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Testing the random walk of stock price returns on the UMOA'S financial market

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Abstract: As part of the analysis of the behavior of financial asset prices, the objective of this study is to test the hypothesis of the random walk of stock prices on the BRVM regional financial market. Based on stock market returns calculated over the period from September 18 to December 30, 2022, stationarity tests and the use of an integrated autoregressive moving average model were used. The results show that the hypothesis of the random walk of returns of the BRVM10 index is verified and that the UMOA's regional financial market is efficient in its weak form.
Keywords: Random walk, informational efficiency, weak form, BRVM 10, stationarity, ARIMA

I. INTRODUCTION

The analysis of the behavior of financial asset prices has always been at the center of financial theory and mainly of scientific reflection on the role and functioning of capital markets. Significant successive work has thus been carried out on the evolution of financial asset prices. Almost at the initiative of these various contributions are scientific reflections on the random nature of the evolution of stock prices with the corollary work on the informational efficiency of financial markets. The random walk model, or the random walk hypothesis, is a mathematical model applied in financial markets. This model is considered one of the most important models for evaluating the price behavior of financial assets. Its objective is to represent stock market variations, and is based on the non-predictability of the prices of financial securities and that they evolve in a random manner.

Tests of scientific postulates on the random behavior of financial asset prices and the informational efficiency of financial markets do not find consensual results which can be explained by several factors including the frequency of trading on financial markets or related structural considerations. to these markets. Thus, according to the random walk model, the prices of financial assets should evolve randomly and therefore be unpredictable. However, all the tests of the random walk of the prices of financial assets on the financial markets do not allow us to conclude that this random walk of prices exists, calling into question in some ways the hypothesis of informational efficiency, particularly in its weak form.

Focusing on the UMOA's regional financial market, the study questions the existence of random behavior of stock prices. Therefore, the objective of this study, as part of the analysis of stock market variations, is to test the hypothesis of the random walk of stock prices on the BRVM regional financial market. Specifically, this involves testing the stationarity of the returns of the BRVM 10 index using the augmented Dickey-Fuller test (ADF), the modified Dickey-Fuller test (DF-GLS) then the Phillips-Fuller test Perron (PP) and, using an ARIMA model (p,d,q), to model the returns of the BRVM 10 index over the period of the study. The study covers a fairly large period of 24 years of daily data, going from September 18, 1998 to December 30, 2022. The WAMU regional financial market, considered an emerging financial market, includes few studies focusing on the behavior of financial asset prices. In addition, various structural shocks influence the functioning of the market and the evolution of the prices of financial assets with a certain evolution in the stock market culture of the players in this regional financial market. Thus, based on this observation and taking into account previous work on this market, this study postulates that the prices of financial assets on the regional financial market of the WAMU follow a random walk. It should be emphasized that testing the random walk hypothesis involves testing the hypothesis of informational market efficiency in the weak sense (Ifleh and El Kabbouri, 2021) [1]. This is of very important interest for financial market participants because the results of such a study could contribute to strengthening the BRVM's investment and financial market control strategies based at least on the predictable nature or not of prices. scholarship holders.

This study has three sections: a critical review of the literature, both theoretical and empirical (section 1), the presentation of the analysis model adopted (section 2) and the presentation of the results and their discussion (section 3).

II. LITERATURE REVIEW

The theoretical framework of the random walk has been the subject of several controversies initially based on mathematical approaches before coming closer and being identified in the theory of informational efficiency of financial markets. The various empirical verification tests were carried out using various approaches and in different environments without reaching a consensus.

1. Theoretical framework

The evolution of the prices of financial assets has, in general, always been assessed from the angle of financial information. A relationship has also almost always been associated with financial information, it is the attitude of investors and other market participants towards this financial information. These investors and other financial market participants are assumed to be rational, while markets are assumed to make financial information accessible to all and prices to reflect its content. This almost perfect framework, however, does not allow us to understand exactly the conditions for formalizing prices and their evolution. Several theoretical attempts with their empirical verifications have tried to provide explanations. Among these contributions is the random walk model which borrows from the content of the theory of informational efficiency, uses econometrics and a mathematical formalization to explain the evolution of the price of financial assets.

Used in finance to represent the evolution of the prices of financial assets, the random walk model initially characterizes a stochastic process with independent and stationary increases in discrete time. Gestating in the work of authors such as Regnault (1863)[2] and Bachelier (1900)[3], the random walk model took on a more established formalization following the work of Fama (1965)[4]. Overall, this model was refined according to a chronological process strongly influenced by econometric methods and the use of mathematics, especially in the context of empirical tests.

The theoretical content of the random walk model was formalized after errors, passing through the postulate of the absence of arbitrage opportunities in financial markets to the theory of informational efficiency which ultimately constitutes its framework and theoretical foundation. In addition, it is generally accepted in the financial literature that the random walk model makes it possible to test the informational efficiency of financial markets. The theory of informational efficiency considers that, in an efficient market, price variations should be random as is new information. Furthermore, the theory maintains that it is not possible to earn a profit higher than the market performance. Thus, informational efficiency would be linked to the martingale model or the random walk model. Ultimately, the link between informational efficiency and the random nature of stock market variations remains established as evidence (Fama, 1965a and 1970, cited by Jovanovic, 2009)[5][6].

2. Empirical review

The aim of the random walk model is to model the behavior of stock prices. The model suggests that past price trend or movement has no effect on predicting future price. Several empirical tests have also been carried out to verify this relationship between past prices and the predictability of future prices. Furthermore, this postulate remains consistent with the statement of the weak form of informational efficiency which notes the impossibility of predicting future prices on the basis of past prices, the current price having already integrated all available market information. Testing the random walk of stock prices would therefore amount to testing, as an implication, the weak form of informational efficiency. Using different and varied approaches, several empirical verifications of the random walk of stock prices have been carried out in different contexts of developed financial markets as well as emerging financial markets. These studies do not all lead to the same conclusions regardless of the developed or emerging nature of the markets.

Dib, Dahhou and Kharbouch (2021)[7] in the context of 11 African financial markets carry out empirical tests of the random walk of financial asset prices. These authors obtain that on 4 of these markets (Morocco, South Africa, Zambia and Tanzania), the hypothesis of the random walk of prices is verified. They therefore conclude that there is a weak form of informational efficiency on these stock markets. Daoui and Boussedra (2018)[8] also carry out tests to verify the existence of the random walk of stock prices on the Moroccan stock market. These authors find that successive price variations are purely random. They therefore confirm the hypothesis of the random walk of stock prices. Mehmood et al. (2012) [9] also confirm the hypothesis of the random walk and the informational efficiency of the Moroccan market. Using the Box-Pierce and Box-Pierce tests corrected for heteroskedasticity, and the runs test, N'Dri (2007)[10] obtains that the BRVM financial market is efficient in its weak form.

Contrary to these results which confirm the hypothesis of the random walk of stock prices, several other studies refute this hypothesis. Hansson and Frennberg (1992)[11], Gradojević et al. (2010)[12] find respectively on the Swedish stock market and the Euro-Serbian dinar exchange rate market that the random walk hypothesis is not verified. Based on tests carried out by Elhami and Hefnaoui (2018)[13] on stock markets in 8 countries in

Africa and the Middle East on daily and monthly index returns. Their tests, carried out over a period of 7 years, disprove the random walk hypothesis of these stock indices. Mlambo and Biekpe (2007) [14]find the same result on several financial markets in African countries such as Tunisia and Morocco, as does Hiremath (2014)[15] on the Bombay Stock Exchange and the National Stock Exchange in India. In an empirical verification on a number of MENA financial markets, Al-Khazali et al. (2007)[16] also calls into question the random walk hypothesis of financial asset prices. In Morocco, Ifleh and Kabbouri (2021)[17], Moudine and El Khattab (2014)[18], Faycal and Mir (2015)[19], Bakir (2002)[20] conclude that there is no random walk in stock prices and therefore the informational inefficiency of the Moroccan stock market.

As part of this study we postulate the existence of the random walk of stock prices (hypothesis 1) and the efficiency of the BRVM financial market in its weak form (hypothesis 2).

III. THE STUDY ANALYSIS MODEL

The objective of this study is to verify the hypothesis of the random walk of stock prices on the regional financial market of the BRVM. The prices used are the daily prices of the BRVM 10 index. The BRVM 10 index traces the activity of the ten most active companies on the stock market on the regional financial market. On a basis of 100 points, the BRVM index is recomposed each quarter taking into account the importance of the activities of companies on the market. The daily prices used in this study relate to the period from September 18, 1998 to December 30, 2022, i.e. 6,339 observations from the BRVM historical database.

The analysis approach adopted in the context of this study is based on verifying the stationarity of our data series and using a class of ARIMA(p,d,q) models. It is an integrated autoregressive moving average model of order p, d and q. The parameter p designates the order of the autoregressive part of the model, q designates the order of the moving average part and d designates the order of integration. The extent of the series suggests, before testing stationarity, the identification and possible correction of the series for any form of seasonality.

IV. RESULTS AND DISCUSSION

The results obtained as part of this study show the existence of a random walk in the behavior of stock prices and confirm the informational efficiency in the weak sense of the BRVM financial market.

1. Graphical analysis of yield behavior

The evolution of the daily returns of the BRVM 10 stock index between September 19, 1998 and December 30, 2022, i.e. 6339 observations, is presented in Fig. 1. This figure shows that the returns fluctuate over time around the value 0 with regular upward and downward movements which almost offset each other. Overall, each upward movement is systematically followed or preceded by a downward movement of the same amplitude. Basically, it appears that fluctuations remain stable over time and that irregular movements such as strong increases or sharp drops remain rare. This trend implies that the market sufficiently integrates the available information to avoid surprise effects. Furthermore, the evolution of yields suggests postulating an additive model. In addition, the stability around the value 0 over time makes it possible to postulate the stationarity of the series.

2. Analysis of series trends by decomposition

By breaking down the series into trend and seasonality, it is easy to notice from Fig. 2 that the series does not include a trend or seasonality, because these two components are almost zero over the entire period. Therefore, it is not necessary to correct the series by removing a seasonality since the latter does not exist.

As can be seen in Fig. 3 which compares the initial series of returns, that is to say the raw series with the series adjusted for seasonal variations (CVS), the two series remain almost identical. This situation makes it possible to support the fact that the initial series does not include a seasonal component and can therefore be used directly for the analysis instead of a CVS series.

3. Stationarity tests

In order to confirm the long-term stability of the stock returns of the BRVM 10 index, various stationarity or unit root tests are carried out. Three tests are used, namely the augmented Dickey-Fuller test (ADF), the modified Dickey-Fuller test (DF-GLS) and then the Phillips-Perron (PP) test. All these tests are based on the null hypothesis of the presence of a unit root in the data, i.e. non-stationarity. The results show that the three tests converge towards the same conclusion: the series of returns is stationary at the 1% significance level. Indeed, the test statistic calculated for the ADF test stands at -31.326 which is greater in absolute value than the critical value which is -3.431. It is the same for the DF-GLS test where the test statistic is -31.321

which is greater in absolute value than the corresponding critical value of -2.565. Finally, the PP test leads to a test statistic of -77.158 greater in absolute value than the critical value of -3.431.

4. Correlogram and identification of the best model for BRVM-10 index returns

The approach consists of searching in the class of ARIMA(p,d,q) models, an autogressive integrated moving average model of order p, d and q, the best model which best fits the returns of the BRVM- index. 10. The parameter p designates the order of the autoregressive part of the model, q designates the order of the moving average part and d designates the order of integration. Since in the case of the present study, the series is stationary, then d=0. For visual identification, the correlogram is shown in Fig. 4.

It appears from this figure that the autocorrelations and partial autocorrelations which are statistically non-zero, which go beyond the confidence interval, are at most of order 4. From order 5, the autocorrelations and partial autocorrelations do not do not escape the confidence interval and therefore are zero. Thus the parameters p and q are at most equal to the value 4 ($p_{max}=4$ and $q_{max}=4$).

We therefore look for the parameter p in the set {0, 1, 2, 3, 4} and the parameter q in the set {0, 1, 2, 3, 4}, which gives rise to 25 models to estimate. For each of the models, the Akaike information criterion (AIC) is calculated. The model which minimizes this criterion is the best which fits well to the modeling of the returns of the BRVM-10 index. Following this iteration, the best model retained is ARIMA(4,0,3) in other words the ARMA(4,3) model.

Table 2 presents the results of estimating the best model in the class of ARIMA models which best fits the series of returns of the BRVM-10 index.

By examining the coefficients linked to the autoregressive (AR) part, it appears that the coefficient of order 1 is not significant which means that the previous day's return does not provide any information on the prediction of the current day's return. However, the coefficients of AR orders 2, 3 and 4 are significant respectively at the thresholds of 1%, 5% and 1%, which reflects the fact that the past returns of the 2nd, 3rd and 4th previous day make it possible to project the return of the current day. Thus, we can note that taking into account fluctuations in yield in the behavior of market players does not happen overnight but the players take 2, 3 or even 4 days to fully integrate the new information arriving on the market. The coefficient of AR(2) is positive (0.5863) which means that the yield achieved two days before has a positive impact on the yield of the current day. The yield achieved 3 days previously negatively impacts the yield of the current day and the yield achieved 4 days previously positively affects the yield of the current day.

Overall, the results obtained allow us to conclude in the existence of the random walk of stock prices and the weak form of informational efficiency on the regional financial market of the BRVM.

These results are consistent with work specifically carried out on the same market. In this case, it concerns the work of N'Dri (2007). These results are also in the same direction as those obtained on the Moroccan, South African, Zambian and Tanzanian markets by Dib, Dahhou and Kharbouch (2021). The same is true of the results of Daoui and Boussedra (2018) and Mehmood et al. (2012), on the Moroccan stock market.

V. FIGURES AND TABLES

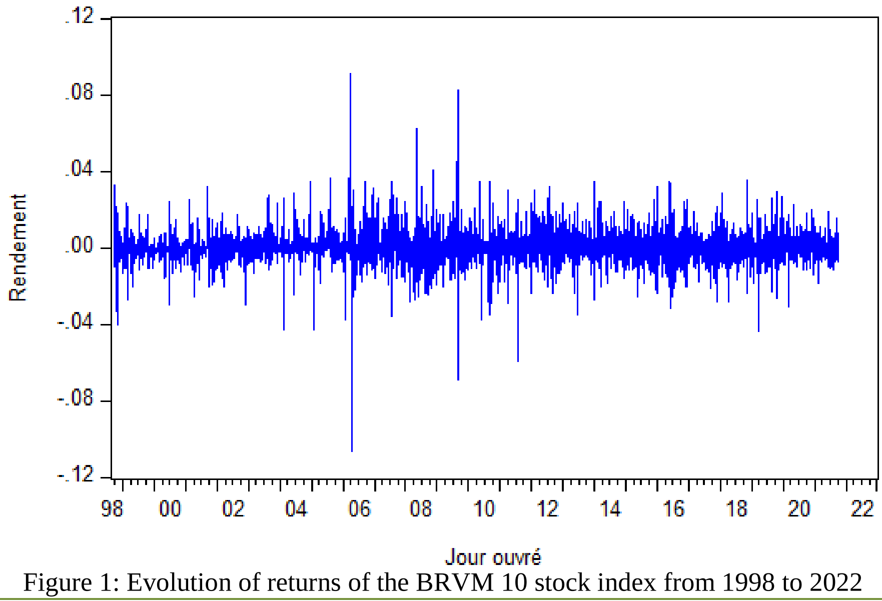


Figure 1: Evolution of returns of the BRVM 10 stock index from 1998 to 2022

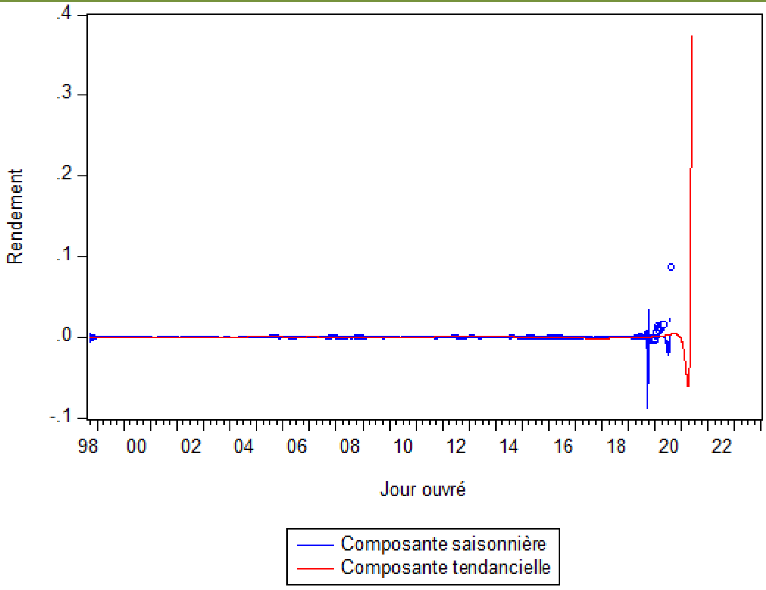


Figure 2: Breakdown of stock returns of the BRVM 10 stock index from 1998 to 2022

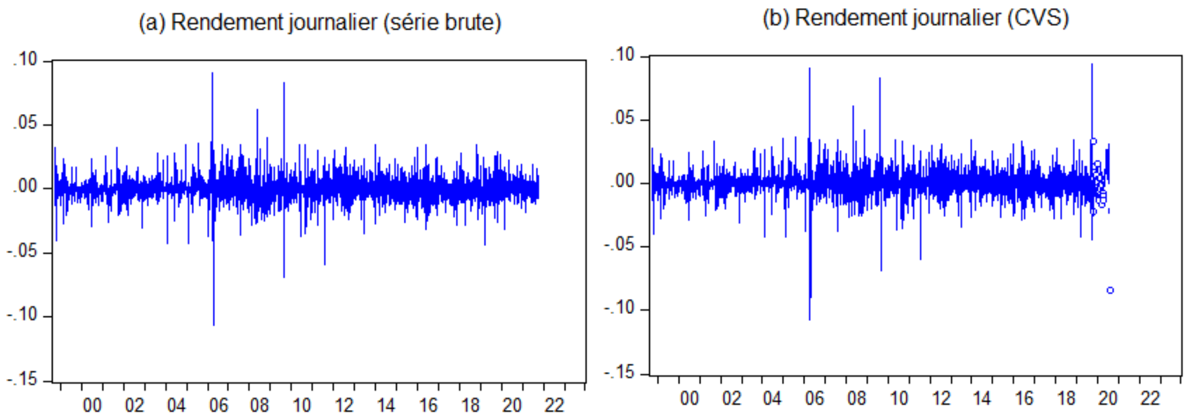
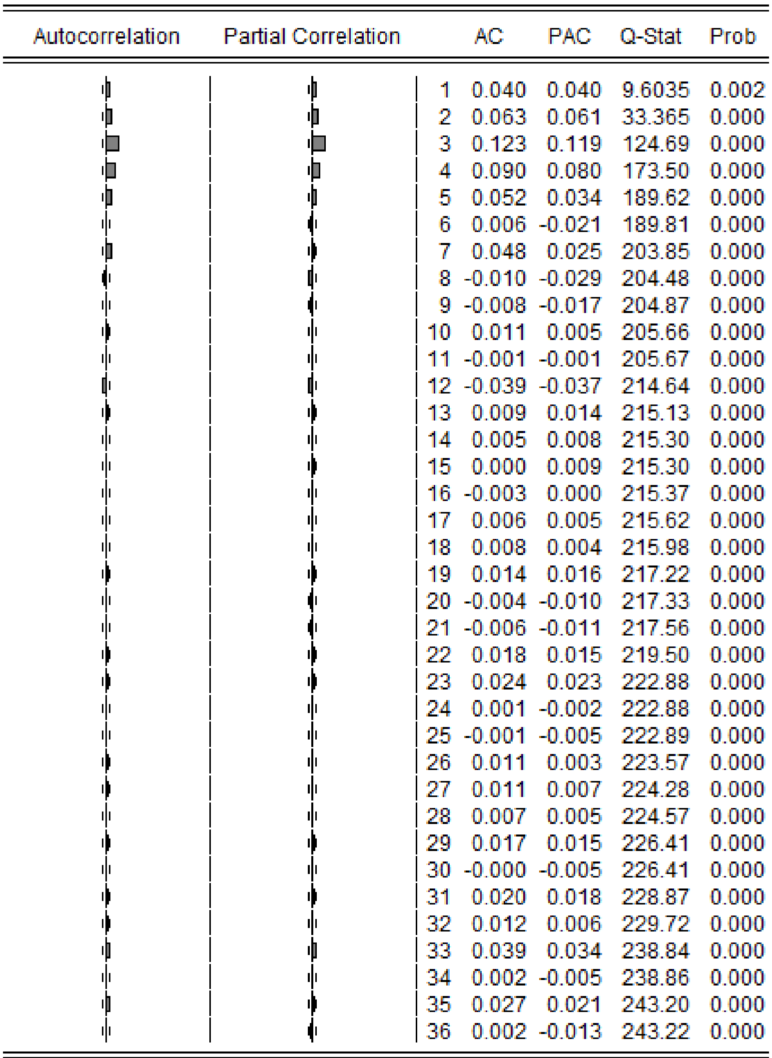


Figure 3: Raw series and seasonally adjusted series (CVS) of stock returns of the BRVM 10 stock index from 1998 to 2022



Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.040	0.040	9.6035	0.002
		2	0.063	0.061	33.365	0.000
		3	0.123	0.119	124.69	0.000
		4	0.090	0.080	173.50	0.000
		5	0.052	0.034	189.62	0.000
		6	0.006	-0.021	189.81	0.000
		7	0.048	0.025	203.85	0.000
		8	-0.010	-0.029	204.48	0.000
		9	-0.008	-0.017	204.87	0.000
		10	0.011	0.005	205.66	0.000
		11	-0.001	-0.001	205.67	0.000
		12	-0.039	-0.037	214.64	0.000
		13	0.009	0.014	215.13	0.000
		14	0.005	0.008	215.30	0.000
		15	0.000	0.009	215.30	0.000
		16	-0.003	0.000	215.37	0.000
		17	0.006	0.005	215.62	0.000
		18	0.008	0.004	215.98	0.000
		19	0.014	0.016	217.22	0.000
		20	-0.004	-0.010	217.33	0.000
		21	-0.006	-0.011	217.56	0.000
		22	0.018	0.015	219.50	0.000
		23	0.024	0.023	222.88	0.000
		24	0.001	-0.002	222.88	0.000
		25	-0.001	-0.005	222.89	0.000
		26	0.011	0.003	223.57	0.000
		27	0.011	0.007	224.28	0.000
		28	0.007	0.005	224.57	0.000
		29	0.017	0.015	226.41	0.000
		30	-0.000	-0.005	226.41	0.000
		31	0.020	0.018	228.87	0.000
		32	0.012	0.006	229.72	0.000
		33	0.039	0.034	238.84	0.000
		34	0.002	-0.005	238.86	0.000
		35	0.027	0.021	243.20	0.000
		36	0.002	-0.013	243.22	0.000

Figure 4: Correlogram of the return series of the BRVM-10 index

Table 1: Unit root tests

		Augmented Dickey-Fuller	Dickey-Fuller GLS	Phillips-Perron
Test Statistics		-31.326***	-31.321***	-77.158***
Critical values	Threshold 1%	-3.431	-2.565	-3.431
	Threshold 5%	-2.862	-1.941	-2.862
	Threshold 0%	-2.567	-1.617	-2.567

Table 2: Estimate of the ARMA(4.3) model for the series of returns of the BRVM-10 index

Variable	Coefficient	Erreur standard	t-Stat	P-value
AR(1)	-0.1203	0.1039	-1.1575	0.2471
AR(2)	0.5863***	0.0406	14.431	0.0000
AR(3)	-0.1994**	0.0794	-2.5100	0.0121
AR(4)	0.0727***	0.0138	5.2597	0.0000
MA(1)	0.1403	0.1050	1.3362	0.1815

MA(2)	-0.5363***	0.0409	-13.095	0.0000
MA(3)	0.3155***	0.0718	4.3892	0.0000
SIGMASQ	6.09E-05***	4.96E-07	122.9037	0.0000

R-squared	0.028525	Mean dependent var	0.000117
Adjusted R-squared	0.027392	S.D. dependent var	0.007919
S.E. of regression	0.007809	Akaike info criterion	-6.865570
Sum squared resid	0.366112	Schwarz criterion	-6.856651
Log likelihood	20642.47	Hannan-Quinn criter.	-6.862473
Durbin-Watson stat	1.999783		

Inverted AR Roots	0.62	0.13 - 0.32i	0.13 + 0.32i	-0.99
Inverted MA Roots	0.43-.37i	0.43 + 0.37i	-1.00	

VI. CONCLUSION

The objective of this present study, as part of the analysis of stock market variations, was to test the hypothesis of the random walk of stock prices on the BRVM regional financial market. The study used the daily returns of the BRVM 10 index over a period of 24 years from September 18, 1998 to December 30, 2022. In addition to the stationarity tests of the series in the present study, the use of an autoregressive model moving average was used. The results obtained, show that the prices of financial assets on the UMOA's regional financial market follow a random walk. In addition, the results verify that the BRVM regional financial market is efficient in its weak form. Thus, the predictability of future prices based on past prices cannot be achieved. These results, which are consistent with the predictions of informational efficiency theory, correspond to the results of previous work on this market and several works on other emerging markets. In terms of contribution, this study is in line with work on the random walk of financial asset prices in an emerging market. The importance of the study period, therefore the number of observations, also constitutes a contribution to consider. These results contribute, like all other work in the same direction, to investment decision-making on financial markets. These results could also, to a certain extent, be used by the regulator in making decisions within the framework of the control and surveillance of this transnational financial market. Furthermore, without calling into question the results on the weak form of financial market efficiency, empirical verifications could test the existence of long memory on this market with a view to assessing the explanatory factors of the evolution of prices of financial assets.

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