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AUTHORS	Leonidas Theodorakopoulos Hera Antonopoulou Vicky Mamalougou Konstantinos C. Giotopoulos

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Leonidas Theodorakopoulos (Greece), **Hera Antonopoulou** (Greece),
Vicky Mamalougou (Greece), **Konstantinos C. Giotopoulos** (Greece)

THE DRIVERS OF VOLUME VOLATILITY: A BIG DATA ANALYSIS BASED ON ECONOMIC UNCERTAINTY MEASURES FOR THE GREEK BANKING SYSTEM

Abstract

In this paper, an investigation is conducted to estimate the effect of economic uncertainty on volume volatility, focusing on four systemic Greek banking institutions, including (i) Alpha Bank, (ii) Eurobank, (iii) National Bank of Greece, and (iv) Piraeus Bank. The purpose of this study is to explain in detail if the EPU is linked with volume volatility in the largest banking institutions in Greece. For the analysis of this paper, data used are monthly data of volume to explain the economic uncertainty on volume volatility. The analysis period covers the period from January 2001 to August 2018, incorporating various market phases, such as the global financial crisis of 2008, the European debt crisis, and capital controls in the Greek economy. The methodology used for the research is the well-known GARCH model. Based on the estimated regressions, the present research findings showed that economic uncertainty has various effects on the volume volatility of the four systemic Greek banking institutions. More specifically, when economic uncertainty receives a high value, then the volatility of the volume in Greek banking institutions increases, receiving a higher value. In conclusion, it is observed that economic uncertainty positively affects the volume volatility of the Greek banking system.

Keywords volume, volatility, economic uncertainty, big data, Greece, banks, GARCH model

JEL Classification F65, G11, G12, G24

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Leonidas Theodorakopoulos, Ph.D., Department of Management Science & Technology, University of Patras, Greece. (Corresponding author)

Hera Antonopoulou, Ph.D., Professor, Department of Management Science & Technology, University of Patras, Greece.

Vicky Mamalougou, Ph.D. Candidate, Department of Management Science & Technology, University of Patras, Greece.

Konstantinos C. Giotopoulos, Ph.D., Assistant Professor, Department of Management Science & Technology, University of Patras, Greece.

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INTRODUCTION

The year 2009 was marked as a milestone for the world economy due to the European economic crisis that has begun to be felt in recent months. Greek government debt was downgraded by the number of reputable rating agencies and bond yields increased. These changes brought the exclusion of Greece from international credit markets and got the country to the point of seeking financial support from the EU and the IMF. The loan that Greece requested in the first place was 45 billion euros. The economic crisis started in Greece and continued to spread rapidly to other European countries, as investors realized how sensitive European countries are to a debt crisis. In 2010, Portuguese and Italian government bonds showed sharp increases in their yields, while the sovereign debt of Italy and Portugal was called into question regarding its viability. The financial crisis also affected Spain and Portugal, which struggled to save large numbers of banks from redundant non-performing loans. Shares were another asset in addition to government bonds affected by Europe's economic crisis. The negative effects of the debt crisis on bank shares have been extensively studied by several researchers because government credit risk has had a deci-

sive effect on equities. The Bank for International Settlement's Global Financial System Committee (see BIS, 2011) has set up a research team to identify the key transmission modes through which banks have been affected by government risk.

In the last decade, Baker et al. (2014, 2016) created an indicator for measuring economic policy uncertainty which is symbolized by EPU. The researchers invented the EPU index, since the measurement of uncertainty has preoccupied a huge group of searchers. The EPU index was initially used to measure the impact of economic policy uncertainty on the volatility of the stock price. The result of the survey showed that stock price volatility is increasing due to uncertainty (Liu et al., 2017). As a result, volatility can be estimated using the EPI index (Liu et al., 2017). According to Karnizova and Li (2014), during difficult economic times, uncertainty and volatility take on higher values due to the increased value of the EPU index. Therefore, the EPU index is considered a good estimator for measuring volatility in the future (Liu et al., 2017; Liu & Zhang, 2015). The interest of several researchers is focused on measuring volatility when the EPU index fluctuates.

1. LITERATURE REVIEW

Research studies on monetary policy and financial stability are taking new data to evolve from the big banks that are considered intermediaries of the financial system occupying a central position in the crisis (Adrian & Shin, 2008). Nowadays, banks are considered as the main topics of discussion in terms of monetary policy and its interventions with reference mainly to non-conventional interventions and have ceased to be the mediator of monetary transmission. The in-depth research first looked at the financial system turmoil associated with mortgages and then addressed the public debt and the debt crisis in the Eurozone. More specifically, it is revealed according to the American empirical results that banks that do not provide security to their investors are more influenced by monetary policy choices. For the EU and, more specifically, for the Eurozone, the key factors associated with the heterogeneous response of banking institutions to monetary policy have not been studied at all. The correlation between prices in the banking market and two indicators is perceived, one related to the monetary value of assets and the other to exposure to risk, indicating a disciplined market (Flannery & Nikolova, 2004). For the US banking industry, several pre-crisis studies have been conducted that show an inverse relationship between an easy impact of the effects of the monetary crisis and the robustness of banking institutions by providing information on a disciplined market. However, it should be noted that there are no empirical studies to examine the European Union after the period of economic crisis.

The financial crisis has forced the European Central Bank (ECB) to take measures such as lowering key policy interest rates, which for the first time are so low (ECB, 2010). Liquidity and monetary easing are also key policy measures taken by the ECB. In addition, measures have been taken to strengthen and support the private sector through more favorable lending and to reduce the transmission of the crisis to the markets (ECB, 2011). In other words, the ECB has made it possible to replace the interbank market and wholesale intermediate lending, which turns into long-term refinancing (Cœuré, 2013, p. 2). Banks located in countries with financial assistance in the face of government objections depend on the ECB and its liquidity (BIS, 2013).

The activities of the banking institutions do not allow the reality to appear in the rest of the business units (Morgan, 2002); but the respective banking activity must follow some strict rules and be subject to controls in the developed countries of the world. Therefore, the interest of researchers has been stimulated by the control of whether the market reaction from monetary policy interventions is affected and how much it is affected by the particular features of banks during the period of the financial system crisis. The elements examined in this paper are focused on the reporting period of contractual and non-contractual measures, and at what time period monetary policy interventions were crucial to support the banking system and therefore the industry as a whole (i.e., the first lender hit by the ECB), resulting in a reduction in the power and efficiency of the disciplined market.

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According to Baker et al. (2014, 2016), the economic policy uncertainty index (EPU) has aroused the interest of researchers for a thorough study from the time it was invented until today (see, e.g., Antonakakis et al., 2013; Colombo, 2013; Karnizova & Li, 2014; Klößner & Sekkel, 2014; Li & Peng, 2017; Ma et al., 2018; Zhang et al., 2019; Xiao & Wang, 2021; Wang et al., 2015). More specifically, several empirical studies have been conducted on the impact of EPU on stock market return or volatility (see, e.g., Amengual & Xiu, 2018; Antonakakis et al., 2013; Brogaard & Detzel, 2015; Chen et al., 2020; Dzielinski, 2012; Fanta & Sum, 2012; Johnson & Lee, 2014; Kang & Ratti, 2013; Lam et al., 2014; Li et al., 2016; Liu et al., 2017; Liu & Zhang, 2015; Mei et al., 2018; Pastor & Veronesi, 2012). This paragraph mentions only some of the research studies that have been conducted to estimate the impact of EPU and the influence of the index on volatility.

In this research study, through the literature, the economic uncertainty and its effects on the volume volatility are examined. The aim of this research study is to examine the EPU and the volume volatility, created by the EPU, in the largest banks in Greece (Gkillas et al., 2019). Researchers have not studied this topic to date. In addition, it should be noted that the volume volatility is clearly affected by EPU. Finally, knowing that portfolio distribution and financial system risk management play a key role in volume volatility, this study offers extra fiscal implications.

2. DATA AND METHODOLOGY

All the data have been pre-processed using Big Data frameworks to reduce their volume, particularly because of the diversity of the data used in this research study; a BLB bootstrap framework for big data sampling is employed to have an efficient sample for data analysis (i.e., without losing data precision). To examine how volume responds to uncertainty, reacted to the news of a newspaper concerning the fear of the causes created, in this study online search traffic data are used, exploring the full potential of Big Data (see e.g., Kanavos et al., 2019; Antonopoulou et al., 2022; Theodorakopoulos, 2022; Dritsas at al., 2019; Hilbert & Lopez, 2011) In this study, data used are monthly data on volume for the four largest Greek banking institutions according to Ricci (2015). The data used come from three main time periods, before the 2007 crisis, during the crisis, and after the financial crisis. More specifically, the period extends from January 2001 to August 2018 based on the data availability. In addition, it should be noted that the volume is being investigated for the following four banks, Alpha Bank, National Bank of Greece, Eurobank, and Piraeus Bank. Data are from Bloomberg.

Table 1 reports basic statistics of the Economic Policy Uncertainty (EPU) and the volume of four Greek banks such as (i) ALPHA, (ii) EUROB, (ii) ETE, and (iii) TPEIR. More specifically, both tables report the following basic statistics: (i) mean (average); (ii) median; (iii) maximum; (iv) minimum; (v) standard deviation (denoted by std. deviation); (vi) skewness; and (vii) kurtosis. In this table, the mean of the volume of Alpha Bank observed equals 5,040,154, with a standard deviation equal to 6,788,785, a maximum of 70,910,000, and a minimum of 170,950. The skewness equals 5.4157 and the kurtosis equals 46.3983. For the volume of National Bank of Greece, the mean equals 2,176,667, with a standard deviation equal

Table 1. Descriptive statistics

Variable	ALPHA	ETE	EUROB	TPEIR	EPU
Mean	5,040,154.0	2,176,667.0	1,376,167.0	518,649.2	102.5130
Median	3,155,000.0	493,380.0	105,820.0	192,710.0	98.44065
Maximum	70,910,000	78,230,000	20,080,000	8,970,000.	188.7045
Minimum	170,950.0	24,090.00	1,940.000	1,230.000	47.1814
Std. dev.	6,788,785.0	7,952,819	3,429,532.0	999,863.8	27.0767
Skewness	5.4157	6.3958	3.2889	4.3895	0.7440
Kurtosis	46.3983	49.8974	14.0756	29.4617	3.3423
J-B	17,673.1300***	20,873.1000***	1,465.7950***	6,866.1100***	20.5944***
J-B Prob.	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
Obs.	212	212	212	212	212

Note: *** stands for statistically significant at 1%.

to 7,952,819, a maximum of 78,230,000, and a minimum of 24,090.00. The skewness and kurtosis equal 6.3958 and 49.8974, respectively. Moreover, the mean of the volume of Eurobank equals 1,376,167, with a standard deviation equal to 3,429,532, a maximum of 20,080,000, and a minimum of 1,940.000. The skewness equals 3.2889 and the kurtosis equals 14.0756. In addition, for the volume of Piraeus Bank, the mean equals 518,649.2, with a standard deviation equal to 999,863.8, a maximum of 8970000. and a minimum of 1,230.0. The skewness and kurtosis equal 4.3895 and 29.4617, respectively. For the Economic Policy Uncertainty, the mean equals 102.5130, with a standard deviation equal to 27.07679, a maximum of 188.7045, and a minimum of 47.18148. The skewness equals 0.7440 and the kurtosis equals 3.3423. The normality of all series has been tested with the Jarque-Bera test, in all series, the null hypothesis of normality is rejected at a 1% significance level.

In recent decades, financial institutions operate in an environment of uncertainty due to globalization and economic, political, and social instability. In August 2007, the global financial crisis broke out in the USA with the collapse of the largest financial institutions and in 2008 the crisis began to spread worldwide, both in Europe and consequently in Greece. Apart from the 2008 crisis, Greece experienced an unprecedented situation at the end of June 2015 with the collapse of the banking system due to financial difficulties. The Greek government suddenly took a decision to close banking institutions for a short period of about three weeks and to impose capital controls (Danchev et al., 2020). Due to the uncertainty experienced by financial institutions worldwide, this study used the methodology GARCH (Generalized Autoregressive Conditional Heteroskedasticity).

This section describes in detail the methodology followed to investigate the volume for the four systemic Greek banks. The GARCH model is estimated using two well-known techniques, the Maximum Likelihood (ML) and the Generalized Method of Moments (GMM). Moreover, it is worth noting that the ARMA (Autoregressive Moving Average) process is in conjunction with the GARCH model. In Table 1, the descriptive statistics are reported in detail.

2.1. GARCH methodology

During the process of information recovery, historical observations are used to provide derivative estimations of both current and future values of the variables which are dependent. Two of the most widespread and popular techniques of estimations are the Maximum Likelihood (ML) and the Generalized Method of Moments (GMM). In the former, the information availability of the whole probability distribution is required, while in the latter, nonparametric procedures and informational requirements of very precise data moments are reduced. A more contemporary and modern technique of estimation is represented by the nonlinear neural network, something that seems to have gained popularity recently. With the condition that the Gaussian distribution concerning the series of time is satisfied, it is recommended that the present methodology adheres to the Box-Jenkins modeling approach of parsimony, that is, the fewest modeling parameters are used, reinforced by the relevant data, to calculate an ARMA process taking into account the GARCH error components.

The definition of the ARMA process, which includes components of moving average terms and autoregressive terms, is as follows:

$$y_t = c + \sum_{i=1}^{p} \varphi_i y_{t-i} + \sum_{i=1}^{p} \theta_i \varepsilon_{t-i}. \quad (1)$$

The application of the backshift operator L ($Ly_t = y_{t\text{-}1}$), ($L^p y_t = y_{t\text{-}p}$) might be defined as:

$$\left(1 - \sum_{i=1}^{p} \varphi_i L^i\right) y_t = c + \left(1 + \sum_{i=1}^{p} \theta_i L^i\right) \varepsilon_t. \quad (2)$$

In a classic ARMA estimation, the standard assumptions concerning the error terms incorporate zero mean and constant variance, or to be more specific:

1. $E(\varepsilon_t) = 0$;
2. $E(\varepsilon_t^2) = \sigma^2$; and
3. $E(\varepsilon_t \varepsilon_s) = 0$, for $s \neq t$.

For accuracy, the homoskedastic constant variance hypothesis does not need to hold. The model class in which the constant variance hy-

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pothesis does not hold is called heteroskedastic. The probability of serial correlation in volatility known as an ARCH (Autoregressive Conditional Heteroskedastic) model class was suggested by Engle (1982). The conditional variance is considered as being time-dependent in the ARCH(q) model $V(\varepsilon_t|\varepsilon_{t-1}) = h_t$.

$$h_t = c + \sum_{i=1}^{q} a_i \varepsilon_{t-1}^2. \quad (3)$$

Another extended ARCH model was proposed by Bollerslev (1986). It is called Generalized Autoregressive Conditional Heteroskedastic (GARCH), and ε_t^2 takes the following form:

$$\varepsilon_t^2 = v_t^2 h_t, \quad (4)$$

which $\sigma_v^2 = 1$ is in its basis a process of white noise, more significant

$$h_t = c + \sum_{i=1}^{p} a_i h_{t-i} + \sum_{i=1}^{p} \beta_i \varepsilon_{t-i}^2. \quad (5)$$

As can be observed from (5), any GARCH(p, q) model can become an ARCH(q) model where $p = 0$. Thus, since a GARCH model incorporates mean reversion, the dynamics of ε_t^2 can therefore be given through shocks of past volatility ε_{t-i}^2.

3. EMPIRICAL RESULTS

The marginal ARMA(p, q)-GARCH(r, m) distribution model described in equation (5) for market returns was estimated by considering different combinations of the parameters *p*, *q*, *r*, and *m* for values ranging from zero to a maximum lag of two; the most suitable model was selected according to AIC values. Specifically, for Alpha Bank, the best model is found to be an ARMA(1,2)-GARCH(1,1) specification, for Eurobank an ARMA(1,2)-GARCH(1,1) specification, for National Bank of Greece an ARMA(1,1)-GARCH(1,1) specification, and finally for Piraeus Bank an ARMA(1,1)-GARCH(1,1). Results are displayed in Table 2.

In general, economic uncertainty is found to be statistically significant across to volume volatility of all Greek banking institutions.

Figure 1 depicts the volume of the four largest banks in Greece, Alpha Bank, Eurobank, National Bank of Greece, and Piraeus Bank. The graph for Alpha Bank shows volume fluctuations throughout the survey. It is also observed that in 2013, the volume of Alpha Bank receives the highest value and in 2014 it decreases rapidly receiving the lowest values in history. The figure for Eurobank reflects very low volume values for several years, but after 2015 huge fluctuations in the volume are observed. Also, the graph of National Bank of Greece depicts low volume throughout the survey with the exception of 2016 when the volume receives the highest values, and some fluctuations are observed. Finally, the graph of Piraeus Bank shows fluctuations every year, and more specifically in 2013, the volume is growing rapidly.

More specifically, Table 2 presents the results of thmean equation at the top, the variance equation at the middle, and the basic statistical results of

Table 2. Parameter estimates for the marginal distribution of returns

Variable	ALPHA	ETE	EUROB	TPEIR
		Mean		
ϕ_0	14.4792	13.0835	11.4016	11.6667
AR(*i*)	0.6444	0.9305	0.9185	0.9515
MA(*j*)	0.1661	–0.4379	–0.0058	–0.6228
		Variance		
ω	–0.0193	–0.0667	1.0664	–0.0944
α_i	1.0317	1.0233	–0.0675	1.0363
β_i	–0.0490	–0.0435	0.4142	–0.0292
EPU	3.10e-04	7.44e-04	4.28e-04	9.71e-04
Q(20)	0.5588	0.0213	0.0171	0.0859
Prob.	1.00	1.00	1.00	1.00
ARCH(10)	0.8256	1.4912	0.0249	0.5158
Prob.	0.3646	0.1452	0.8747	0.8777

Note: Lags *p*, *q*, *r*, and *m* were selected using the AIC for different combinations of values ranging from 0 to 3 lags.

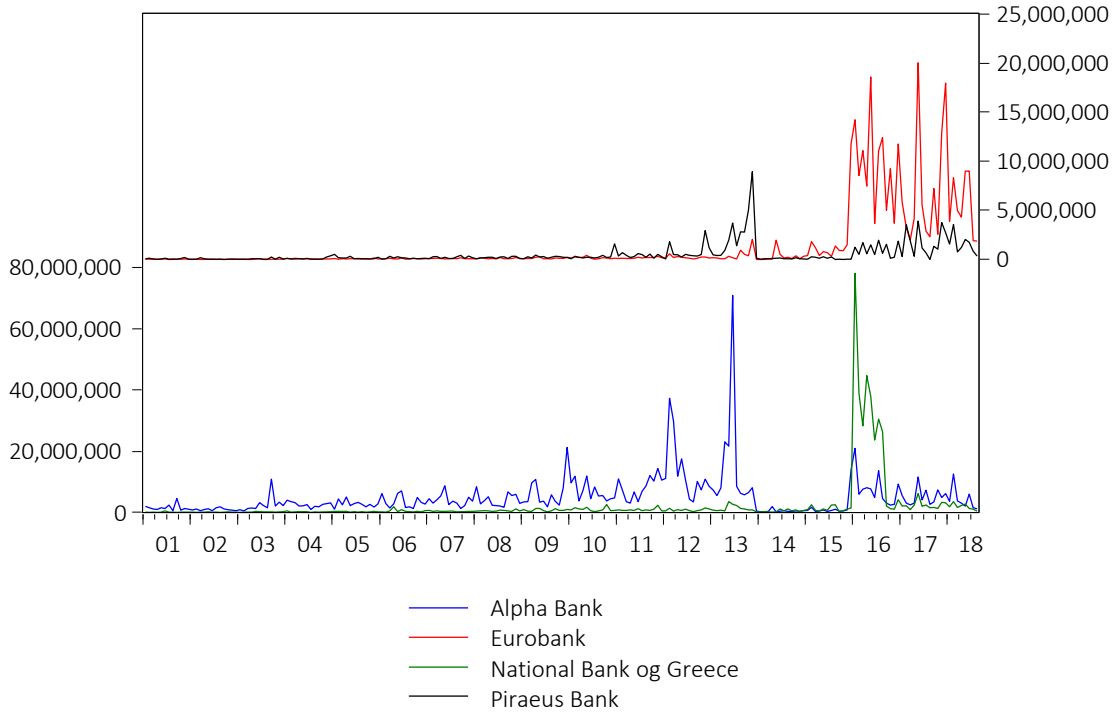

Figure 1. Greek banks' volume (in y axes) evolution from 2001 to 2018

the regression at the bottom of the table for the four largest banking institutions, Alpha Bank, National Bank of Greece, Eurobank, and Piraeus Bank. Focusing on Economic Uncertainty and its impact on volume volatility, the observation is focused on the EPU which is equal to 3.10e-04, statistically significant at 5% for Alpha Bank having a positive impact on Alpha Bank's volume volatility. As for National Bank of Greece, the results of the variance equation observed are as follows, EPU impact is equal to 7.44e-04 with the significance level of 1%. However, as for Eurobank, the EPU has a negative impact on Eurobank's volume volatility equal to 4.28e-04 with a 5% significance level. Finally, as for Piraeus Bank, the EPU is equal to 9.71e-04 and statistically significant at a 1% significance level on volume volatility of Piraeus Bank.

The present research study was conducted to identify the impact of economic uncertainty on volume volatility in the four largest banking institutions in Greece. The research findings showed that economic uncertainty has a positive effect on volume volatility. In other words, it was observed that the higher the economic uncertainty, the greater the increase in volume volatility in the Greek banking system. It should also be noted that the highest EPU appears in Piraeus Bank and National Bank of Greece. While the lowest EPU appears in Alpha Bank, and the EPU of Eurobank is slightly higher than the EPU of Alpha Bank.

4. DISCUSSION

Conducting a research study helps to determine the impact of economic policy uncertainty on volume volatility. In recent years, plenty of researchers have studied the economic uncertainty and volatility in financial markets. Among others, Liu and Zhang (2015) studied the economic policy uncertainty and its prediction on the stock market volatility, concluding that market volatility increases significantly when EPU is increased. Similar research to Liu and Zhang (2015) was conducted by Mei et al. (2018) investigating economic policy uncertainty in the United States and how the stock market volatility is affected in Europe. The findings of these research studies revealed a positive relationship between stock market volatility and economic policy uncertainty. Therefore, this investigation makes a decisive contribution to the revelation that EPU positively affects the volume volatility by focusing on Greek banking system.

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CONCLUSION

This investigation aims to explain the economic policy uncertainty and the volatility of the volume due to the economic policy uncertainty in the Greek banking system. Volume is a key measure in a financial market as it measures the amount of assets traded in a specific time period, say a day. In this case, trading volume is quantified by the number of trades happened in the Greek market. This study estimated how economic uncertainty affects the volume volatility in four major banking institutions in Greece, such as Alpha Bank, National Bank of Greece, Eurobank, and Piraeus Bank. The period of investigation extends from January 2001 to August 2018, and the data were collected on a monthly basis. This period is very important because the Greek banking system faced several major issues such as the capital controls closely related with the EPU. More specifically, the Greek banking system was one of the few cases in European Union applying strict controls in the capital. By investigating these major points, it is possible to bring light on how all these events affect the investors' behavior in the banking system. Such evidence is extremely important for European policymakers and for the central bank governors.

To generate the results, the model used in the investigation is a well-known econometric model called GARCH (Generalized Autoregressive Conditional Heteroskedastic). More specifically, in this study, the marginal ARMA-GARCH model was used with different variants in order to select the appropriate one for each of the four banks. The result of the study is that economic uncertainty has a positive impact on volume volatility, indicating that higher economic uncertainty increases volume volatility in the largest Greek banking institutions. This is something that must be taken into account by market participants, since it indicates a clear evidence that investors become more nervous when economic policy uncertainty rises.

AUTHOR CONTRIBUTIONS

Conceptualization: Leonidas Theodorakopoulos, Vicky Mamalougou, Konstantinos C. Giotopoulos.
Data curation: Leonidas Theodorakopoulos.
Formal analysis: Vicky Mamalougou.
Funding acquisition: Leonidas Theodorakopoulos, Vicky Mamalougou.
Investigation: Vicky Mamalougou.
Methodology: Leonidas Theodorakopoulos.
Project administration: Hera Antonopoulou, Konstantinos C. Giotopoulos.
Resources: Leonidas Theodorakopoulos, Hera Antonopoulou, Vicky Mamalougou, Konstantinos C. Giotopoulos.
Software: Leonidas Theodorakopoulos, Vicky Mamalougou.
Supervision: Hera Antonopoulou.
Writing – original draft: Vicky Mamalougou.
Writing – review & editing: Leonidas Theodorakopoulos, Hera Antonopoulou, Vicky Mamalougou, Konstantinos C. Giotopoulos.

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