African Scientific Journal
ISSN : 2658-9311
Vol : 3, Numéro 23, Avril 2024

Foreign exchange risk associated with debt: Application of the VaR approach to Morocco's foreign debt portfolio.

Auteur 1 : Nouhaila BELFATMI.
Auteur 2 : Hicham OUAKIL.

Nouhaila BELFATMI, (Doctorante)
Université Ibn Tofail / Faculté d'Economie et de Gestion de Kénitra - Maroc

Hicham OUAKIL, (Professeur Universitaire Phd)
Université Ibn Tofail / Faculté d'Economie et de Gestion de Kénitra - Maroc

Déclaration de divulgation : L'auteur n'a pas connaissance de quelconque financement qui pourrait affecter l'objectivité de cette étude.

Conflit d'intérêts : L'auteur ne signale aucun conflit d'intérêts.

Pour citer cet article : BELFATMI .N & OUAKIL .H (2024) « Foreign exchange risk associated with debt: Application of the VaR approach to Morocco's foreign debt portfolio », African Scientific Journal « Volume 03, Numéro 23 » pp: 0427 – 0441.

Date de soumission : Mars 2024

Date de publication : Avril 2024

DOI : 10.5281/zenodo.11032437

African Scientific Journal
ISSN : 2658-9311
Vol : 3, Numéro 23, Avril 2024

Abstract

The aim of this article is to assess the exchange rate fluctuation risk associated with Morocco's foreign debt, using the Value At Risk (VaR) method. To this end, daily data concerning the value of the Moroccan dirham against two major currencies used for debt, namely the Euro and the Dollar, were analyzed. The study focuses on the period after flexibilization, running from 01/01/2018 to 31/12/2021.

Examination of the currency betas in the portfolio, together with VaR analysis, indicates that the US Dollar presents a significant risk. However, the euro could serve as a hedge against this currency risk for Morocco's external debt portfolio. It is therefore strongly recommended to adopt a hedging policy to improve the efficiency of foreign exchange risk management. This involves specifying acceptable risk limits and appropriate hedging methods, using financial instruments such as forward contracts. These strategies make it possible to fix an exchange rate in advance to limit the impact of fluctuations on repayments.

Keywords

Foreign exchange risk, External public debt, Value at Risk, Morocco.

Résumé

Cet article vise à évaluer le risque de fluctuation des taux de change lié à la dette extérieure du Maroc en utilisant la méthode de la Value At Risk (VaR). Pour ce faire, des données quotidiennes concernant la valeur du Dirham marocain par rapport à deux devises majeures utilisées pour l'endettement, à savoir l'Euro et le Dollar, ont été analysées. L'étude se concentre sur la période après la flexibilisation, s'étendant du 01/01/2018 au 31/12/2021.

L'examen des bêtas des devises dans le portefeuille, ainsi que l'analyse des VaR, indique que le dollar américain présente un risque significatif. Cependant, l'euro pourrait servir de couverture contre ce risque de change pour le portefeuille de la dette extérieure du Maroc. Par conséquent, il est fortement conseillé d'adopter une politique de couverture afin d'améliorer l'efficacité de la gestion du risque de change.. Cela implique d'indiquer d'une part les limites de risque acceptables et dans une autre part, les méthodes de couverture appropriées en recourant à des instruments financiers à titre des contrats à terme. Ces stratégies permettent de fixer un taux de change à l'avance pour limiter l'impact des fluctuations sur les remboursements.

Mots clés :

Risque de change, Dette publique extérieure, Value at Risk, Maroc

African Scientific Journal
ISSN : 2658-9311
Vol : 3, Numéro 23, Avril 2024

Introduction:

External debt is the total amount a country owes to other nations or international organizations. This includes loans obtained from banks, bonds issued on financial markets, and loans granted by lenders such as the IMF. External debt can serve as a means for countries to finance their economic growth, but it can also prove to be a burden if interest rates are high, or if the country is experiencing difficulties in repaying its financial obligations.

Several international agreements and mechanisms have been established to regulate the external debt of nations. For example, the WB and IMF offer lines of credit and loan programs designed to assist countries in times of economic and financial crisis. These programs are usually accompanied by conditions, such as economic reforms or budget adjustments, with the aim of guaranteeing the long-term sustainability of national debt.

Other initiatives, such as the Debt Transparency Initiative, seek to stimulate transparency, accountability and responsibility in the administration and management of nations' external debt. The idea is to ensure that borrowing countries can repay their debt in a sustainable manner, and that lenders understand the risks associated with their loans.

At the end of 2022, Morocco's outstanding foreign debt [1]stood at MAD 423.6[2] billion, corresponding to 31.8%[3] of the country's GDP. Morocco's external debt is made up of two main components: loans contracted with international lenders such as the World Bank and the IMF, and sovereign debt in the form of bonds issued on the financial markets.

Over the past few years, public external debt has evolved, reaching an outstanding amount of DH339.9 billion in 2019, an increase of 4.1% compared with the end of 2018. During this period, the ratio of public external debt as a % of GDP remained stable at 29.5%. This trend is influenced by various factors, including crises, external shocks and the global geopolitical context.

Our article adopts the following structure: the first section is dedicated to a literature review. The second examines the main stylized facts in Morocco. The third section describes the data, introduces the VaR approach and outlines the research methodology. The fourth section focuses on the VaR calculation for each sub-portfolio and the main outputs of this study.

[1] From treasury funds plus guaranteed debt
[2] HCP data
[3] HCP data

African Scientific Journal
ISSN : 2658-9311
Vol : 3, Numéro 23, Avril 2024

I. Literature review

The World Bank and the IMF have repeatedly noted that the public debt portfolio generally represents a country's most important financial asset. This imposes on governments the need to control the risks that expose their economies to external shocks. Consequently, numerous empirical studies have used the Value at Risk method to assess the risks present in these portfolios.

Pritsker (1997) examined six VaR models using currency option portfolios to compare the calculation time required and the accuracy of the results, demonstrating that delta normal simulation was the most accurate of the six methods used. Danielsson and de Vries (2000) reported that VaR methods are appropriate for data with normal and heavy-tailed distributions, but do not support the analysis of intra-day and daily VaR as it is not necessarily appropriate. Consequently, they concluded that historical simulation methods outperformed the VaR method but were subject to high variances and discrete sampling towards the extremes of stock distributions.

The study by Wissem Ajili (2008) looks at the evaluation of the foreign exchange risk associated with Tunisia's public debt, using the VaR approach with the normal delta version. This methodology requires the use of daily exchange rate data, transformed into geometric returns, in order to assess this risk. The author observed that the non-normality of the overall portfolio can be better managed by subdividing it into annual sub-portfolios.

The study by kbar, F., & Chauveau, T. (2009) analyzes the foreign exchange risk associated with three currencies, namely the Euro, US Dollar and Japanese Yen, on Pakistan's Public Debt Portfolio (PDPP) using Value-at-Risk (VaR) methodology for the period 2001 to 2006. It was found that Pakistan's public debt management with regard to exchange rate exposure lacks a hedging strategy. This is evident from the fact that none of the currencies making up the PDPP has a negative beta or negative component VaR. Analysis of the marginal betas and VaRs reveals that the dollar is individually the least risky currency and the Japanese yen the riskiest currency making up the PDPP.

Mensah, A. C et al (2014) assessed the foreign exchange risk associated with Ghana's public debt using the daily exchange rates of the Ghanaian cedi relative to the three main currencies: the dollar, the euro and the pound during the period from 04/01/2000 to 31/12/2009. Their results show that the VaR result is very high and that it is necessary for the government to also trade in a currency that can serve as a potential hedge against the risk.

African Scientific Journal
ISSN : 2658-9311
Vol : 3, Numéro 23, Avril 2024

The study by Ragbi, Nihou and Tounsi (2016) highlights the role of exchange rate policy in public debt sustainability. Their research suggests that coordination between monetary policy-and fiscal policy-is necessary to contribute to local currency stability and, by extension, public debt sustainability. A well-coordinated exchange rate policy can play a crucial role in public debt management. Fluctuations in exchange rates can have a significant impact on the real cost of external debt, affecting the overall sustainability of a country's debt. Effective coordination between monetary policy and the exchange rate regime can help mitigate the risks associated with exchange rate fluctuations, thereby helping to maintain the stability of the national currency.

In their study Ogawa, M. Aet al (2018) aimed to measure the risk of the Brazilian real's exchange rate, as well as to test the hypothesis stipulating that there is a remarkable difference in volatility between the baskets of emerging and developed country currencies. Using parametric VaR based on extreme value distributions, it was observed that the Brazilian real presented a higher exchange rate risk. The results also showed that distribution assumptions do not seem to follow any specific pattern when comparing emerging and developed countries, and that emerging countries also showed lower volatility, reflecting the predominance of factors external to the foreign exchange market in determining the risk of certain currencies.

Saadah, S., & Sitanggang, M. L. (2020) aimed to measure the risk associated with IDR /USD exchange rate fluctuations using the value-at-risk (VaR) method. The authors mobilized data on the daily exchange rate of the IDR[4] / USD between July 31, 2018 and July 31, 2019. The authors' results assert that, for banks, higher capital reserves equate to a higher opportunity cost. Thus, they highlight the value of the strict backtesting [5]approach is important to prevent a bank from underestimating its potential risks.

II. The Value at Risk approach: methodological analysis

Value at Risk is a risk management approach developed in the 1990s by financial risk professionals and academics. Initially designed to assess market risk, it has been extended to assess other financial risks such as credit and liquidity risk. VaR is widely adopted in the financial industry, employed by a variety of institutions including banks, investment firms and

[4] Indonesian Rupiahs

[5] Backtesting is an essential method for evaluating how a trading strategy would have performed on historical data. This involves applying the trading strategy to past data to see how it would have performed under real conditions. This enables traders and analysts to understand the strategy's potential behavior in different market scenarios, and to adjust the strategy accordingly to improve its future performance.

African Scientific Journal
ISSN : 2658-9311
Vol : 3, Numéro 23, Avril 2024

insurers to assess and control their risk exposures. Regulatory authorities also use VaR to establish capital requirements for financial institutions.

VaR is also a tool for measuring the risk of loss associated with an investment or portfolio of investments. It evaluates the maximum probable loss that an investment could incur over a specific period, taking into account a given level of confidence. In the context of exchange rates, VaR would quantify the potential loss on a position exposed to a foreign currency, influenced by fluctuations in exchange rates. For example, a company holding debt denominated in a foreign currency could use VaR to estimate the possible loss on this debt due to movements in the exchange rate between this foreign currency and the company's domestic currency. VaR can be calculated over various periods, such as daily, weekly or monthly, and for different confidence levels, such as 95% or 99%.

Three main methods are generally used to assess the Value at Risk (VaR) of a portfolio: the parametric method, the historical method and the Monte Carlo method. These approaches were identified and discussed by C. Semper and M. Clemente in their 2003 paper.

The parametric VaR method offers a practically straightforward analytical approach, but is based on restrictive theoretical assumptions. The most famous model, such as that of Risk Metrics (Peter J. G. Vlaar 2000), is based on significant simplifying assumptions. It assumes that distributions of market price changes follow normal probability distributions, and that instruments exhibit a linear risk profile. This method uses the variance-covariance matrix to directly calculate the VaR of positions held. However, its main strength and weakness lies in its dependence on the assumption of normal distribution. An alternative method bypasses this assumption.

The historical VaR method is based on the assumption that potential future market evolutions will be similar to those of the past, generally based on daily variations in market prices or risk factors observed over a given period, such as the previous year. These variations are then applied to current positions to estimate the distribution of potential losses, as described by D. Bams, T; Lehnert and C.C. P. Wolff in 2005.

The third method combines aspects of the previous approaches, while avoiding exclusive reliance on normal distribution. Known as the Monte Carlo simulation method, introduced by David J. Bolder in 2008, it requires a large number of simulations. Initially, this method defines the return distributions of the risk factors affecting the value of the portfolio, using stochastic models in particular. It then simulates multiple future scenarios to represent the various possible risk factor trajectories. The results of these simulations are used to model the distribution of

African Scientific Journal
ISSN : 2658-9311
Vol : 3, Numéro 23, Avril 2024

profits and losses, thus facilitating VaR calculations, as detailed by Selim Cakir and Faezeh Raie in 2007.

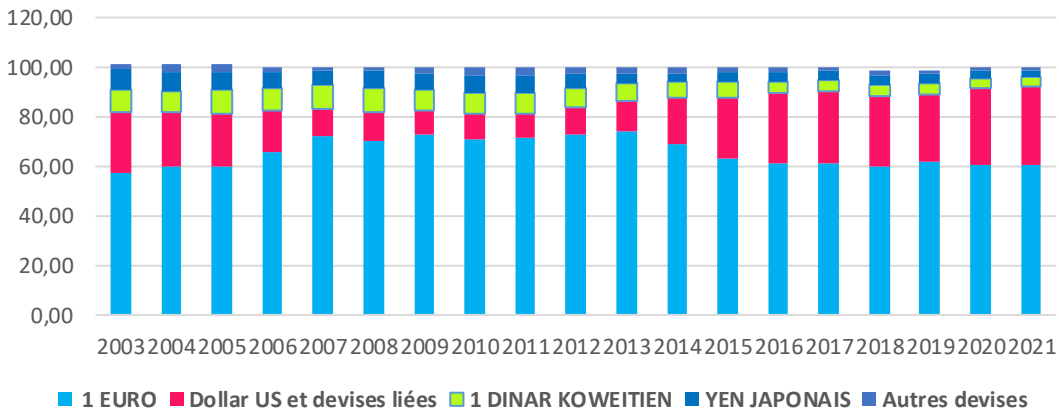
III. Exchange rate regime and external public debt: stylized facts

Morocco's exchange rate regime represents the system or method used to establish the value of the national currency in relation to foreign currencies, encompassing approaches such as fixed, floating or intermediate exchange rate regimes. Over time, Morocco has adopted different exchange rate strategies, aiming to stabilize its currency while adjusting to economic conditions and international influences. These exchange rate choices can have an impact on various economic aspects, such as international trade, inflation, foreign investment flows and export competitiveness.

Morocco's external public debt is the total amount of funds borrowed by the government from foreign entities or international organizations. These funds are intended to finance infrastructure projects, social programs or cover the country's financial needs.

The components of public debt by currency stand out for the growing predominance of the euro, rising from 57% in 2003 to 60.6% in 2023, while the share of the Japanese yen has declined from 8% in 2003 to 2.6% in 2023, mainly due to a lack of issues on the market. On the other hand, the dollar rose significantly during this period, as a result of the government's strategic reorientation towards these new markets (see figure below).

Figure 1: ***breakdown of public external debt by currency (in millions of moroccan dirhams)***



Source: Author's elaboration (MEF-Morocco data)

The amounts and breakdown of Morocco's external public debt by creditor may vary over the years, depending on the State's budgetary policies, repayment terms and specific agreements

African Scientific Journal
ISSN : 2658-9311
Vol : 3, Numéro 23, Avril 2024

with the various lending institutions and countries. In 2021, 42.78% of this debt will be held by multilateral creditors, 24.73% by the IMF and commercial banks, and 19.26% by bilateral creditors.

Table 1: ***Outstanding public external debt by main creditors in million MAD***

	2012	2014	2016	2019	2021
Bilateral	8 878	9 072	8 945	9 114	9 084
UE	2 077	1 914	1 771	1 540	1 390
Arab countries	807,00	769,00	867,00	1 282	1 105
Other countries	2 169	1 814	1 950	1 816	1 719
FMI & Commercial banks	3 935	7 719	7 799	8 900	11 662
International institutions	12 409	13 961	14 206	17 586	20 173

Source: Author's elaboration (MEF-Morocco data)

Public debt servicing, which includes repayment of borrowed capital as well as debt servicing and any other associated costs, has increased considerably in recent years, particularly in the post-Covid period.

Public debt is currently a crucial issue, especially in a multi-crisis context. Indeed, governments have taken emergency measures to support affected economies, resulting in a remarkable increase in public debt in many countries. Massive spending on economic support, stimulus packages and social welfare programs has increased government borrowing, thereby raising debt servicing costs.

This increase in debt servicing can have long-term implications for public finances. Governments must juggle repayment of borrowed capital, associated interest, and sometimes other charges, which can weigh on the budget and limit investment capacity in growth sectors such as education, health, or infrastructure.

Morocco is establishing debt management strategies to maintain the sustainability of its external financial commitments. This may involve differentiating sources of financing, refinancing existing debts on more favorable terms, negotiating new agreements with creditors, or closely monitoring exchange rates and global financial markets to assess the potential impact on debt. Exchange rates and global financial markets to assess the potential impact on debt.

African Scientific Journal
ISSN : 2658-9311
Vol : 3, Numéro 23, Avril 2024

Table 2 ***: Total external public debt service in million MAD***

	2012	2014	2015	2019	2021
creditors	19 958	22 585	24 694	29233,00	41446,00
Bilateral	7590,00	8006,00	8568,00	11478,00	11374,00
UE	4690,00	5529,00	5815,00	8183,00	8290,00
Arab countries	873,00	883,00	955,00	1212,00	1645,00
Other countries	2027,00	1594,00	1798,00	2083,00	1440,00
FMI & Commercial banks	10525,00	11579,00	11730,00	13326,00	16545,00
International institutions	1843,00	2999,00	4396,00	4429,00	13527,00

Source: Author's elaboration (MEF-Morocco data)

IV. Data and empirical methodology

This research highlights the impact of exchange rate variations on public external debt, emphasizing the importance of a more effective exchange rate policy and strategic debt management. By focusing specifically on the two main currencies present in Morocco's external debt portfolio, namely the euro and the dollar, Morocco could reduce volatility by adjusting the currency allocation of its external debt. The key idea is that the structure of this debt offers policy-makers opportunities to guard more effectively against disadvantageous exchange rate fluctuations.

The aim of this article is to calculate the maximum loss associated with Moroccan foreign debt, attributable to variations in the currencies in its portfolio. To achieve this, we will use the Value at Risk (VaR) method, adopting the historical approach with a confidence level of 95%.

1. Variables and data

Our database consists of two exchange rates for the Moroccan dirham: Dh/USD and Dh/EUR. These choices are motivated by the fact that a large proportion of Morocco's external public debt is denominated in these currencies. Our study is based on daily data covering the period 01/01/2018 to 31/12/2022. These exchange rates, which represent current currency values, are

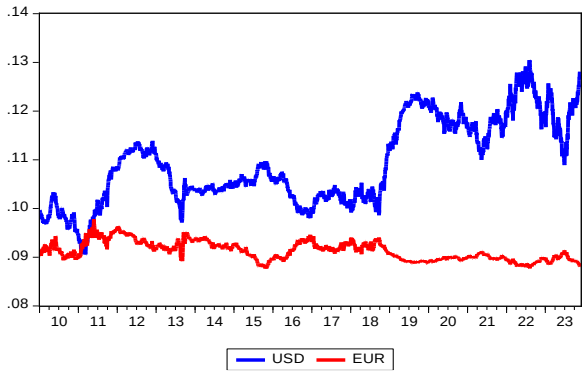
African Scientific Journal
ISSN : 2658-9311
Vol : 3, Numéro 23, Avril 2024

obtained from the investing[6] database. To assess the currency risk associated with Morocco's external public debt, the initial exchange rate data are transformed into geometric mean returns, expressed as a percentage.

1. Descriptive statistics

Before 2012, the exchange rate of the Moroccan dirham against the dollar and the euro showed fluctuations in which the dollar was relatively close to the euro. However, after 2012, this trend changed, with a significant increase in the gap between the exchange rate of the Dollar and that of the Euro against the Moroccan Dirham.

Figure 2 : ***Moroccan dirham exchange rate trends (2010-2023)***



Source: Elaboration by the author based on investing data

Descriptive statistics are shown in table (3), while table (4) shows the correlation between the different currencies. Indeed, we note that the average value of the USD exchange rate over the period is 0.109252, against a value of 0.091277 for the Euro. Also, the maximum USD rate is recorded in 05/03/2011. While the maximum value for the Euro is 0.091277 recorded 05/03/2011. Dispersion within the data seems relatively low, as standard deviations are generally smaller than the observed averages.

[6] https://www.investing.com/currencies/usd-mad-historical-data

African Scientific Journal
ISSN : 2658-9311
Vol : 3, Numéro 23, Avril 2024

Table 3 : ***Descriptive statistics for variables***

	USD	EUR
Mean	0.109252	0.091277
Median	0.106879	0.091200
Max.	0.130387	0.097840
Min	0.090519	0.087650
Std Dev.	0.008699	0.001912
Skewness	0.314358	0.355717
Jarque-Bera	193.5165	161.7065
Probability	0.000000	0.000000
Sum	396.6941	331.4263
Sum Sq. Dev.	0.274665	0.013276

Table 4 : ***Correlations between variables***

	USD	EUR
USD	1	-0.6477
EUR	-0.6477	1

Source: Compiled by the author on the output of Eviews

The correlation matrix reveals a negative correlation between the euro and the dollar: as the dollar exchange rate rises, the euro exchange rate falls, and vice versa.

2. Estimating VaR for Morocco

To assess the foreign exchange risk associated with Morocco's foreign debt, we choose to use the Value at Risk approach, applying the historical method with a confidence level of 5%. This method is used to estimate the risk associated with the fluctuation of each currency involved in the debt.

VaR analysis based on the historical method led to the results summarized in the graph below, representing the VaR of the various sub-portfolios. The values on the vertical axis indicate the maximum loss in millions of Moroccan dirhams per day associated with a government debt

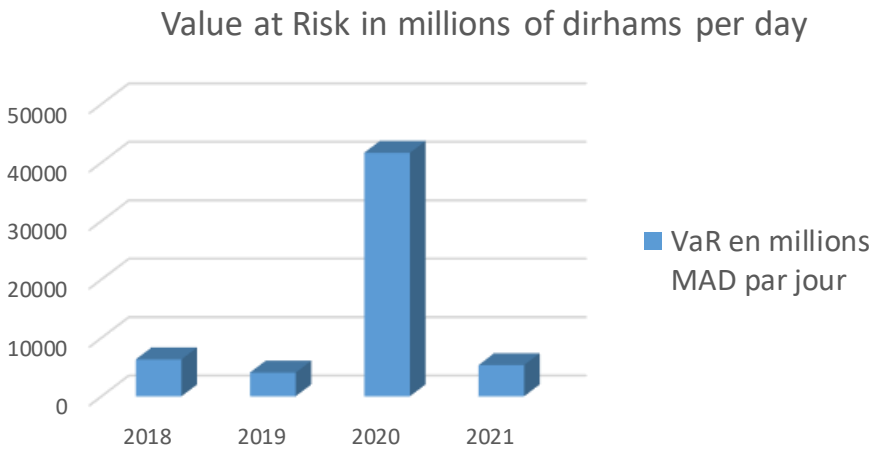
African Scientific Journal
ISSN : 2658-9311
Vol : 3, Numéro 23, Avril 2024

portfolio. This portfolio is considered to have an invariant currency composition with a confidence level of 95%.

The results of the VaR analysis highlight the relatively controlled management of currency risk in the Moroccan public debt portfolio, with the exception of the year 2020, marked by external shocks due to the repercussions of Covid-19. On a representative portfolio of 1425.073 billion Moroccan dirhams, the maximum possible daily loss for this portfolio ranges from 4 to 42 billion MAD over the period 2018 to 2021.

Year-on-year, the relative stability of currency risk in Morocco's debt portfolio appears to be better controlled, particularly during the first two years of transition to a more flexible exchange rate regime. Despite this, the Value at Risk (VaR) associated with the various annual sub-portfolios remains unstable, peaking in 2020, mainly due to the disruption caused by the pandemic crisis.

Figure 3 : ***Calculated VaR (95% confidence level)***



Source: Compiled by the author from Excel output

Calculating betas by currency, as summarized in the table below, shows that the slope associated with the euro is lower than that of the dollar. Consequently, the euro acts as a risk buffer within the Moroccan public external debt portfolio, while the dollar is more of a source of risk. This is clearly demonstrated by the currency structure[7] of Moroccan public external debt and trading partners.

[7] At the end of 2020, the breakdown of currencies within public external debt showed a predominance of euro-denominated debt, accounting for 60.6% of the total, followed by debt denominated in US dollars and other related currencies (30.7%). The Kuwaiti dinar accounted for 3.9%.

African Scientific Journal
ISSN : 2658-9311
Vol : 3, Numéro 23, Avril 2024

This structure, closely aligned with the composition of the dirham reference basket, helps to reduce the exposure of the public external debt portfolio to currency risk. This limits the impact of these fluctuations on the total amount of debt as well as on the associated interest payments. In 2018, Morocco began a transition to a more flexible exchange rate regime by gradually widening the fluctuation band of its currency. Initially set at ± 0.3%, this margin was extended to ± 2.5% in 2018, then to 5% in March 2020. This move towards a more flexible exchange rate regime may impact both monetary policy and the domestic economy, allowing the currency to fluctuate more in line with market conditions.

*Table 5 :**Betas calculated by currency (2018-2021)***

	USD	EURO
Bêtas par devises	0,73597784	0,26402216

Source: Compiled by the author

African Scientific Journal
ISSN : 2658-9311
Vol : 3, Numéro 23, Avril 2024

Conclusion:

The foreign exchange risk associated with Morocco's foreign debt represents a potential vulnerability to fluctuations in exchange rates. It encompasses the potential loss of financial exposure due to fluctuations in foreign currencies against the domestic currency. Since Morocco borrows on international markets, it is exposed to exchange rate fluctuations, which can influence the real cost of debt repayment in domestic currency. Tools such as Value-at-Risk (VaR) are used to estimate and assess this risk by quantifying the maximum potential loss at different confidence levels in the event of adverse movements in exchange rates.

An assessment of the Value at Risk of Morocco's external public debt portfolio reveals stability in the management of this risk from one year to the next. The VaR analysis carried out using the historical simulation method shows that the US dollar is a significant source of risk over the period from 2018 to 2021.

Our analysis shows that Morocco's public debt policy management, particularly with regard to currency risk, adopts a convergent hedging strategy. This solid approach to debt sustainability is designed to protect the country from sudden fluctuations in the financial markets, as well as the economic disruptions that could ensue.

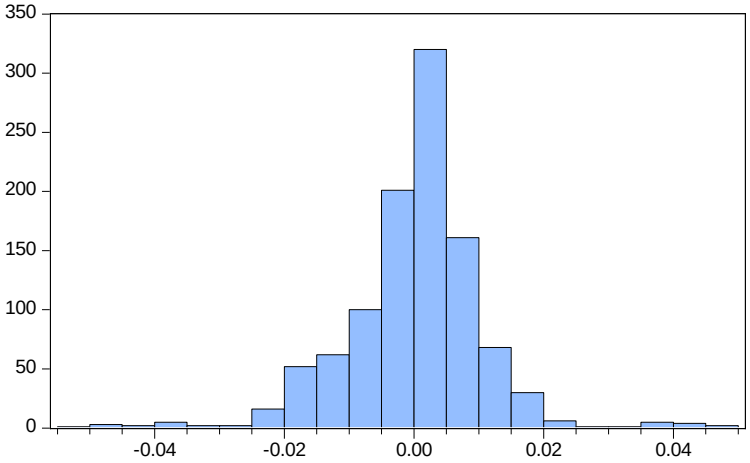
Consequently, assessing the risks associated with public debt is a crucial step in its management. This approach helps to minimize fragility, particularly in the face of global financial fluctuations. For Morocco, it is essential to focus on the risk induced by exchange rate fluctuations when managing the public debt portfolio, especially in times of multiple crises.

Consequently, a hedging policy is strongly recommended for a more effective foreign exchange risk management strategy. This involves defining acceptable risk limits and appropriate hedging methods, using financial instruments such as forward contracts. These strategies make it possible to fix an exchange rate in advance to limit the impact of fluctuations on repayments.

African Scientific Journal
ISSN : 2658-9311
Vol : 3, Numéro 23, Avril 2024

Annexes : Test for reliability

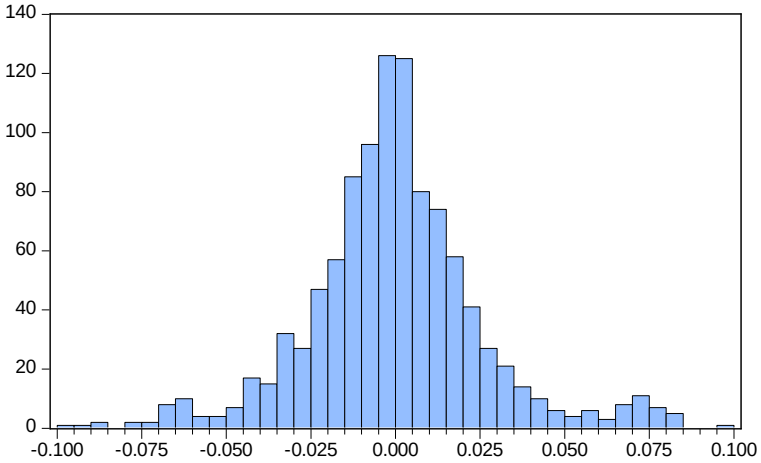
Table 6 : ***Normality of the Euro***



Series: _EUR	
Sample 1/01/2018 12/31/2021	
Observations 1044	
Mean	4.81e-05
Median	0.001110
Maximum	0.049056
Minimum	-0.050924
Std. Dev.	0.010551
Skewness	-0.255581
Kurtosis	7.182751
Jarque-Bera	772.4159
Probability	0.000000

Source: Eviews output

Table 7 : ***Dollars normality***



Series: _USD	
Sample 1/01/2018 12/31/2021	
Observations 1044	
Mean	-0.000150
Median	-0.000844
Maximum	0.095260
Minimum	-0.096967
Std. Dev.	0.026078
Skewness	0.224464
Kurtosis	4.835090
Jarque-Bera	155.2555
Probability	0.000000

Source: Eviews output

African Scientific Journal
ISSN : 2658-9311
Vol : 3, Numéro 23, Avril 2024

Références bibliographiques

Ajili, W. (2008). A value-at-risk approach to assess exchange risk associated to a public debt portfolio: the case of a small developing economy. In *Risk Management And Value: Valuation and Asset Pricing* (pp. 11-60).

Bams, D., Lehnert, T., & Wolff, C. C. (2005). An evaluation framework for alternative VaR-models. Journal of International Money and Finance, 24(6), 944-958.

Bolder, D. J., & Romanyuk, Y. (2008). Combining Canadian Interest Rate Forecasts. In Interest Rate Models, Asset Allocation and Quantitative Techniques for Central Banks and Sovereign Wealth Funds (pp. 3-30). London: Palgrave Macmillan UK.

Danielsson, J., & De Vries, C. G. (2000). Value-at-risk and extreme returns. Annales d'Economie et de Statistique, 239-270.

kbar, F., & Chauveau, T. (2009). Exchange rate risk exposure related to public debt portfolio of Pakistan: Application of value-at-risk approaches. *SBP Research Bulletin*, *5*(2), 11-27.

Maroc, R. (2022). Projet de Loi de Finances pour l'année budgétaire 2022. MINISTÈRE DE L'ÉCONOMIE ET DES FINANCES, Morocco.Saadah, S., & Sitanggang,

Mensah, A. C., Okyere, E., Antwi, O., Kumi, P., Dadzie, J., & Amoamah, M. O. (2014). Assessing foreign exchange risk associated to a public debt portfolio in Ghana using the value at risk technique. International Journal of Economics, 3(2), 21-34.

M. L. (2020). Value at risk estimation of exchange rate in banking industry. Jurnal Keuangan dan Perbankan, 24(4), 474-484.

Ogawa, M. A., Costa, N. J. D., & Moralles, H. F. (2018). Value-at-Risk (VaR) Brazilian Real and currencies of emerging and developing markets. *Gestão & Produção*, *25*, 485-499.

Pritsker, M. (1997). Evaluating value at risk methodologies: accuracy versus computational time. Journal of financial services research, 12(2-3), 201-242.