattarai et al., 2026). This study has utilized the time series data of maize import, production and other five explanatory variables from the year 1997 to 2024. The time series plot of maize production and import data is graphically presented in Fig. 1 (a) and (b). The maize production and import data from 1997 to 2024, suggest that maize import has increased despite increase in production, so it is important to know both macroeconomic and microeconomic factors that are responsible for maize import in Nepal. This will inform policy makers about the strategies Nepal should employ to check the import dependency on maize and thereby to ensure food security of the country.

This study uses Autoregressive distributed lag (ARDL) with cointegration and error correction model to examine short run and long run relationships between the variables affecting import demand of maize. There are several past studies on the use of ARDL model to estimate determinants of trade. Abodi et al. (2021) used ARDL model to identify long-run and short-run relationships between maize import volume and variables. Dhungel (2018) examined the impact of Gross Domestic Product (GDP), remittance and consumers price index on import demand function in Nepal using ARDL model. Baral (2022) employed ARDL model to estimate determinants of import performance in Nepal, where import value index, private consumption, educational expenditure and population growth were evaluated for import performance for the period 1980 to 2021. ARDL methods have been extensively used for identifying factors affecting production as well. The long-run relationships and short-run relationships between rice production and rice cultivated area, fertilizer use, annual mean temperature and precipitation were estimated using ARDL model by Joshi et al. (2023). Ashiagbor et al. (2023) used ARDL model to estimate determinants of agriculture growth in Ghana for the period 1980-2020. The ARDL is applied with mixed integration of either I(0) or I(1) or mutually cointegrated and is also a good fit for small sample size (Narsullah et al., 2021). Fikri et al. (2025) used 28 years dataset from 1993 to 2020 to examine the effects of carbon dioxide emissions, renewable energy consumption, foreign direct investment, government general consumption spending and economic growth in the Moroccan context using ARDL approach. It provides a logical choice to use ARDL approach for small sample size of 28 years' time series data for this study when other conditions are plausible.

Although maize is the second most imported cereal crop after rice in Nepal, contributing a substantial share to the agricultural trade deficit, empirical studies examining the determinants of maize import demand remain limited. While numerous studies have analyzed import determinants in developed and some developing countries, evidence specific to agricultural import demand in Nepal is scarce. In particular, rigorous estimation of the determinants of maize import demand in the Nepalese context has received little scholarly attention. The objective of this study was to identify short-run and long-run relationships between various factors affecting maize import demand in Nepal. The study proposed policy options to reduce maize imports in Nepal. The findings are highly valuable for policymakers working in the agriculture and trade sectors, as well as for researchers interested in time-series analysis and international trade dynamics.

The materials and methods are described in section 2 of this article, followed by results, discussions, and conclusions in the subsequent sections.



(a) (b)

Fig. 1. Time series plot of maize production (a) and maize import trend (b) in Nepal (1997-2024)

RESEARCH METHODS

Sources of data

Different secondary data sources were used to generate 28 years annual data on maize import volume in metric tons, import price of maize US dollar (USD) per metric tons, remittances in million Nepalese Rupees (NPR), domestic maize production in metric tons, import price of rice close substitute USD per metric tons, consumer price inflation (CPI) and trade openness index. Maize import data for the period 1997-2021 were obtained from FAOSTAT, while data for 2022-2024 were collected from the Department of customs, Government of Nepal, forming a complete time series for 1997-2024.The data from the Department of customs, which are reported in Nepali month and fiscal years, were converted to annual Gregorian calendar value to maintain consistency and avoid potential discrepancies in the analysis. The production data for the period of 1997 to 2024 were collected from published data of Ministry of Agriculture and Livestock Development and Ministry of Finance of the Government of Nepal (MoF, 2024). The import price of maize and import price of rice per metric in USD for the period of 1997 to 2024 were collected from FAOSTAT and Department of Customs (DoC, 2025). The consumer price inflation data for the period of 1997 to 2024 was collected from Nepal Rastra Bank (NRB, 2025). The total export, total import and GDP data used for calculating openness index were collected from the Nepal Rastra Bank (NRB, 2025).

Description of variables

Maize import volume, maize production, import price of maize, import price of rice, maize consumption, per capita income, exchange rate, remittance and trade openness index were initially tested for multicollinearity using the variance inflation factor (VIF). Variables with high VIF values, indicating strong multicollinearity were excluded from analysis, while variables with low VIF values were retained for further analysis. Thus, maize import volume, maize production, import price of maize, import price of rice, remittance, consumer price inflation and trade openness index were the final variables used for this study. The dataset for each variable was extracted from published sources; therefore, outliers were not specifically considered for the analysis.

Maize import volume (import) used as dependent variable in this study is based on the assumption that import of maize in Nepal is determined by the import price of maize, domestic maize production, remittance, import price of close substitute which is rice, consumer price inflation and trade openness index. The use of import volume as dependent variable is justified by the past studies (Abodi et al., 2021; Bista & Adhikari, 2021).

Maize production (**mpro**) is supposed to affect directly to the maize import. We assume that lower the maize production, higher the demand for maize consumption thereby increasing the imports. The domestic maize production is measured in tones. The inclusion of this variable in the study is justified by the past study by Abodi et al. (2021).

Import price of maize (mimp_p) and import price of rice (rimpp) are another explanatory variable used in this study. We suppose that increased import price of maize affect maize imports inversely; while higher the import price of rice which as close substitute of maize, higher the import of maize expected due to competition effect.

Remittance (rem) is another explanatory variable used in this study. It is believed that increased remittance inflow to increase the purchasing capacity and consumption demand for protein and meat product thereby increasing the import demand of maize for feed. The inclusion of remittance as variable in this study is justified by earlier empirical studies (Aryal, 2024; Biswakarma et al., 2024; Dhungel, 2018)

Consumer price inflation (CPI) is used as a macroeconomic explanatory variable, capturing the general price level in the economy and its potential influence on maize imports (Dhungel, 2018)

Trade openness index (OI) is included as a proxy for trade liberalization. It is calculated by the sum of total exports and imports normalized by GDP. It measures a country's integration in the international trade, indicating the enabling environment for external trade. We presume that more the country unlocks to international trade, more the imports. The use of this variable as an explanatory variable is justified by the past empirical study (Abodi et al., 2021).

All of the dependent and explanatory variables except consumers price inflation and openness index were log transformed with natural log to normalize the skewed data. The analysis was conducted using R studio.

Test of stationarity

The ARDL bounds testing to cointegration developed by Pesaran et al. (2001) require the time series to be stationary at either I(0) or I(1). The Augmented Dickey-Fuller test (ADF), Phillips-Perron (PP) test and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test were used to test stationarity and unit root. The ADF test is calculated as;

$$\Delta Y_t = \alpha + \beta t + \gamma Y_{t-1} + \textstyle\sum_{i=1}^{p} \Delta Y_{t-1} + \varepsilon_t \tag{1}$$

Where, $\Delta Y_t = Y_t - Y_{t-1}$, first difference of the series

α = constant intercept; βt = deterministic time trend; γY_{t-1} = lagged level term;

$\sum_{i=1}^{p} \Delta Y_{t-1}$ = lagged dıfferences; p = number of lagged difference term and ε_t = error term

The decision rule is that if p-value< 0.05 or chosen level of significance; null hypothesis is rejected; i.e. the time series is stationary. And if p-value > 0.05, we fail to reject null hypothesis, which means the data are non-stationary.

The Phillips-Perron (PP) test is calculated as;

Let the regression;

$$\Delta Y_t = \alpha + \beta Y_{t-1} + \Upsilon_t + \varepsilon_t \tag{2}$$

$\Delta Y_t = Y_t - Y_{t-1}$ = first difference of the series, t= trend term, ε_t= error term

The test statistic is given by;

$$Z_t = t_\beta - \frac{\hat{\lambda} - \hat{\gamma}_0}{2}\left(\frac{T}{\hat{\sigma}^2}\right) \tag{3}$$

Where, t_β= t statistic of β, T= sample size, $\hat{\sigma}^2$ = Variance of residuals, $\hat{\gamma}_0$ = residual variance; and $\hat{\lambda}$ = long run variance estimate

Decision rule is same as ADF test; if if p-value< 0.05 or chosen level of significance; null hypothesis is rejected; i.e. the time series is stationary. And if p-value > 0.05, we fail to reject null hypothesis, which means the data are non-stationary.

The KPSS test statistic is calculated using following formula;

Let, $Y_t = \delta_t + r_t + \varepsilon_t$ (4)

Where, δ_t= deterministic trend, r_t= random walk component and ε_t=Stationary error

$$KPSS = \frac{1}{T^2}\sum_{t=1}^{T} S_t^2 / \hat{\sigma}^2$$

Where, T= sample size, S_t= partial sum of residuals and $\hat{\sigma}^2$ = long-run variance estimate

The decision rule is opposite of ADF test and PP test;

if p-value> 0.05 or chosen level of significance; we fail to reject null-hypothesis; i.e. the time series is stationary. And if p-value < 0.05, reject null hypothesis, which means the data are non-stationary.

Model estimation

All the data variables were tested for stationarity. The ADF test, PP test and KPSS test confirms the stationarity. If the data were non-stationary; it was differenced until it became stationary with the verification from all three tests. The ARDL model requires the data to be stationary either at I(0) or I(1) (Nasrullah et al., 2021). After confirming the variables stationary at I(0) or I(1), we performed bound test of cointegration to check existence of long-run relationships among the variables. The ARDL is estimated as;

Suppose optimal lag structure is;

$ARDL\ (p, q_1, q_2, q_3, q_4, q_5, q_6)$

$$\ln import_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i \ln import_{t-i} + \sum_{j=0}^{q_1} \beta_{1j} \ln mimp\_p_{t-j} + \sum_{j=0}^{q_2} \beta_{2j} \ln mpro_{t-j} + \sum_{j=0}^{q_3} \beta_{3j} \ln rem_{t-j} + \sum_{j=0}^{q_4} \beta_{4j} \ln rimpp_{t-j} + \sum_{j=0}^{q_5} \beta_{5j}\, CPI_{t-j} + \sum_{j=0}^{q_6} \beta_{6j}\, OI_{t-j} + \mu_t \tag{6}$$

The bound test of cointegration model is specified as;

$$\Delta \ln import_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i \Delta \ln import_{t-i} + \sum_{j=0}^{q_1} \beta_{1j} \Delta \ln mimp\_p_{t-j} + \sum_{j=0}^{q_2} \beta_{2j} \Delta \ln mpro_{t-j} + \sum_{j=0}^{q_3} \beta_{3j} \Delta \ln rem_{t-j} + \sum_{j=0}^{q_4} \beta_{4j} \Delta \ln rimpp_{t-j} + \sum_{j=0}^{q_5} \beta_{5j} \Delta CPI_{t-j} + \sum_{j=0}^{q_6} \beta_{6j} \Delta OI_{t-j} + \lambda_1 \ln import_{t-1} + \lambda_2 ln\, mimp\_p_{t-1} + \lambda_3 ln\, mpro_{t-1} + \lambda_4 ln\, rem_{t-1} + \lambda_5 ln\, rimpp_{t-1} + \lambda_6\, CPI_{t-1} + \lambda_7 OI_{t-1} + \varepsilon_t \tag{7}$$

The F calculated from cointegration test is compared with the critical values of upper and lower bound. The decision rule given by Pesaran et al. (2001) and Narayan (2006) is that If F < F(lower bound); there is no cointegration; if F> F (upper bound); co-integration exists and if F (lower bound) < F calculated < F (upper bound), inconclusive.

Now, we specify error correction version of the ARDL model to facilitate the analysis of long-run and short-run effects of explanatory variables on maize import volume. The ECM version of ARDL model is written as;

$$\Delta \ln import_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i \Delta \ln import_{t-i} + \sum_{j=0}^{q_1} \beta_{1j} \Delta \ln mimp_{p_{t-j}} + \sum_{j=0}^{q_2} \beta_{2j} \Delta \ln mpro_{t-j} + \sum_{j=0}^{q_3} \beta_{3j} \Delta \ln rem_{t-j} + \sum_{j=0}^{q_4} \beta_{4j} \Delta \ln rimpp_{t-j} + \sum_{j=0}^{q_5} \beta_{5j} \Delta CPI_{t-j} + \sum_{j=0}^{q_6} \beta_{6j} \Delta OI_{t-j} + \emptyset ECT_{t-1} + \varepsilon_{1t} \tag{8}$$

Where, ECT_{t-1} is the error correction term and should be negative, $\emptyset$ is the speed of adjustment to the long-run equilibrium.

RESULTS AND DISCUSSION

Unit root and stationarity test results

The unit root and stationarity test results of all variables is presented in Table 1. The order of integration of variables was examined using Augmented Dickey-Fuller test (ADF), Phillips-Perron test (PP) and KPSS test. The ADF and PP tests examine the null hypothesis of a unit root (non-stationarity), while KPSS test examines the null hypothesis of stationarity. These three complementary tests ensure the robustness of determining integration properties of the data series. The result indicates that ln_import is non-stationary at level, as evidenced by the insignificant p-values in ADF (p-value> 0.05) and PP (p-value>0.05) tests and rejection of stationarity by KPSS (p-value> 0.05) test. However, after first differencing all three tests confirm the stationarity of logarithm of maize import volume data. This implies that, ln_import is integrated at the order of I(1).

Unit root test results present mixed evidence across variables. The ADF and KPSS tests indicate that *ln_mimp_p* and *ln_mpro* are non-stationary at level but stationary at first difference, supporting integration of order I(1), despite the PP test suggesting level stationarity. For *ln_rem*, conflicting test outcomes exist; however, greater weight is given to PP and KPSS results, leading to its classification as I(1). Similarly, *ln_rimpp* and *CPI* show inconsistent stationarity patterns across tests, but overall evidence supports treating them as integrated of order I(1). In contrast, *OI* is consistently identified as I(1) by all three-unit root tests. Overall, the majority of variables are considered integrated of order one, justifying further cointegration analysis.

Overall, the findings reveal that the variables are a mixture of I(0) and I(1) and none is integrated at the order of I(2). This mix order justifies the application of ARDL bounds testing approach for examining long-run and short-run dynamics among the variables.

Table 1. Unit root and stationarity test results

Variables		ADF test		PP test		KPSS test	
		Dickey fuller	p-value	Dickey fuller Z (alpha)	p- value	KPSS level	p-value
ln_import	Level	-0.7655	0.953	-17.09	0.070	0.939**	0.01
	First diff	-4.36 *	0.0102	-24.358 **	0.01	0.167	0.1
*ln*_mimp_p	Level	-1.969	0.584	-20.54 *	0.022	0.742**	0.01
	First diff	-4.547 **	0.01	-30.012 **	0.01	0.063	0.1
ln_mpro	Level	-1.653	0.705	-18.86 *	0.040	1.009**	0.01
	First diff	-3.146	0.134	-37.56 **	0.01	0.091	0.1
ln_rem	Level	-3.656 *	0.045	-4.53	0.842	0.991**	0.01
	First diff	-3.74 *	0.039	-31.21 **	0.01	0.041	0.06
ln_rimpp	Level	-4.670 **	0.01	-19.589 *	0.031	0.954**	0.01
	First diff	-3.538	0.058	-29.369	0.01	0.084	0.1
CPI	Level	-1.695	0.689	-14.641	0.170	0.121	0.1
	First diff	-3.216	0.108	-34.45 **	0.01	0.075	0.1
OI	Level	-2.161	0.510	-12.446	0.316	0.473 *	0.047
	First diff	-3.938 *	0.025	-27.8 **	0.01	0.069	0.1

Bound test for long-run relationships

The existence of a long run relationship among the variables was examined using ARDL bound testing to cointegration developed by Pesaran et al. (2001). Result of bound test for long-run relationships is presented in Table 2. The calculated F statistic for the selected ARDL (1,2,1,2,2,2,2) model is 11.182 with highly statistically significant (p=0.00001). The lag length was selected automatically by using R software on the basis of AIC/ BIC criterion.

The computed F-statistic is compared with the critical values provided by Pesaran et al. (2001) and Narayan (2005). The F calculated exceeds the critical values of lower bound I(0) and upper bound I(1) provided by both Pesaran and Narayan at all significance level 1%, 5% and 10%. As critical values at 1% level of significance are well below at both lower and upper bound than calculated value, the null hypothesis of no long-rung relationship is rejected.

The result shows that there is existence of long run cointegration relationships among maize import volume and its determinants. The findings are important for estimating long-run coefficients and error correction model (ECM) within the ARDL model framework.

Table 2. Bound test for long-run relationship

Lag length	F-Statistics			
ARDL (1,2,1,2,2,2,2)	11.182 ** (p=0.00001)			
Significance level	Critical values at k=6			
	Lower bound I (0)		Upper bound I(1)	
	Pesaran	Narayan	Pesaran	Narayan
1%	2.88	3.976	3.99	5.691
5%	2.27	2.794	3.38	4.148
10%	1.99	2.334	2.94	3.515

Estimation of coefficients of long-run relationship in ARDL cointegration form

Table 3. presents the estimated long-run coefficients derived from ARDL cointegration model. The results provide evidence on long-run elasticities of maize import demand with respect to its key determinants.

The coefficient of *ln_mimp_p* (import price of maize) is -0.097 but is insignificant, which means import price of maize does not affect significantly on maize import volume in long-run. The negative value is consistent with the demand theory, higher the import price, lower the import volume. Coefficient of *ln_mpro* (domestic maize production) is -3.59, indicating an inverse relationship between maize production and import; which is in consistent with the general assumption that increase in the domestic production reduces the import demand. However, the coefficient is insignificant (p= 0.148) implying the domestic production does not significantly determine maize import in long-run.

Remittance (*ln_rem*) has a positive coefficient (0.958), and statistically weakly significant (p-value=0.057). This indicates that higher remittance flow increases the maize import demand, possibly due to increased purchasing power and higher consumption demand. The elasticity suggests that 1 percent increase in remittance flow increases the maize import demand by 0.95% in long run.

The coefficient of *ln_rimpp* (import price of rice which is a close substitute of maize) has positive coefficient and is statistically significant (p-value=0.0215). This implies that increase in price of substitute goods leads to higher maize imports, consistent with substitution theory. The higher value of coefficient (3.75) indicates a strong cross price elasticity in long run.

The consumer price inflation (*CPI*) has a positive and very significant coefficient. This suggests general price inflation are associated with the higher maize imports. The openness index (*OI*) has a positive but insignificant coefficient, suggesting the trade environment does support more import but does not significantly influence maize imports in long run.

Overall, the result indicated that the remittance inflows, substitute prices and consumer price inflation are the primary long-run determinants of maize import in Nepal. The import price, domestic production and openness do not exert statistically significant long run effects.

Table 3. Coefficients of long-run relationships in ARDL cointegration form

Variables	Coefficients	Std error	t-statistic	p-value
ln_mimp_p, 1	-0.097	0.829	-0.118	0.909
ln_mpro, 1	-3.539	2.178	-1.624	0.148
ln_rem, 1	0.958	0.422	2.266	0.057
ln_rimpp, 1	3.751 *	1.273	2.945	0.0215
CPI, 1	0.266 **	0.075	3.527	0.009
OI, 1	0.095	0.069	1.374	0.211

Short run results on determinants of maize import volume

Table 4. presents the short-run estimates of the ARDL error correction model for maize import demand in Nepal. The dependent variable is the first difference of the logarithm of maize import volume (*Δln _import*). The result shows that the constant term is positive (26.16) but statistically insignificant (p=0.287). The short-run results indicate that both contemporaneous and lagged coefficients of maize import price (*Δln_mimp_p*) are statistically insignificant, suggesting changes in import prices do not significantly affect maize import in short run. Similarly, domestic production of maize (*Δln_mpro*) exhibits a positive but statistically insignificant coefficient (β = 1.451, p = 0.586), implying no short-run impact on import demand.

Remittance (*Δln_rem*) however, demonstrates strong and statistically significant short-run effect. The contemporaneous coefficient is negative and significant at 1% (β = -4.247, p = 0.005), indicating that 1% increase in remittance reduces imports approximately by 4.25% in short run. The lagged value of remittance is also negative and significant at 10% (β = -2.149, p = 0.081). This suggests that increased remittance inflows may reduce maize import in the short-run, possibly by supporting the domestic production or consumption preference.

The import price of substitute goods (*Δln_rimpp*) shows mixed results. The contemporaneous effect is insignificant, but the lagged coefficient is negative and weakly significant at 10% (β = -2.170, p = 0.066), implying a delayed short run adjustment effect. The consumer price inflation (ΔCPI), has a positive and significant short run impact on imports. The contemporaneous coefficient (β = 0.243, p = 0.011) indicates that rising domestic prices increases import demand in short run, possibly due to substitution towards foreign goods. The lagged inflation however, has insignificant coefficient. The trade openness index (*ΔOI*), do not exhibit any significant short-run influence on maize import, as both current and lagged coefficients are statistically insignificant.

The error correction term (ECT_{t-1}) is negative and highly significant (∅ = -1.038, p=0.0012), confirming the existence of a stable long-run relationship among variables. The magnitude of the coefficient indicates that approximately 103.8% of deviations from the long-run equilibrium are corrected within one period, implying a rapid adjustment process with slight overshooting toward equilibrium.

The overall model demonstrates strong explanatory power with an R^2 of 0.985 and an adjusted R^2 of 0.945. The F-statistic (27.2, p=0.0001) confirms the joint significance of the regressors.

Table 4. Short-run estimates of ARDL error correction model (ECM) model (dependent variable: Δln_import)

Variables	Coefficient	Std error	t-statistic	p-value
Constant	26.161	22.742	1.150	0.287
Δln_mimp_p	0.416	0.529	0.787	0.457
Δln_mimp_p (-1)	0.037	0.493	0.076	0.941
Δln_mpro	1.451	2.543	0.571	0.586
Δln_rem	-4.247 **	1.089	-3.899	0.005
Δln_rem (-1)	-2.149	1.059	-2.030	0.081
Δln_rimpp	1.827	1.003	1.822	0.111
Δln_rimpp (-1)	-2.170	1.002	-2.167	0.066
ΔCPI	0.243 *	0.071	3.416	0.011
ΔCPI (-1)	0.028	0.072	0.397	0.703
ΔOI	0.006	0.046	0.132	0.898
ΔOI (-1)	-0.098	0.054	-1.816	0.112
ECT_{t-1}	-1.038 **	0.199	-5.218	0.0012
R^2 0.985				
Adjusted R^2 0.945				
F-statistic (p-value) 27.2 ** (0.00001)				

Post diagnostic test results of ARDL-ECM model are presented in Table 5. The normality test results shows that model satisfies the assumption of normality. The Jerque-Bera test statistic (JB statistic= 0.346) shows that we fail to reject the null hypothesis of normality (p-value> 0.05), suggesting the normality of residuals. Similarly, we fail to reject null hypothesis of normality in Shapiro-wilk test statistic (w=0.975, p- value> 0.05). Likewise, the D' Agostino skewness test result suggests that there is no significant skewness (z=0.658, p-value>0.05). All these three tests reflect that the residuals are normally distributed, which satisfies the normality assumption of ARDL-ECM model.

The serial autocorrelation test Bruesch-Godfrey LM test result suggests that model does not contain serial autocorrelation (LM=3.378, p-value>0.05), there is no autocorrelation. The Bruesch-Pagan test result shows there is absence of heteroskedasticity in the residuals. The RESET statistic (RESET=0.325, p=0.589) indicates that null hypothesis of correct functional form cannot be rejected. Thus, there is no evidence of model misspecification or omitted variable bias, or incorrect functional form. Thus, the post diagnostic test results reveal that the model satisfies the requirement of normality, absence of autocorrelation and heteroskedasticity; and the model is correctly specified. These finding validate the robustness, stability and reliability of the estimated long-run and short-run relationships.

Table 5. Post diagnostic test results of ARDL-ECM model

Tests	Test statistic	p-value	Interpretation
Jerque- Bera Statistic X^2	0.346	0.84	Residuals are normally distributed
Shapiro-wilk test statistic (w)	0.975	0.766	Residuals are normally distributed
Bruesch-Godfrey test statistic LM (p-value)	3.378	0.184	Absence of serial autocorrelation
Studentized Bruesch-pagan Test statistic BP (p-value)	17.198	0.505	Absence of heteroskedasticity
D'Agostino skewness test statistic skew (z-value)	0.267 (z =0.658)	0.510	Residuals are symmetric
RESET	0.325	0.589	No model misspecification

The variance inflation factor (VIF) test result for multicollinearity among explanatory variables is presented in Table 6. The estimated VIF values ranged from 1.153 to 1.968, which are below the commonly accepted threshold value of 5 (Shrestha, 2020). This indicates the absence of serious multicollinearity among the explanatory variables included in the ECM model.

Table 6. Variance inflation factor (VIF) test for multicollinearity in the ECM model (dependent variable ln_import)

Variables	VIF value	Interpretation
Δln_mimp_p	1.967	No multicollinearity
Δln_mpro	1.340	No multicollinearity
Δln_rem	1.684	No multicollinearity
Δln_rimpp	1.968	No multicollinearity
ΔCPI	1.855	No multicollinearity
ΔOI	1.686	No multicollinearity

DISCUSSION

Among the variables examined, the long-run results indicate that remittance inflows, relative import price of substitute goods and inflation exert a positive influence on imports of maize in Nepal. The findings are in line with the past empirical studies by Dhungel (2018), suggesting total import demand of Nepal is determined by the remittance and CPI positively in long run. The result suggests the domestic production decreases import in long-run but coefficient is not significant, however it is in line with trade theory higher the domestic supply lower the import and is also supported by the similar long-run maize import behavior in Kenya (Abodi et al., 2021).

In contrast, remittance inflows exhibit a significant negative effect on maize imports in short-run. This suggests that a sudden increase in remittance may initially reduce imports, possibly due to loan repayment, temporary savings behavior, investment allocation or adjustment delays before consumption materializes. This finding is consistent with evidence from (Abodi et al.,2021). The consumer price inflation has positive effects on maize import in short-run similar to the long-run effects. The findings are supported by the similar study results in Nepal's import performance (Aryal, 2024). Lagged change in relative import price of substitute goods shows marginally significant negative effect in short run, indicating short term price sensitivity.

Interestingly import price of maize did not exert significant impact on maize import; possibly because of increased domestic demand had no other options than to import. Likewise, another tested variable trade openness index also did not affect significantly on maize import, although positive coefficient value suggested that it creates favorable environment for the import, which is in consistent with the theoretical assumptions.

Although the ARDL methodology is robust, its application in a relatively small sample size of 28 years may limit the efficiency of the estimators. Nevertheless, the use of a low maximum lag length of 2 is appropriate for the dataset (Fikri et al., 2025). The results indicate strong evidence of cointegration, as shown by a highly significant F-statistic (p=0.00001). In addition, the post estimation of diagnostic tests confirms the reliability of the model. The residuals are normally distributed, and there is no evidence of serial autocorrelation, heteroskedasticity, model misspecification, or multicollinearity in the ECM framework. Overall, these results support the validity and robustness of the estimated model.

CONCLUSION

This study utilized 28 years' time series data with maize import volume as dependent variable and maize import price, domestic maize production, remittance inflow, import price of substitute goods rice, consumer price inflation and openness index as explanatory variables. The bound testing to cointegration confirmed the existence of long-run relationships among the variables, which led to development of ARDL-ECM model to estimate long run and short run relationships.

The empirical findings indicate that remittance, consumers price inflation and import price of substitute goods (rice) are the major determinants of maize imports in Nepal. The domestic maize production exhibits a negative relationship with imports in the long-run, although the coefficient is statistically insignificant. In contrast maize import price and openness index affected little on maize import as suggested by the insignificant coefficients in both long-run and short-run estimates.

Based on the findings; the following conclusions and policy recommendations are drawn;

(i) The remittance inflow affected the import of maize, it reduced import in short run but increased in long-run suggesting consumption behavior. We suggest to create enabling environment to utilize remittance income more in production of either maize or substitute commodities to reduce overdependence on import created by consumption demand.

(ii) The consumer price inflation has a positive effect on maize imports, indicating that rising domestic prices may increase reliance on imports. The government should focus on restricting inflation through appropriate monetary, fiscal and supply side policies. Specially, for reducing the impact of consumer price inflation on agriculture imports, the supply side policy measures should be enhanced to increase domestic production and creation of all enabling environment on maize value chain.

(iii) The increased import price of substitute goods like rice has affected significantly the maize import in Nepal. This indicates the increasing domestic production of maize or substitute goods could help in reducing the maize import.

(iv) Although not statistically significant, the negative relationship between domestic maize production and imports align with economic theory. Therefore, policies should focus on promoting domestic maize production through targeted interventions, including input subsidies (improved and hybrid seeds, fertilizer, energy for irrigation), mechanization supports, infrastructures development (irrigation and post-harvest storages), increased investments in research and development, improved market access and price assurance, strengthening the maize supply chain, and enhanced trainings and extension supports.

By adopting these measures, Nepal can reduce its import dependency in maize and can achieve self-sufficiency in long-run. It will not only reduce the maize import but also help to reduce the overall agricultural trade deficit of Nepal.

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AUTHOR CONTRIBUTIONS

BKB: Conceptualization, Methodology, Software, Investigation, Data curation, Formal analysis, Writing – original draft, Writing – review & editing, Project administration; **RRK:** Conceptualization, Methodology, Formal analysis, Writing – review & editing, Supervision; **SCD:** Conceptualization, Methodology, Formal analysis, Writing – review & editing, Supervision; **GRJ:** Conceptualization, Methodology, Formal analysis, Writing – review & editing, Supervision.

CONFLICT OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

ETHICAL APPROVAL AND PERMITS

This study did not require ethical approval as most of the data were collected from secondary sources.

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