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Central Bank of Tunisia's foreign exchange reserves during the crisis period: Key determinants and a currency-based approach to optimizing structure

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Abstract

This paper examines the main determinants of foreign exchange reserves in Tunisia over a period from 1992 to 2022, totalling 30 annual observations. Using the ARDL model, we include several variables in our study, such as total international reserves, the balance of current payments, public foreign debt, the official exchange rate, inflation, foreign direct investment and workers' abroad remittances. The aim is to identify the variables that affect Tunisia's foreign exchange reserves. The results indicate that trade deficit reduces foreign exchange reserves, highlighting the importance of stimulating exports. Foreign debt shows a positive correlation with reserves, although this relationship is less pronounced than expected. Depreciation of domestic currency and inflation increase reserves, as do foreign direct investment and workers' remittances. In the short term, almost all determinants have an effect on reserves, with the exception of workers' remittances. Readjustment to long-term equilibrium is rapid, with a 43% recovery. It is therefore essential to optimally manage reserves to balance risks.

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1. Introduction

Managing foreign exchange reserves is much more than just a financial practice, it is a central component of a country's economic strategy. They act as a buffer against financial fluctuations and economic crises. Mainly consisting of foreign currencies and managed by central banks, these reserves play a fundamental role in maintaining the value of the national currency and facilitating trade with international partners. Their importance has been particularly highlighted by events such as the Asian crisis of 1997, which underlined the need for countries to hold adequate reserves in order to preserve economic stability in an uncertain global environment.

This study focuses on the economic dynamics underlying the management of foreign exchange reserves in Tunisia over the 1992 to 2022 period. Using the ARDL model, it seeks to identify the main factors influencing the level of these reserves.

This study aims to deepen understanding of the mechanisms involved, and to formulate strategic recommendations for improving the management of foreign exchange reserves in the country.

Thus, the main objective is to determine the long-term and short-term relationships between foreign exchange reserves and various key economic variables, such as trade deficit, foreign debt, the official exchange rate, inflation, foreign direct investment and workers' remittances. These factors are not independent; they interact and influence each other, shaping the overall economic environment and influencing foreign exchange reserve management.

According to Simamora, R. M., and Widanta, A. A. (2021), several factors have affected Indonesia's foreign exchange reserves between 2014 and 2019. Using secondary data and multiple linear regression models, the authors showed that the value of exports and the exchange rate had a positive and significant effect on foreign exchange reserves. Inflation, on the other hand, had a negative and insignificant effect on these reserves. On the other hand, Misztal, P. (2021), studying the evolution of the People's Central Bank of China's foreign exchange reserves between 1990 and 2019, revealed a significant correlation between changes in foreign exchange reserves and movements in foreign direct investment as well as fluctuations in import expenditure. These results indicate that foreign exchange reserve management was aimed at providing adequate protection against potential economic crises, in order to maintain an optimal level of financial robustness.

The results of this study reveal several important conclusions. In the long term, the trade deficit exerts significant negative pressure on foreign exchange reserves. Although foreign debt positively correlates with reserves, this effect remains moderate, underlining the importance of prudent management to avoid excessive indebtedness. Thus, depreciation of the domestic currency and inflation contribute to increasing reserves, while foreign direct investment and workers' remittances also play a role in strengthening them.

In the short term, almost all determinants appear to influence foreign exchange reserves, indicating a dynamic of rapid readjustment towards a long-term equilibrium. These results highlight the importance for Tunisian decision-makers of implementing economic policies aimed at stimulating exports, prudently managing foreign debt and encouraging foreign investment. By adopting these measures, they can maintain optimal foreign exchange reserves, thereby ensuring the country's financial stability.

In conclusion, this study provides a valuable perspective on the determinants of foreign exchange reserves in Tunisia, offering a crucial analytical framework to guide the country's future economic policies. By promoting exports, prudently managing foreign debt and encouraging foreign investment, Tunisia can strengthen its financial stability and promote sustainable, inclusive economic growth. By adopting a proactive and strategic approach, Tunisian decision-makers can ensure the economy's resilience to external shocks, while supporting long-term sustainable economic development.

2. Research methodology

This study uses a rigorous methodology, consisting of annual data from 1992 to 2022 from sources such as the World Bank and the Central Bank of Tunisia (CBT). Adopting a quantitative approach, our analysis is based on the Auto-Regressive Distributed Lag (ARDL) model, recognized for its ability to explore long- and short-term relationships between various economic variables. This method enables us to examine in depth the determinants of foreign exchange reserves in Tunisia, providing an informed understanding of the underlying economic dynamics. Through this combination of empirical data and advanced statistical analysis, our study aims to provide essential insights to guide policymakers in their efforts to optimize foreign exchange reserve management and strengthen the country's economic stability.

The general formulation of the ARDL model equation is:

$$\Delta Y_t = \alpha_0 + \sum_{t=1}^{p} \emptyset_i \Delta Y_{t-i} + \sum_{j=0}^{q} \theta_j \Delta X_{t-j} + \delta_1 Y_{t-1} + \delta_2 X_{t-1} + \varepsilon_t \qquad (1)$$

Our model is written as follows:

$$\mathrm{LFORE} = \alpha_1 + \sum_{i=1}^{p} \beta_{1\,i} * \mathrm{LBPC}_{t-i} + \sum_{i=1}^{p} \beta_{2\,i} * \mathrm{LDEX}_{t-i} + \sum_{i=1}^{p} \beta_{3\,i} * \mathrm{LEXR}_{t-i} + \sum_{i=1}^{p} \beta_{4\,i} * \mathrm{LINF}_{t-i} + \sum_{i=1}^{p} \beta_{5\,i} * \mathrm{LIDE}_{t-i} + \sum_{i=1}^{p} \beta_{6\,i} * \mathrm{LTRE}_{t-i} + \nu_t \qquad (2)$$

Where P represents the optimal number of lags for each variable and i varies from 1 to p.

Table 1: Description of variables

Variables	Description	Source
Dependent variable **LFORE**	Total international reserves	World Bank
Independent variables **LBPC**	Balance of current payments	World Bank
LDEX	Foreign debt	Ministry of Finance's website
LEXR	Official exchange rate	World Bank
LINF	Inflation	World Bank
LIDE	Foreign direct investments	World Bank
LTRE	Workers' remittances	Central bank of tunisia

Source : Author

All the variables in the model are expressed in logarithmic form, a method that offers a number of analytical advantages. In addition, the use of logarithms facilitates interpretation of the coefficients like elasticities of the variables against each other.

3. Test results

Table 2: Descriptive statistics

	LFORE	LBPC	LDEX	LEXR	LINF	LIDE	LTRE
Mean	14.05933	1.464736	4.142059	0.387093	1.513766	0.849253	7.227424
Median	14.18337	1.399299	4.094458	0.307809	1.506994	0.764086	7.383750
Maximum	14.88899	2.381001	4.605759	1.076514	2.647970	2.243337	8.033944
Minimum	12.92775	-0.075400	3.905689	-0.122808	0.754466	-0.106386	6.353290
Std. Dev.	0.578322	0.642440	0.190552	0.342585	0.400107	0.498530	0.487984
Skewness	-0.366293	-0.428914	1.127161	0.694674	0.612877	0.564552	-0.347597
Kurtosis	1.877613	2.374206	3.360070	2.509615	3.927117	3.585165	1.734905
Jarque-Bera	2.245542	1.409360	6.514518	2.713460	2.952524	2.021615	2.604701
Probability	0.325377	0.494267	0.038494	0.257501	0.228490	0.363925	0.271892
Sum	421.7798	43.94208	124.2618	11.61279	45.41297	25.47760	216.8227
Sum Sq. Dev.	9.699237	11.96916	1.052991	3.403575	4.642490	7.207434	6.905719
Observations	30	30	30	30	30	30	30

Source: Author's calculations

This table summarizes the descriptive statistics of the variables studied from 1992 to 2022, highlighting the proximity between means and medians, suggesting almost symmetrical distributions. Some variables, such as LFORE, LBPC, LIDE and LTRE, show high volatility and increased risk. The negative skewness of LFORE, LBPC and LTRE indicates a left-skewed distribution, which may have unfavourable implications, while the other variables show positive skewness, reflecting favourable economic conditions. Thus, all variables show a kurtosis greater than 0, indicating a leptokurtic distribution with thick tails, and a kurtosis

greater than 3 suggests a higher frequency of outliers. In addition, the Jarque-Bera test results are below 5% for most variables, with the exception of LDEX, suggesting some uncertainty in the latter's prediction.

Table 3: Correlation analysis

	LFORE	LBPC	LDEX	LEXR	LINF	LIDE	LTRE
LFORE	1	0.144389	0.127913	0.609671	0.103254	-0.012561	0.944565
LBPC	0.144389	1	0.317124	0.516061	0.373976	-0.187697	0.314360
LDEX	0.127913	0.317124	1	0.716654	0.166447	-0.331370	0.274122
LEXR	0.609671	0.516061	0.716654	1	0.204301	-0.293928	0.757339
LINF	0.103254	0.373976	0.166447	0.204301	1	-0.198636	0.085126
LIDE	-0.012561	-0.187697	-0.331370	-0.293928	-0.198636	1	-0.130651
LTRE	0.944565	0.314360	0.274122	0.757339	0.085126	-0.130651	1

The correlation matrix highlights several significant relationships between the studied variables. A significant positive correlation (+0.944565) is observed between foreign exchange reserves and workers' remittances, underlining the importance of these transfers in supporting foreign exchange reserves and economic stability. In contrast, foreign exchange reserves show low correlation with foreign debt (+0.127913), balance of current payments (+0.144389) and inflation (+0.103254), suggesting prudent and diversified financial management. To check and assess the potential impact of these correlations, we will use the unit root test

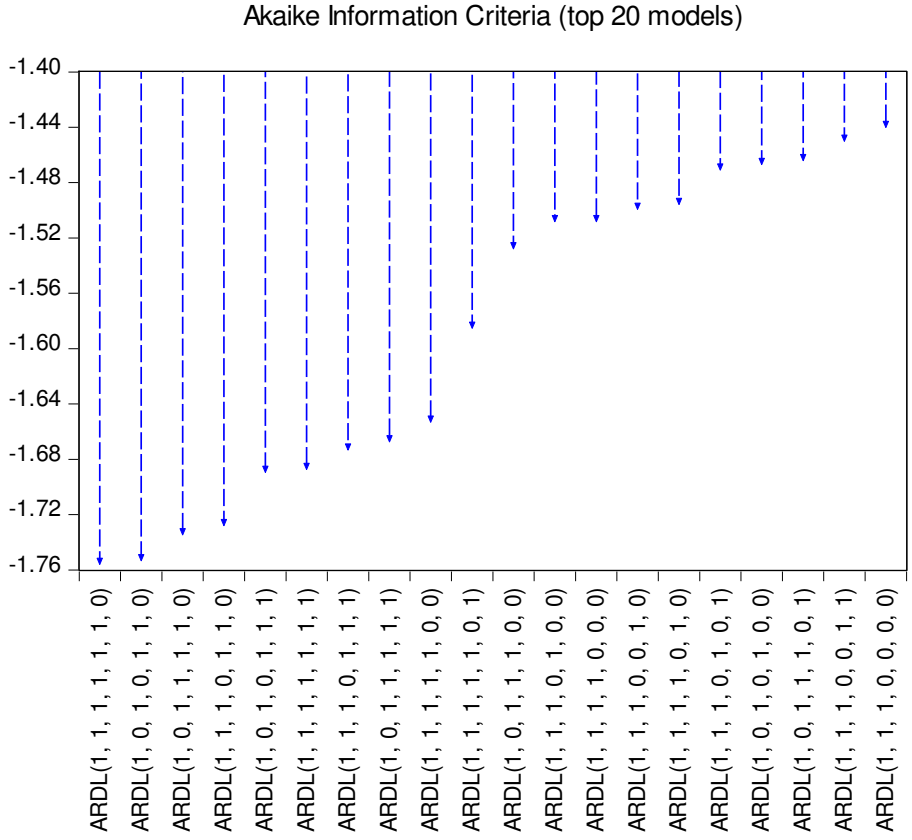
Table 4: Unit root test

	ADF				***PP***			
	In level		**In first difference**		**In level**		**In first difference**	
	Constant	**Constant and tendency**	**Constant**	**Constant and tendency**	**Constant**	**Constant and tendency**	**Constant**	**Constant and tendency**
LFORE	-1.779028 (0.3829)	-1.680597 (0.7340)	-4.896890 (0.0005)	-5.438748 (0.0018)	-1.775130 (0.3847)	-1.869292 (0.6443)	-4.927534 (0.0005)	-5.048639 (0.0018)
LBPC	-1.687223 (0.4269)	-2.880878 (0.1832)	-5.826390 (0.0000)	-5.921965 (0.0002)	-1.730663 (0.4059)	-2.323586 (0.4090)	-5.808949 (0.0000)	-5.921965 (0.0002)
LDEX	-0.343299 (0.9063)	-0.928955 (0.9387)	-3.887771 (0.0062)	-4.106749 (0.0163)	-0.892709 (0.7761)	-1.288888 (0.8707)	-4.007810 (0.0046)	-4.103360 (0.0164)
LEXR	0.461083 (0.9823)	-1.009821 (0.9275)	-4.131519 (0.0033)	-4.310070 (0.0100)	0.461083 (0.9823)	-1.197413 (0.8930)	-4.131519 (0.0033)	-4.292921 (0.0104)
LINF	-2.283471 (0.1837)	-5.026000 (0.0017)	-11.01593 (0.0000)	-10.88516 (0.0000)	-4.901823 (0.0004)	-5.076241 (0.0015)	-24.22792 (0.0001)	-35.16215 (0.0000)
LIDE	-3.881671 (0.0060)	-3.980866 (0.0206)	-8.903724 (0.0000)	-8.732469 (0.0000)	-3.830329 (0.0068)	-3.946038 (0.0222)	-13.00911 (0.0000)	-12.77362 (0.0000)
LTRE	-0.969699 (0.7510)	-2.034766 (0.5587)	-4.275407 (0.0023)	-4.232094 (0.0120)	-0.977102 (0.7484)	-1.760376 (0.6985)	-4.293076 (0.0022)	-4.219202 (0.0123)

Table 6 shows that, with the exception of LIDE, all variables become stationary after an initial differentiation, justifying the use of the ARDL model. The Phillips-Perron (PP) test confirms these results.

Foreign exchange reserves, balance of current payments, foreign debt, the exchange rate, inflation and workers' remittances are order 1integrated, showing a rapid response to economic shocks and convergence towards equilibrium in the long term. Foreign direct investment, stationary at order 0, is less sensitive to transitory shocks. In fact, the PP test largely validates the results of the ADF test. Thus, the use of the ARDL model is appropriate.

Figure 1: Lag length criteria selection



Source: Author's calculations

The choice of the optimal number of lags, using the Akaike Information Criterion (AIC), is made by selecting the lowest AIC value, indicating the best balance between complexity and goodness of fit. For most of the studied variables, a lag of 1 is optimal, suggesting that a model taking into account past values for up to one year offers the best forecast and fit without unnecessary complexity.

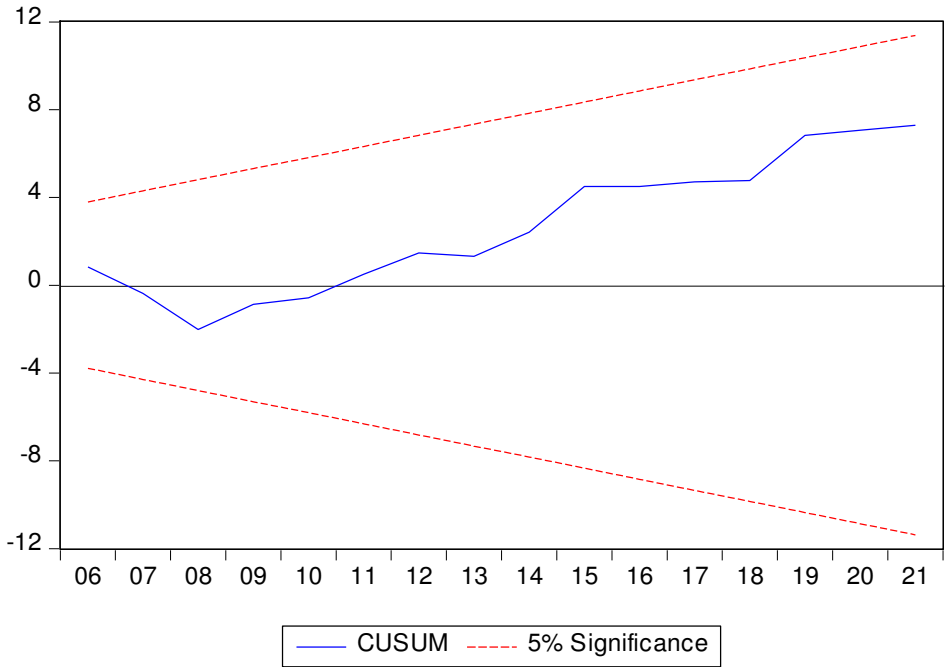
Table 5: ARDL model validity and robustness tests

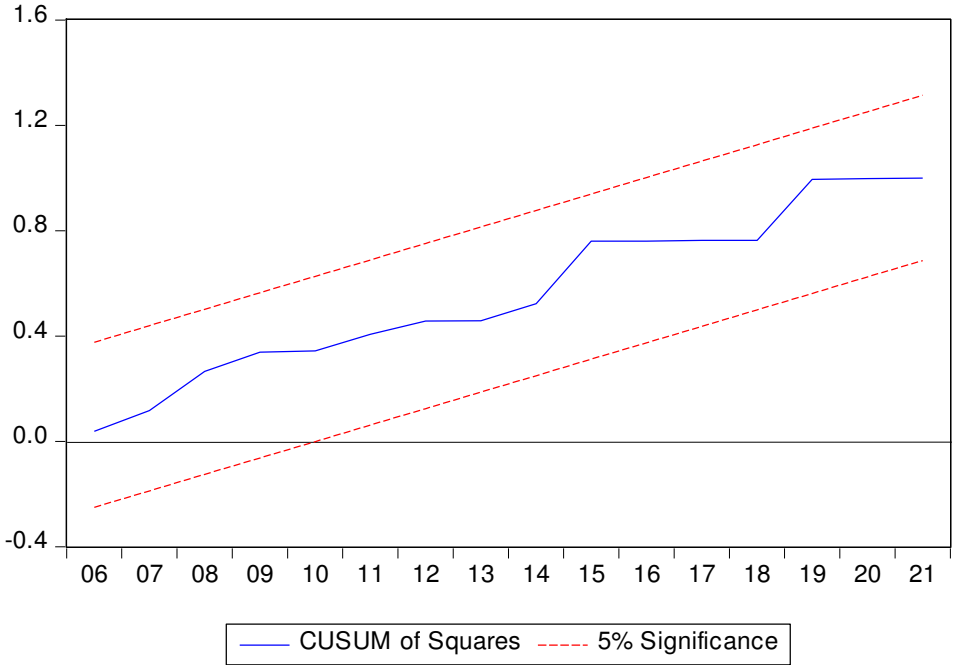
Tests	H0	Results	Interpretation
Ramsey test	The model is correctly specified	0.007855 (0.9306)	The model is correctly specified
Breusch-Godfrey test	No autocorrelation	0.891671 (0.5189)	Errors do not auto-correlate
ARCH Test	No heteroscedasticity	0.264221 (0.6116)	Errors are homoscedastic
Jarque-Bera Test	Normal distribution	0.992398 (0.608841)	Normal distribution
CUSUM Test	Distribution is stable	between -4 and 4	Model is stable

Source: Author's calculations

The model's validation tests indicate its accuracy and reliability. In fact, the Ramsey test confirms the model's correct specification, while the Breusch-Godfrey test shows absence of autocorrelation with a probability of 0.5189. Furthermore, the ARCH test indicates homoscedasticity of errors with a probability of 0.6116, and the Jarque-Bera test reveals a normal distribution of residuals with a probability of 0.608841. These results attest to the robustness and reliability of the model, guaranteeing reliable economic forecasts.

Figure 2: CUSUM Test





Source: Author's calculations

The CUSUM curve remains within the 5% significance limits, attesting to the model's stability over the studied period, a finding reinforced by concordance with the squared CUSUM curve.

Table 6: Co-integration Bound test

F- statistic	Significance	I(0) Lower bound	I(1) Upper bound
6.953096	10%	2.12	3.23
	5%	2.45	3.61
	2.5%	2.75	3.99
	1%	3.15	4.43

Source: Author's calculations

Table 5 displays test results highlighting an F-statistic of 6.953096, exceeding both the lower and upper bounds. This indicates a long-term Co-integration relationship between the variables, confirming a stable and sustainable relationship over the long term. This finding reinforces the validity and reliability of the results obtained.

Table 7: Long-term relationship results

Variables	Coefficients	St.Dev	T-Student	Probability
LBPC	-0.491752	0.175725	-2.798421	0.0129
LDEX	0.287180	0.624623	0.459765	0.6519
LEXR	-0.545552	0.489634	-1.114204	0.2816
LINF	0.943000	0.326745	2.886046	0.0107
LIDE	0.516238	0.239601	2.154573	0.0468
LTRE	1.486163	0.223489	6.649841	0.0000

Source: Author's calculations

Table 8: Short-term relationship results

Variables	Coefficients	St.Dev	T-Student	Probability
C	0.544537	0.056642	9.613694	0.0000
D(LBPC)	-0.307635	0.039291	-7.829668	0.0000
D(LDEX)	1.457538	0.223063	6.534192	0.0000
D(LEXR)	-0.853251	0.271372	-3.144212	0.0063
D(LINF)	0.268047	0.037021	7.240354	0.0000
D(LIDE)	0.140240	0.026471	5.297933	0.0001
CointEq(-1)*	-0.425583	0.052023	-8.180681	0.0000

Source: Author's calculations

$$EC = LFORE - (-0.4918 * LBPC + 0.2872 * LDEX - 0.5456 * LEXR + 0.9430 * LINF + 0.5162 * LIDE + 1.4862 * LTRE) \quad \textbf{(3)}$$

This study shows that workers' remittances increase foreign exchange reserves by 1.486% for every 1% increase. Balance of current payments decreases reserves by 0.492% per 1% increase, while foreign debts and foreign direct investment increase them by 0.287% and 0.5162% respectively. The exchange rate reduces reserves by 0.547% per 1% increase, while inflation increases them by 0.943%.

In the short term, variations in the balance of current payments, foreign debt and the exchange rate have a strong effect on reserves. A return to equilibrium after an imbalance takes around 2 years, 4 months and 73 days. Appropriate policy adjustments are required to maintain financial stability.

4. Conclusion

This study adds to the recent empirical literature by examining the determinants of foreign exchange reserves in Tunisia. We found a long- and short-term relationship between the studied variables. The trade deficit, for example, reduces foreign exchange reserves, highlighting the need to stimulate exports. While foreign debt shows a positive but moderate correlation with reserves, currency depreciation, inflation and foreign investment contribute to their increase. In the short term, almost all factors affect reserves, with the exception of workers' remittances.

These conclusions are supported by the ARDL model, recognized for its empirical robustness, and corroborated by previous studies such as Jena and Sethi (2021).

It is also essential to consider the optimal structure of foreign exchange reserves to guarantee a country's economic and financial stability. Indeed, a less-than-optimal structure of reserves can lead to international imbalances.

Consequently, it is imperative that Tunisian policy-makers pay particular attention to maintaining foreign exchange reserves, while taking into account the country's development needs.

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