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Determinants of Nepal's Foreign Exchange Reserve: An Empirical Study

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Abstract

With the intent to fill the gaps in the empirical literature on foreign exchange reserve in Nepal, the paper aims to evaluate the empirical evidence of determinants of foreign exchange reserve in Nepal and to investigate the dynamic relationship among variables of interest using an autoregressive distributed lag (ARDL) error correction model and impulse response functions (IRFs) with 40 years of data from the period 1980-2020. The stylized facts of the employed model in the short run, reveal that the previous year's foreign exchange reserve itself, and all other predictors except gross fixed capital formation and official exchange rate (have negative) have a positive effect on foreign exchange reserve. The empirical evidence also insights that net flows of foreign direct investment, GDP per capita, inflation, and official exchange rate have positively influenced the foreign exchange reserve in long run. On the contrary, gross fixed capital formation has negative effects in long run. Moreover, anticipated crucial proxies—current account balance and trade are positively influenced but not significant. However, any impulse on the current account balance reports a significant response of foreign exchange. Thus, the central bank of Nepal and policymakers are needed to focus on the productivity of gross fixed capital formation or domestic investment to maintain the reserve adequacy and should give their attention to the current account balance (import and export) that can maintain the foreign exchange reserve and financial/economic stability and safety.

*Keywords: f*oreign exchange reserve, exchange rate, ARDL, impulse response functions

Introduction

Foreign exchange reserve implies that those readily available external assets to monetary authorities and controlled by them for maintaining the financial needs for the balance of payments, for overriding foreign exchange markets in order to alter the rate of exchange, for maintaining currency confidence and the economic tranquil, and medium for external borrowing according to a country's international reserves (IMF, 2009). Suitable level of gold or holding or foreign currency is essential to interfere the international exchange (Blackman, 1981). Foreign exchange reserves act as an important agent to link emerging markets with developed economies (Sa, 2013).

Foreign exchange reserve is inevitable to achieve the development needs and economic stability. It is essential to maintain the financial cum economic stability through liquidity and safety in the economy. It can be aligned and integrated with the economy throughout the globe. In this stage of economic dependency, it would be the barometer of economic hegemony. An import-dependent economy like Nepal is largely concerned about the foreign exchange reserve. It would be the threshold to being an independent nation in the epoch of globalization and proliferated liberalization across the world. Thus, an optimal level of reserve especially in small sized economy depends on import is a debatable issue. Worrell (1976) stated that foreign exchange earnings from a country can either be spent on goods and services or accumulated as a foreign exchange reserve.

The volume of trade, net remittance flow, tourism, foreign debt and grants, physical and human capital movement, exchange rate policy, economic policy, availability of gold and minerals, etc. are the crucial determinants of foreign exchange reserve holdings. So, an adequate level of reserves should be maintained by every economy. Mainly, the size of trade (export and import), remittance, and international tourism are the prime determinants of exchange reserves. Whether there is an adequate level of foreign exchange reserve, it provides opportunities to explore the economy in the world. Shrestha (2016) reported that when there is sufficient foreign exchange reserve accumulated and utilized productively, it will accelerate economic growth and assure internal and external balances. Theoretically and empirically confirms that the holdings of foreign reserve acts as a crucial agent of exchange rate stability, and safeguarding the effects of unintended economic shocks and crisis (Mishkin, 1999; Frenkel, 2005).

The foreign exchange reserve crisis of the Sri Lankan economy initiates to discuss of the reserve crisis in South Asian countries. Meantime, Nepal also has faced a gradual decline in exchange reserves due to an increase in imports that is motivated by increasing revenue. Despite the Covid-19 crisis, the economy was predicted to be robust and thrive in a V-shape because inflation was kept under control, the balance of payments and foreign exchange reserves were stable, the financial sector was growing stronger, and developing infrastructure reconstruction, but the spread of the second wave of the Covid-19 caused the economy to falter (Economic Survey, 2020/21). As reported by NRB (2022), gross foreign exchange reserves decreased 14.7 percent from 11.75 billion US$ in mid-July 2021 to 10.03 billion US$ in mid-December 2021.

Declining foreign reserves and other related phenomena caused structural retarding of the Nepali economy. The reserve crisis has had severe effects on the external sector of Nepal. It may create a supply shock of imported goods in Nepal. The worsening condition of Nepal should be surfaced if we don't care about it. Reserve adequacy and economic stability are mutually correlated. This concern stimulates to study of the determinants of foreign exchange reserve. This paper is an attempt to fill the empirical gap in Nepal and provides background for more discussion on it. To achieve the anticipated goal, this paper is intended to evaluate the determinants of foreign exchange reserve in Nepal by employing an autoregressive distribution lag model (ARDL) with error correction form and impulse response functions (IRFs) covering the data set over the period of 1980-2020.

Research Problems

The considerable, ongoing, and uphill trade deficit has caused to fail the stable exchange reserve in Nepal. However, the exact causes of reducing momentum of exchange reserves in Nepal are not explored. The lack of empirical assessment of determinants of foreign exchange reserve in Nepal motivates to conduct this empirical study where it focuses to discover the factor determining foreign exchange reserve in Nepal. This study is focused on answering the following research questions:

i. What is the empirical evidence of determinants of foreign exchange reserve in Nepal?
ii. How does the variable of interest dynamically related?
iii. What dynamic relationships exist between the variables?

Research Objectives

The study has two-fold objectives. They are:

i. to evaluate the empirical evidence of determinants of foreign exchange reserve and
ii. to investigate the dynamic relationship among variables of interest with the impulse response.

Rationale of the Study

The quest to identify its influencing factors is driven by the growing concerns about an adequate level of foreign exchange reserve in underdeveloped countries. The key factors affecting Nepal's foreign exchange reserve have been investigated in this study. Knowing the essential components of a foreign exchange reserve and the dynamic relationships between the relevant variables is important. It fills the gap in the literature by providing background information on Nepal's foreign exchange reserves. It gives policymakers and official authorities a foundational understanding of how to be cautious about maintaining the appropriate level of reserves to maintain economic stability and prevent crises brought on by import pressure.

Research Limitations

This study employs the autoregressive distribution lag model (ARDL) with error correction form and impulse response functions (IRFs) only covering the data set over the period of 1980-2020. To identify the determinants of foreign exchange reserve, some crucial and relevant macroeconomic aggregates have targeted due to the limitation of data, methodological constraints, and limitation of paper wording.

Despite the introduction, the rest of the paper has divided into four-fold broad sections. These are literature review—encompasses extensive empirical literature on the same study, research methods, and materials—providing all the methodological strategies data, variables of interest, appropriate model to report estimated findings, results, and discussion—consisting of data presentation, finding results by employing specified model, and proper discussion on the result findings, and conclusion—covering overall impression of research findings and insights policy implication respectively.

Literature Review

The earlier studied by Heller (1966) concluded that the optimal level and size of currency reserve of the world economies. Same other literature about optimal international reserve reported that trade volume and variance in reserves (Officer, 1976) and variation in international payments and receipts (Frenkel and Jovanovic, 1981) are the determinants of the efficient and adequate international reserve. Obstfeld, Shambaugh, and Taylor (2010) portrayed that the need for foreign exchange reserves is a result of financial stability and financial openness in a world of globalized markets. Moreover, Drummond, Mrema, Roudet, and Saito (2009) suggested that shares of imports in consumption, potential growth, or level of the risk-free rate are the determinants of foreign reserve.

A NRB working paper of Adhikari (2018) to assess the impact of exchange rates on foreign exchange reserves using OLS over the period of 1975-2015 in Nepal concluded that when one percentage point depreciation of the rupee caused to rise in foreign exchange reserve by 0.82 percentage points. Thus, it can be found that exchange rate is the prime determinants of foreign exchanger reserve in Nepal. In Sri Lankan experiences over the period January 2003 to February 2020, Ariyasinghe, and Cooray (2021) applied ARDL then they concluded that the exchange rate influences the foreign exchange reserve.

Jena and Sethi (2020) employing ARDL-ECM with data of 1960-2018 concluded that current account balance, domestic credit of private sector, exchange rate, per capital GDP, inflation, real interest rate are long-run determinants of foreign exchange reserve in Brazil. A similar approach applied by Andriyani, et al. (2020) in the case of Indonesia over the period of January 2016 to December 2018 reported that foreign debt, inflation, export, and exchange rate affect the foreign exchange reserve.

According to empirical research, Bangladesh's foreign exchange reserves, exchange rate, broad money, remittances, home interest rate, export and import, and per capita GDP are all strongly correlated (Chowdhury, Uddin and Islam, 2014). Moreover, Narayan and Smyth (2006) applying ARDL-cointegration covering the data of 1980 to 2002 highlighted that the real exchange rate is positively impact on foreign exchange reserves in long-run in China. Sanusi, Meyer, and Hassan (2019) concluded that in the long run, exports, and import, inflation rate, and exchange rate are noteworthy determinants of foreign reserve in Southern African countries.

Suman and Aman (2021) studied in case of India using data over the period of 1991 to 2017 which reported that inflow of FDI, exports, exchange rate, and short-term debt affect the foreign exchange reserve. Similarly, Khomo, Mamba and Matsebula (2018) employing ARDL from 1990 to 2014 found that in long-run, GDP per capita and exchange rate positively and current account and government expenditure negatively influenced in the foreign exchange reserve in Eswatini. Gereziher and Nuru (2021) also applied ARDL in case of Ethiopia over the period of 1981 to 2017 which established the significant relations of inflation and external debt in foreign exchange reserve.

Most of the reviewed literatures focused on the optimal size of reserve, demand of reserves, and some macroeconomic determinants of reserve. There are so many literature available to report the effects of foreign exchange reserve in economy, conversely, we do not obtain the contribution sufficiently on determinants of foreign exchange reserve. In case of Nepal, there are only one study available while reviewing. Subsequently, this study is an attempt to fill the gap of such loopholes on the determinants of foreign exchange reserve in Nepal by applying ARDL-ECM model for short- and long-run effects and impulse response of its determinants on reserve.

Methods and Materials

To evaluate the determinants of foreign exchange reserve, this paper has used the time series data covering the period of 1980-2020. The data was exacted from the World Development Indicators (WDI) of World Bank. All variables of interest have transformed into a natural logarithm. Jena and Sethi (2020) applied most of the variables mentioned below in the context of Brazilian economy but this study has introduced other crucial variables and examined them in the context of the Nepali economy. In Table 1, dependent and explanatory variables, along with measurement units and sources, are described in detail.

Table 1

Description of Variables

Proxies	Description	Unit of measurement	Source
Dependent variable:			
TR	Total reserves (includes gold)	Current US$	WDI
Explanatory and Control variables:			
CAB	Current account balance	% of GDP	WDI
DCP	Domestic credit to private sector	% of GDP	WDI
EDS	External debt stocks	% of GNI	WDI
FDI	Foreign direct investment, net inflows	% of GDP	WDI
GFCF	Gross fixed capital formation	% of GDP	WDI
GPC	GDP per capita	Constant 2015 US$	WDI
INF	Inflation, GDP deflator	Annual %	WDI
M2	Broad money	% of GDP	WDI
OEX	Official exchange rate	LCU per US$, period average	WDI
TRADE	Trade	% of GDP	WDI

Note. GDP = Gross Domestic Product, WDI = World Development Indicators, LUC = Local Currency Units, US$ = United States dollar, GNI = Gross National Income.

This paper is based on a casual-comparative research design. The secondary time series data have used to estimate the determinants of foreign exchange reserve in Nepal. For that, econometric modeling with ARDL based regression and cointegration model has employed. For data processing and analysis, EViews and Excel have applied. To estimate the determinants of foreign exchange reserve in Nepal, the general functional model specification can be written as

$$TR = f(CAB, DCP, EDS, FDI, GFCF, GPC, INF, M2, OEX, TRADE)$$

$$TR_t = \alpha_0 + \alpha_1 CAB_t + \alpha_2 DCP_t + \alpha_3 EDS_t + \alpha_4 FDI_t + \alpha_5 GFCF_t + \alpha_6 GPC_t + \alpha_7 INF_t + \alpha_8 M2_t + \alpha_9 OEX_t + \alpha_{10} TRADE_t + \varepsilon_t$$

Firstly, unit root tests—Augmented Dickey Fuller (ADF) is employed to ensure the stationarity of the variables of interest. The autoregressive distributed lag (ARDL) model is employed due the the mixed order of integration of regressors. This paper thus, adopts the ARDL bound test for cointegration to determine the short and

long run determinants of foreign exchange reserve in Nepal. The Pesaran et al. (2001) model for ARDL for estimating short-run and long-run relationship can be expressed as:

$$\Delta Y_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i \Delta Y_{t-i} + \sum_{i=1}^{q} \alpha_j \Delta X_{t-i} + \beta_i Y_{t-i} + \beta_j X_{t-i} + \varepsilon_t$$

Short-run Long-run White noise

Here, parameters α_i and α_j are the short run and β_i and β_j are long run coefficients. Similarly, Y is the dependent and X is the explanatory and control variables. Likewise, ε_t is the white noise or error term. Similarly, p and q are the optimum lags for dependent variable and regressors respectively. With the given dependent variables and regressors, the ARDL model can be modified as follows:

$$\Delta RGPD_t = \alpha_0 + \sum_{i=1}^{p} \alpha_1 \Delta TR_{t-i} + \sum_{i=1}^{q} \alpha_2 \Delta CAB_{t-i} + \sum_{i=1}^{q} \alpha_3 \Delta DCP_{t-i} + \sum_{i=1}^{q} \alpha_4 \Delta EDS_{t-i} + \sum_{i=1}^{q} \alpha_5 \Delta FDI_{t-i} + \sum_{i=1}^{q} \alpha_6 \Delta GFCF_{t-i} + \sum_{i=1}^{q} \alpha_7 \Delta GPC_{t-i} + \sum_{i=1}^{q} \alpha_8 \Delta INF_{t-i} + \sum_{i=1}^{q} \alpha_9 \Delta M2_{t-i} + \sum_{i=1}^{q} \alpha_{10} \Delta OEX_{t-i} + \sum_{i=1}^{q} \alpha_{11} \Delta TRADE_{t-i} + \beta_1 TR_{t-i} + \beta_2 CAB_{t-i} + \beta_3 DCP_{t-i} + \beta_4 EDS_{t-i} + \beta_5 FDI_{t-i} + \beta_6 GFCF_{t-i} + \beta_7 GPC_{t-i} + \beta_8 INF_{t-i} + \beta_9 M2_{t-i} + \beta_{10} OEX_{t-i} + \beta_{11} TRADE_{t-i} + \varepsilon_t$$

To confirm the existence of cointegration or long-run relationship by employing bound test, this paper estimates the ARDL error correction model (ECM). The ARDL-ECM model can be specified as:

$$\Delta RGPD_t = \alpha_0 + \sum_{i=1}^{p} \alpha_1 \Delta TR_{t-i} + \sum_{i=1}^{q} \alpha_2 \Delta CAB_{t-i} + \sum_{i=1}^{q} \alpha_3 \Delta DCP_{t-i} + \sum_{i=1}^{q} \alpha_4 \Delta EDS_{t-i} + \sum_{i=1}^{q} \alpha_5 \Delta FDI_{t-i} + \sum_{i=1}^{q} \alpha_6 \Delta GFCF_{t-i} + \sum_{i=1}^{q} \alpha_7 \Delta GPC_{t-i} + \sum_{i=1}^{q} \alpha_8 \Delta INF_{t-i} + \sum_{i=1}^{q} \alpha_9 \Delta M2_{t-i} + \sum_{i=1}^{q} \alpha_{10} \Delta OEX_{t-i} + \sum_{i=1}^{q} \alpha_{11} \Delta TRADE_{t-i} + \xi ECT_{t-i} + \varepsilon_t$$

Accordingly, ξ is a parameter that shows the speed of adjustment and a short-run shock adjusts long-run equilibrium quickly via ECT, which is an error correction term.

Eventually, this paper has applied the impulse response functions (IRFs) to determine the response of TR when any innovation or standard shocks or impulse given to regressors.

Results and Discussion

This paper examines the determinants of foreign exchange reserve in Nepal where twelve explanatory and control variables have used. Under this section, the basic robustness test and ARDL model have employed. The results of such tests are presented below.

Unit Root Test

Stationarity of variables is very essential and crucial to apply ARDL model. To run ARDL, the conformation of order of integration is to be needed. To test the stationarity of variables of interest, Augmented Dickey Fuller (ADF) and Phillips Perron (PP) unit root techniques are used. The results of unit root tests are shown in the Table 2.

Table 2

Augmented Dickey Fuller (ADF) Unit Root Test Results

Variables	At Level			At First Difference			Order
	Cons.	Cons. & Trend	Non	Cons.	Cons. & Trend	Non	
	t-Stat	t-Stat	t-Stat	t-Stat	t-Stat	t-Stat	
TR	0.7972	-3.2581*	3.4325	-3.8254***	-3.9074**	-3.1348***	I(0)
CAB	-2.5389	-2.9639	-0.9051	-7.2736***	-7.1929***	-7.373***	I(1)
DCP	-0.071	-3.7109**	3.3429	-5.0919***	-5.0468***	-4.1868***	I(0)
EDS	-1.697	-2.6285	-0.2002	-3.6573***	-3.9245**	-3.6572***	I(1)
FDI	-3.3495**	-4.7039***	-0.5625	-9.7883***	-9.6587***	-9.8627***	I(0)
GFCF	-1.3744	-2.4942	1.1722	-7.3948***	-7.2529***	-7.0369***	I(1)
GPC	0.6493	-1.902	6.6771	-6.6993***	-7.1249***	0.0530	I(1)
INF	-3.504**	-3.8869**	-0.747	-9.1594***	-9.0976***	-9.2635***	I(0)
M2	0.3848	-3.648**	4.0503	-5.306***	-5.2845***	-3.8543***	I(0)
OEX	-3.0517**	-1.2275	2.2873	-4.3437***	-5.1287***	-2.9309***	I(0)
TRADE	-1.816	-1.3753	0.4171	-4.9464***	-5.0013***	-5.0226***	I(1)

Note. (*) Significant at the 10%; (**) Significant at the 5%; (***) Significant at the 1%.

Table 2 shows the test results of ADF unit root. ADF test confirms that all the variables are stationary at mixed order of I(0) and I(1) integration. Thus, the ADF test provides the evidence of stationary of variables of interest being consider under study. Based on this stationarity test, ARDL requirement of none of the variables are integrated with I(2) and above has satisfied.

Optimum Lag Selection

The lag length criteria in the ARDL model are established using the best lag selection criteria following the stationarity test. The ideal lag is chosen based on VAR lag order selection criteria. The optimal lag criteria are displayed in the Table 3.

Table 3

Results of Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	169.3946	NA	8.23e-18	-8.122798	-7.653588	-7.954450
1	539.1413	511.9570	2.98e-23	-20.87904	-15.24852*	-18.85886
2	721.7221	149.8099*	6.92e-24*	-24.03703*	-13.24521	-20.16502*

Note. * Implies the lag order selected by the criterion. LR = Sequential modified LR test statistic (each test at 5% level), FPE = Final prediction error, AIC = Akaike information criterion, SC: Schwarz information criterion, HQ = Hannan-Quinn information criterion

Table 3 reports the lag order selection criteria. LR, FPE, AIC, SC, HQ which are the basis criteria to select the optimal lags for the ARDL model. All these criteria allow lag 2 except SC is the optimal lag for the model. As most of the criteria suggested, in this paper, lag 2 has taken to run the ARDL model.

Model Selection

Pesaran et al. (2001) advanced the ARDL model for short and long run relationship between the variables of interest under study. It can be used while these variables are in mixed order of integration and none of them is I(2) and more. Most of the lowest values of FPE, AIC, and HQ criteria are suggested the 2 is the optimal lag for the ARDL model. Taking the consideration of optimal lag 2, the best ARDL model is ARDL (2, 0, 2, 2, 0, 1, 0, 1, 1, 2, 2). The 20 best models selected by AIC are exhibited in Figure 1.

Figure 1

Top 20 Models with Akaike Information Criteria

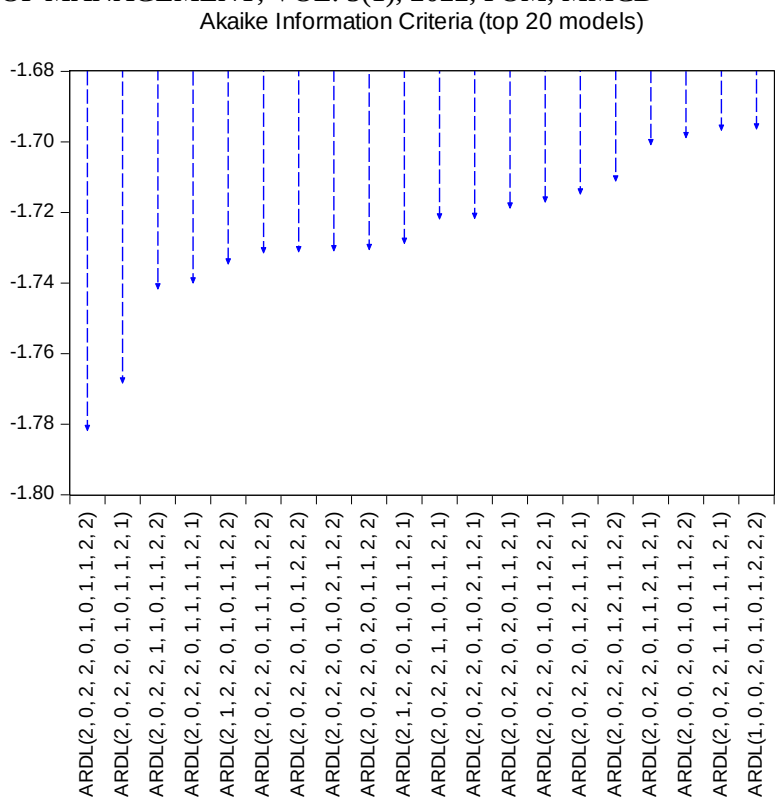


Figure 1 examines 20 best models before zeroing on the best ARDL models among all possible models with available variables and data set. The *ARDL* (2, 0, 2, 2, 0, 1, 0, 1, 1, 2, 2) may be the best model because of the lowest AIC. This model estimates the relation of lagged regressors with dependent variables. This ARDL model itemized the appropriate lags for regressors, namely, 2 lag for TR, 0 for CAB, 2 for DCP, 2 for EDS, 0 for FDI, 1 for GFCF, 0 for GPC, 1 for INF, 1 for M2, 2 for OEX, and finally 2 for TRADE.

Bound Test for Long-run Cointegration

ARDL bound test for cointegration test have applied to estimate the existence of long-run relationship among variables of interest. F-statistics of bound test for cointegration confirms such relationship. Pesaran, et al. (2001) provided the lower and upper bounds critical values to nullify the hypothesis of long-run or level relationship. The results of F-bound test with selected optimal lags are presented in the Table 4.

Table 4

Bounds Test Results

Test Statistic	Value	Signif.	I(0)	I(1)
			Asymptotic: n=1000	
F-statistic	9.150781	10%	1.83	2.94
K	10	5%	2.06	3.24
		2.5%	2.28	3.5
		1%	2.54	3.86

Table 4 exhibits the bound test results under ARDL model. In the table, F-statistics (9.150781) is greater than upper bound, I (0) at 1%, 2.5%, 5%, and as well as 10% level of significant which is failed to support the null hypothesis of level relationship. Thus, the bound test of cointegration reveals that there is strong level relationship or existence of long-run relationship between variables of interest accounting in this paper.

ARDL Error Correction Regression: Short-run Effects

Bound test for cointegration confirms to apply the ARDL-ECM. Bound test has evidence of cointegration among variables under study. Now, the ARDL-ECM is employed for short and long-run effect of regressors in foreign exchange reserve in Nepal. The FDI, CAB, and GPC are automatically excluded by the selected model in short run. The estimated results of rest of the regressors on TR as error correction regression are presented in the Table 5.

Table 5

Results of ARDL Error Correction Regression

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-2.710827	0.209357	-12.94832	0.0000
D(TR(-1))	0.203448	0.067674	3.006273	0.0089
D(DCP)	0.154662	0.134363	1.151073	0.2677
D(DCP(-1))	0.405518	0.146879	2.760903	0.0146
D(EDS)	0.882322	0.155034	5.691151	0.0000
D(EDS(-1))	0.749425	0.122443	6.120598	0.0000
D(GFCF)	-0.539285	0.187312	-2.879068	0.0115
D(INF)	0.180567	0.030140	5.990912	0.0000
D(M2)	0.737479	0.217424	3.391884	0.0040
D(OEX)	-0.210959	0.201708	-1.045861	0.3122
D(OEX(-1))	-1.689404	0.331023	-5.103585	0.0001
D(TRADE)	-0.208369	0.180642	-1.153490	0.2668
D(TRADE(-1))	0.324038	0.158453	2.045010	0.0588
CointEq(-1) = ECT_{t-1}	-0.349353	0.026972	-12.95239	0.0000
R-squared	0.904772	F-statistic		18.27145
Adjusted R-squared	0.855254	Prob(F-statistic)		0.000000

Table 5 portrays the ARDL model-based error correction term and short-run coefficient of regressors with foreign exchange reserve (TR). It is observed from Table 6, ECM_{t-1} is negative and significant at 1% level of significant. The statistically significant and negative ECM_{1-t} or cointegration equation implies that adjustment speedy or 34.9353% converses back in long-run if any previous year disequilibrium in regressors (CAB, DCP, EDS, FDI, GFCF, GPC, INF, M2, OEX, TRADE). It also confirms the existence of strong long-run or level relationship among the variables of interest under study.

Table 5 also reveals that differencing TR with lag 1 value itself positively and significantly influenced the TR in short-run. Present value of DCP is not significant but lagged value of DCP is positively significant and affects the TR. It is also observed that, the current and lagged values of EDS are significant and positively determined the TR. Likewise current value of GFCF is significant and negatively influenced the TR. Similarly current values of INF and M2 are statistically significant and positively affect the TR. Current year OEX does not statistically influence the TR but lagged value of OEX is significant and negatively affect the TR. Current year TRADE is not also significant but lagged or previous year TRADE is positively influenced the TR.

Moreover, adjusted R^2 elucidates that regressors (CAB, DCP, EDS, FDI, GFCF, GPC, INF, M2, OEX, TRADE) explain the change in foreign exchange reserve by 85.5254%. It assures the goodness-of-fit for ARDL model. Similarly, significant F-statistic also reveals that there is significant relationship between regressors and predicted variable.

Level Relationship: Long-run Effects

ARDL Error correction form of cointegration confirms that there is strong long-run relationship between variables of interest. The results of long-run coefficients are presented in the Table 6.

Table 6

Results of Long-run Coefficient

Variable	Coefficient	Std. Error	t-Statistic	Prob.
CAB	0.140525	0.139387	1.008163	0.3294
DCP	-1.135122	1.320499	-0.859616	0.4035
EDS	-0.455998	0.483302	-0.943505	0.3604
FDI	1.874873	0.720793	2.601124	0.0201
GFCF	-4.134605	1.590379	-2.599761	0.0201
GPC	6.324556	3.414528	1.852249	0.0838
INF	1.100157	0.428805	2.565633	0.0215
M2	-1.608239	1.326720	-1.212192	0.2442
OEX	2.366209	0.955540	2.476307	0.0257
TRADE	0.105079	1.383879	0.075931	0.9405

Table 6 demonstrates the long-run coefficient of regressors on TR. In long-run, CAB, DCP, EDS, M2, and TRADE are not significantly influenced the TR in long-run. However, rest of the variables have significant effect on TR. TR is

positively influenced by FDI, GPC, INF, and OEX and negatively by GFCF. Table also reveals that when 1% rise in FDI would result to increase TR by 1.874873% in long-run. Similarly, when 1% increase in GPC, INF, and OEX, then in long-run it would cause to rise in TR by 6.324556%, 1.100157%, and 2.366209% respectively. In contrary, TR would reduce 4.134605% when 1% rise in GFCF in long-run in Nepal.

Diagnostic and Stability Tests The robustnessss of selected *ARDL* is fulfilled by various diagnostic tests. Serial correlation, heteroskedasticity, normality, and model specification tests have been used to determine the fitness of the model. The estimated results are present in Table 7.

Table 7

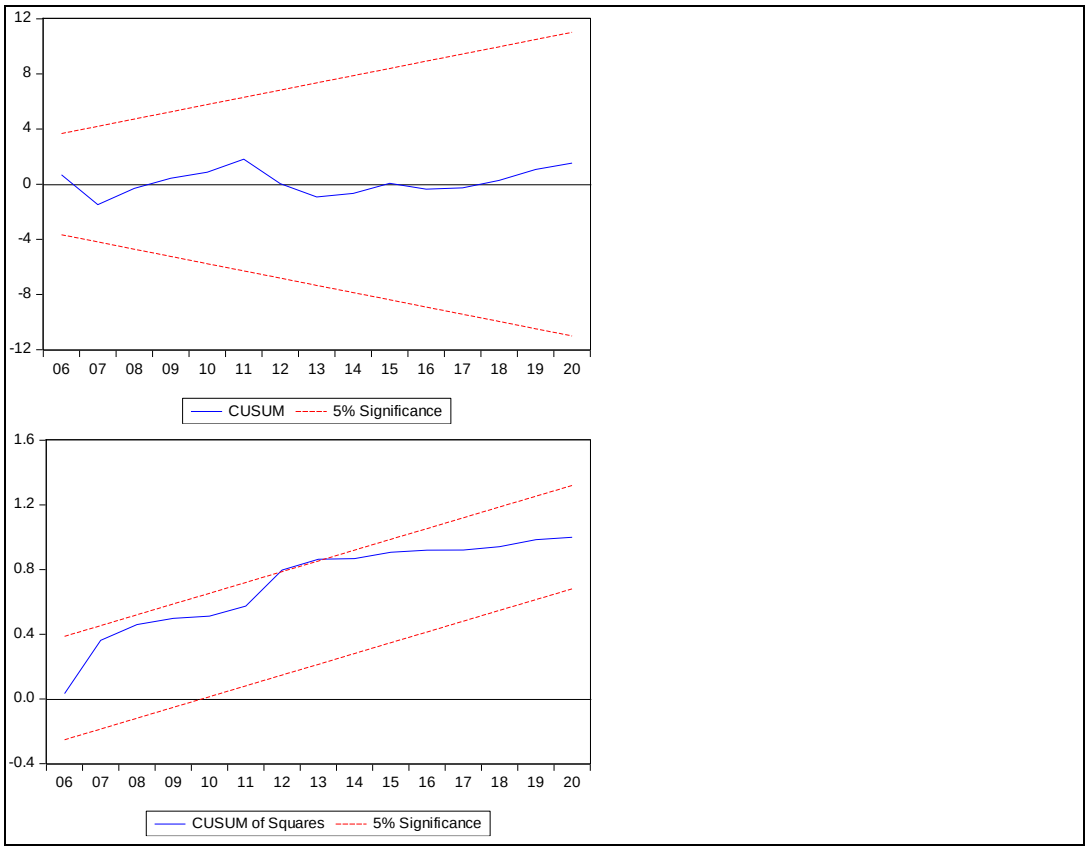
Results of Various Diagnostic Test

Diagnostic Test	Observed R^2	Prob. χ^2	Remarks
Breusch-Godfrey Serial Correlation LM Test	2.946482	0.0861	No serial correlation (at 5%)
Heteroskedasticity Test: Breusch-Pagan- Godfrey	22.82206	0.4712	No heteroskedasticity
Normality Test (Jarque-Bera)	3.476489	0.175829	Residuals are normally distributed

Table 7 reveals that all the diagnostic test results are not significant at 5% level of significant. Thus, the test against serial correlation (Breusch-Godfrey test) confirms that there is no serial correlation. Test against heteroskedasticity (Breusch-Pagan-Godfrey) also supports the view that there is no heteroskedasticity and is free from autocorrelation. Jarque-Bera statistic of normality test shows the residuals are normally distributed. Thus, the selected ARDL model is well fitted and specified. CUSUM and CUSUM of square confirm the ARDL-ECM parameters' stability. The Figure 2 shows the stability test results with CUSUM and CUSUM of square of the selected model.

Figure 2

CUSUM and CUSUM of Square



The plot of CUSUM and CUSUM of Square lies between the 5% level of critical boundary which confirms that ARDL-ECM parameters are stable. The plots fail to reject the null hypothesis of stability of parameter and hence the mode is stable and robust to study the determinants of foreign exchange reserve over the period of 1980 to 2020.

Impulse Response Functions (IRFs): Robustness of Cointegration

The impulse responses is derived from standard structural vector autoregressive models (SVAR) where there are highly nonlinear functions of the model parameters. It can be applied with the series which have both I(0) and I(1) order of integration (Lütkepohl and Krätzig, 2004). This is applied to illustrate the dynamic relationship of variables and their shock in one or more variables of interest. IRFs

describe the responsiveness of the foreign exchange reserve (TR: dependent variable) to the shocks to each of the variables under study (Brooks, 2008; Hamilton, 1994). Apart from ARDL model, the IRFs have applied and the results are presented in the Figure 3.

Figure 3

Impulse Responses of TR to Predictors

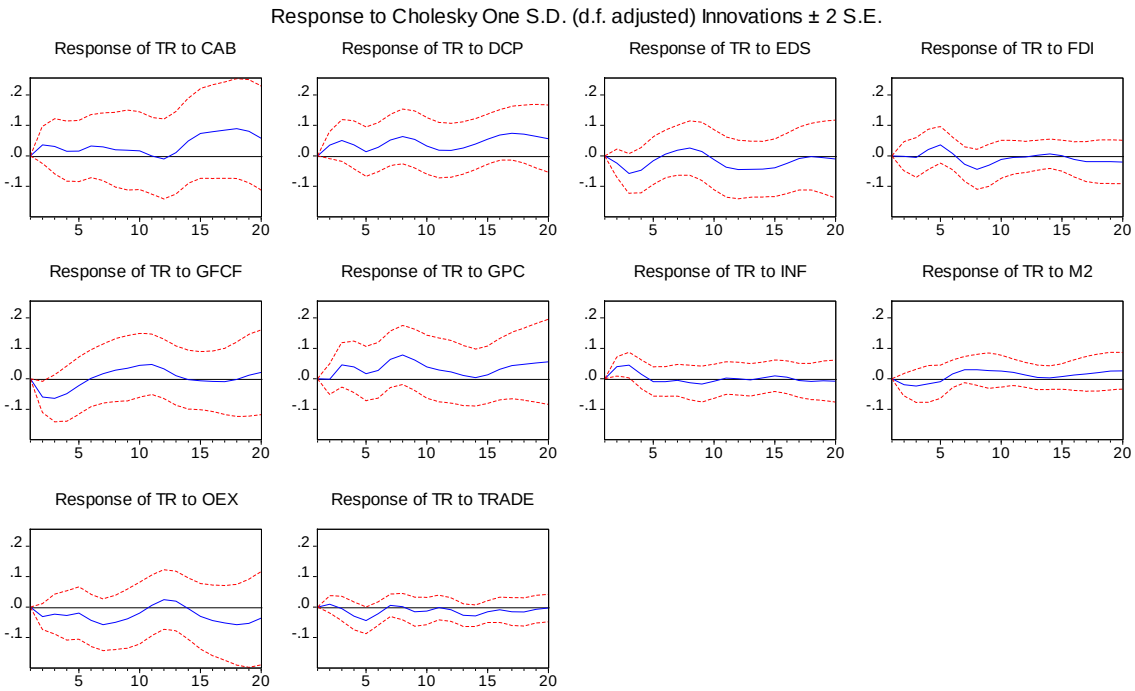


Figure 3 shows the responses of TR when one-unit standard shock or innovation is given to explanatory variables based on SVAR. The table summarizes the effects of one unit innovation in different impulses on TR.

Table 8

Summarization of Impulses and Response of TR

Impulses	Responses
CAB	The TR is initially increased, then falls to the 12th period, and then it is increased again.
DCP	There is always a positive fluctuation in TR.
EDS	TR falls from the very beginning, then turns positive after the 6th period. After period 10, it becomes negative.
FDI	In the first six periods of TR, there is a positive TR, then a negative TR until the thirteenth period. From period 15 onwards, it increases a little, then falls.
GFCF	From the 6th period onward, TR is negative, but by the 13th period, it has increased. Thereafter, it falls until period 18 and then increases.
GPC	The TR is a positive trend that fluctuates throughout all periods.
INF	More or less, TR is reducing and walking on a zero line.
M2	There is a decline in TR until period 6, then there is a positive response.
OEX	Up until the 11th period, TR is negative, then it increases slightly.
TRADE	The TR fluctuates from period to period and is always negative.

Conclusion and Implication

This paper explores the determinants of foreign exchange reserve in Nepal that attempts to fill the empirical gap. ARDL-ECM and IRFs are employed to estimate the long-run and short-run effects including ten explanatory and control variables—CAB, DCP, EDS, FDI, GFCF, GPC, INF, M2, OEX, TRADE covering the period of 1980-2020. ARDL error correction regression reveals that foreign exchange reserve (TR) with lag 1, lagged value of domestic credit to private sector (DCP), the current and lagged values of external debt stocks (EDS), the current values of inflation (INF) and broad money (M2), lagged value of TRADE have positive effects on foreign exchange reserve (TR) in short run. However, the current value of gross fixed capital formation (GFCF) and lagged value of official exchange rate (OEX) have negatively influenced on foreign exchange reserve (TR) in the short run. The stylized facts also insight that net flows of foreign direct investment (FDI), GDP per capita (GPC), inflation (INF),

and official exchange rate (OEX) have positively influenced the foreign exchange reserve (TR) in long run. On the contrary, gross fixed capital formation (GFCF) has negative effects on TR in long run. However, current account balance (CAB), domestic credit to private sector (DCP), external debt stocks (EDS), broad money (M2), and TRADE have no significant effect on TR. On the other hand, impulse response functions also reveal that any one unit of innovation or standard shock is given to CBA, DCP, and GPC, and foreign exchange reserve (TR) responses positively all the periods. There is an inverse response of TR when one unit impulse on FDI and Trade. Any one unit of innovation to EDS, GFCF, INF, M2, and OEX, foreign exchange reserve (TR) responds both positively and negatively, where most of the period, TR negatively responses while the impulse is given to OEX.

The study also reports that GPC, INF, and OEX are largely and positively determined the shape of TR. Apart from that GFCF is crucial to downsize the TR. On contrary, the anticipated crucial proxies—CAB and TRADE are positively influenced but not significant. However, any impulse on CAB results a significant response of TR. Thus, the central bank of Nepal and policymakers are needed to focus on the productivity of gross fixed capital formation or domestic investment to maintain reserve adequacy. It is also suggested that policymaker should give their attention to the current account balance (import and export) that can maintain the foreign exchange reserve and financial/economic stability and safety. Additionally, a rise in the exchange rate can make exports less profitable, a rise in GDP per capita is a sign of rising productivity, a rise in inflation may raise living expenses, and policymakers should concentrate on the challenges and adversity of these consequences.

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