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ANALYSIS OF THE IMPACT OF THE COVID-19 PANDEMIC ON STOCK EXCHANGE INDICES IN ITALY [1]

Abstract. The present paper investigates the impact of the COVID-19 pandemic on the prices of the Italian stock exchange indices. During the pandemic, the global economy as well as financial markets suffered due to isolation and social distancing. Paired models of the dependence of the key indices of the Italian stock exchange on the number of patients, recovered and died were analysed using the least squares method. Further, various tests were performed to verify the feasibility of the Gauss-Markov conditions by applying Gretl tools: White Test for heteroskedasticity of residues, Durbin-Watson test for autocorrelation of residuals and normality of distribution of residuals. Statistically significant regression models were constructed that characterise the impact of morbidity and mortality in the Italian population during the COVID-19 pandemic on the price of 11 key stock exchange indices. Based on this, the study examined the COVID-19 pandemic period in the spring of 2020 in Italy, the results of which revealed a loss in stock returns and high volatility in stock returns during this period compared to the normal study period. The econometric model shows that COVID-19 had a negative impact on stock returns and a number of other stock market indicators in Italy. It was revealed that the number of deaths from coronavirus is statistically significantly interconnected with all key stock exchange indices.

Keywords: coronavirus, COVID-19, Italian stock exchange indices, Italy, econometric model, mortality, correlation, stock exchange, pandemic

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ИССЛЕДОВАТЕЛЬСКАЯ СТАТЬЯ

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Анализ влияния пандемии COVID-19 на индексы фондовой биржи Италии

Аннотация. Изоляция и меры социального дистанцирования негативно повлияли на развитие мировой экономики и финансовых рынков. В настоящей статье исследуется влияние пандемии COVID-19 на цены индексов итальянской фондовой биржи. Парные модели зависимости основных индексов итальянской фондовой биржи от числа выздоровевших и умерших пациентов были проанализированы с помощью метода наименьших квадратов. Использование программного пакета Gretl позволило провести различные тесты для проверки выполнимости условий Гаусса-Маркова: тест Уайта для тестирования гетероскедастичности остатков, критерий Дарбина-Уотсона для анализа автокорреляции остатков, а также оценка нормальности распределения остатков. Построенные статистически значимые регрессионные модели демонстрируют влияние заболеваемости и смертности населения Италии в период пандемии COVID-19 на цену 11 основных биржевых индексов. Результаты исследования выявили снижение и высокую волатильность доходности акций в период пандемии коронавируса весной 2020 года в Италии по сравнению с обычным периодом. Разработанная эконометрическая модель показала, что COVID-19 оказал негативное влияние на доходность акций и ряд других показателей фондового рынка Италии. Также была выявлена статистически значимая связь между количеством умерших от коронавируса и ключевыми биржевыми индексами.

Ключевые слова: коронавирус, COVID-19, индексы итальянской фондовой биржи, Италия, эконометрическая модель, смертность, корреляция, фондовая биржа, пандемия

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1. Introduction

The history of mankind has witnessed many epidemic diseases that have so far led to numerous deaths. In the last 20 years, the following have been recorded: severe acute respiratory syndrome (SARS), which was recorded in Asia and Canada between 2002 and 2003, Ebola and swine flu.

COVID-19 coronavirus (2019-nCoV) is a type of outbreak that first appeared in December 2019 in the city of Wuhan, Hubei province, China (Ruiz Estrada et al., 2020). It was declared a pandemic by the World Health Organisation on March 12, 2020. In addition to China, there was a serious increase in the number of cases and deaths, especially in Italy. These events began to influence social and cultural activities around the world, in particular, in Italy. Due to the virus, international flights between many countries were cancelled, as well as border crossings with dangerous countries were closed. In some countries, a state of emergency has been declared, training has been suspended for a certain period of time. The transition to an online course system is another example of how COVID-19 affects life, especially in China, Italy, and many other countries. In addition, there was the cancellation of matches of the Italian football League Serie A, which is a significant indicator for the population of Italy. All these aspects have led to a slowdown or shutdown of production, the closure of entire industries, and the plight of small businesses with a small margin of financial strength.

The COVID-19 epidemic has a negative impact on global trade, investment, and social and cultural life. The epidemic has particularly affected tourism, which is so important for Italy, trade in raw and non-raw materials, and the manufacturing and transport sectors. Accordingly, the rating agencies Moody's and Standard & Poor's lowered their forecast for Italian economic growth in 2020. Many countries that import goods from Italy or have their production facilities in Italy have decided to stop this activity. Given all these negative consequences, it seems inevitable that stock markets, economic growth and exchange rates will also have corresponding changes. Accordingly, this study aims to examine the relationship between COVID-19 and the stock markets in Italy, where this virus is most strongly manifested. These relationships were investigated using a statistical model implemented in the Gretl statistical software.

The aim of the manuscript is to investigate the relationship between daily total COVID-19 mortality and daily total COVID-19 cases and sectoral stock market indices in Italy, where COVID-19 has been widespread.

The hypothesis of the study is that the serious economic losses due to the COVID-19 pandemic in

Italy were reflected in the country's financial markets, in particular, the stock market. A study of the main characteristics showing the dynamics and current state of the stock market in Italy will allow us to determine the severity of the impact, which is presumably very high.

Based on this hypothesis, the applied part of the study will use a mathematical model to determine whether there is a long-term relationship between variables. To test this relationship, it is necessary to determine the stationary levels of indicators that characterise the development of the Italian stock market by using the available statistics.

2. Literature Review

Various international monetary organisations and platforms are warning that the recent COVID-19 will have serious consequences for the global economy and possibly surpass the global economic crises of 2007/2008. In the World Economic Forum review, it is stated: «Globally, the coronavirus shock is severe even compared to the great financial crisis in 2007–08»[1]. The 2020 outbreak of the new coronavirus (COVID-19) will go down in history due to its enormous impact on the global economy. Economic processes will recover, but they will no longer be the same as before. China has been hit hard by the devastating coronavirus outbreak. China's manufacturing and services sector fell to an all-time low, car sales in China fell a record 80 %, and Chinese exports fell 17.2 % in January and February 2020 (Omarova, Gelmanova, 2020).

Literature data show that COVID-19 has had a significant impact on stock markets around the world. Indicators of the impact of COVID-19 on financial markets were noted in various financial markets around the world, in particular in the US on the Dow and S&P index, the trends in trading rates significantly decreased to respond to the situation of COVID-19 in America and the world as a whole (Omarova, Gelmanova, 2020).

Experts in the field of economics predicted a serious impact of COVID-19 on the national economy. Economic experts have analysed that COVID-19 will have an impact on social welfare and the economy as a whole, especially on trade in financial markets, overall business in terms of imports and exports, production and fuel prices. Researcher Shambaugh (2020) argued in support of this question, stating that «the crucial actions taken to limit the spread of the pandemic will have the greatest impact for both the broader welfare and the economy». The researcher points out that COVID-19 had an impact on all financial markets in the world; in particular, the trend in stock prices fell significantly and continuously. Another global indication of the influence of financial markets around the world is the data from the Nikkei, which trades on the Tokyo stock exchange. The Nikkei market price trend has also experienced share price volatility and mostly a downward trend throughout the period following the COVID-19 outbreak and the emergence of a worldwide pandemic.

Various literature sources suggest that COVID-19 will have a serious impact on the global economy, with attention drawn to the fact that the world is heading for a global recession, which will affect stock markets.

For more than two hundred years of the development of the world financial system, its normal functioning was interrupted under the influence of crises of varying depth and severity. Certain elements of the global financial system suffered to varying degrees from the impact of these crises (Vorontsova, Karlov, 2020).

Ramelli and Wagner (2020) identified the response of financial markets to the recent COVID-19 pandemic. Experts have shown that financial markets have reacted quickly to COVID-19 as it changes direction and becomes a pandemic in the process of spreading around the world. This will lead to a global recession related to the reaction of financial markets to COVID-19. The researchers clearly insisted that these early results indicated that the market was responding fairly quickly to concerns about the possible economic consequences of the new coronavirus (Shikov, 2020).

Baret and his colleagues (Baret et al., 2020) discussed in detail the impact of COVID-19 on financial markets and banks in a 2020 article. The researchers argued that COVID-19 has a significant impact on overall financial markets, as the world has recently witnessed a drop in stocks, oil and bonds around the world. This indicates that COVID-19 has seriously pushed financial markets in a different direction and responded to investment. Baret and colleagues analyse in detail and explain that since February 21, 2020, bond yields, oil prices, and stocks have plummeted, and trillions of dollars in almost all asset classes have sought safety (Ramelli, Wagner, 2020; Baret et al., 2020).

From a global business perspective, COVID-19 has also had a significant impact. Various compa-

[1] World Economic Forum. (2020). The IMF Explains The Economic Lessons From China Fight Against Corona Virus. IMF Blog. Retrieved from: https://www.weforum.org/agenda/2020/03/imf-economic-lessons-from-china-fight-against-coronavirus/. (Date of access: 03.04.2020)

nies experience a low level of production, which leads to a decrease in revenue collected. Deloach identified the scale of companies affected by the COVID-19 pandemic. Deloach clarified that companies are experiencing lower revenues, higher operating costs and/or cash flow problems due to COVID-19, which consequently affects the value of their shares and causes a collapse in the stock market (Deloach, 2020).

S&P Global (2020) published that it is presently apparent that the hit to global economic recreation from the standards to hamper the stretch of the coronavirus pandemic will be massive.

Russian researcher Barinov (2020) believes that as the world is experiencing an economic downturn, economic recovery is only possible in the long term due to the serious large negative impact of COVID-19 on the world economy. The ICAEW (2020) report on their contribution to the report stated that the COVID-19 pandemic led to a difficult, if not entirely unexpected, hearing, but gave hope for a long-term recovery.

States are trying to minimise the consequences of the economic crisis that followed the pandemic by using reserve funds. The banking sector is urged to give entrepreneurs, who are forced to restore their business, interest-free loans. However, not all financial structures are ready for such a step to ease the monetary burden. As an alternative to the complete exemption of debtors from interest on loans, its employees are going to reduce the interest rates on the funds provided (Tsvetikova, 2020).

The problem of the Italian stock market has received little attention in the literature so far. Segal and Gareth (2020) analysed the sense of concern about investment in Italy and proved in detail that fears about the impact of the coronavirus outbreak on the economy were justified, and its economic impact spread to stock markets in March (Deloach, 2020).

National healthcare systems are facing the contagion with incredible strength, but concern regarding the psychosocial and economic effects is growing quickly. Healthcare workers and people living in northern Italy reported a significantly worse outbreak impact on health, but not on the economy. In the whole sample, distress and loneliness were key variables influencing the perceived impact of the COVID-19 outbreak on health, while empathy and coping style affected the perceived impact on the economy. The COVID-19 pandemic is a worldwide emergency in terms of psychological, social, and economic consequences (Cerami et al., 2020).

Therefore, the economy's response to the COVID-19 pandemic is believed to be causing concern for investors in the stock markets. The literature suggests that the spread of COVID-19 around the world led to serious concerns and uncertainty in stock markets. As a result, various global markets became too volatile and stock prices declined significantly. At the same time, Italy, as one of the most affected countries, is not considered much in the literature on the impact of COVID-19 on the economy and stock market.

3. Theory of the Relationship between the Epidemic and the Stock Exchange

The COVID-19 virus is the most common in Europe — Italy and France. In addition, Italy is one of the countries where COVID-19 is spreading rapidly. The consequences of COVID-19 for the Italian economy and financial markets are as follows: the economic blockade of major cities, leading to economic losses, especially for the daily income from small and medium-sized businesses, the withdrawal of money by investors from the stock market and the fall in oil prices and the global economy (Ozili, 2020). But against the backdrop of such significant economic changes (McKibbin, Fernando, 2020), the impact of COVID-19 can also not be overestimated, since it can lead to a huge external debt of any country.

In addition, since the world is heavily dependent on Chinese goods and production, the import of goods becomes a problem, because as the corona virus spreads, production and exports are severely halted. Therefore, a large number of countries that depend on imports of goods from China automatically suffer because of COVID-19. Larry (2020) explained in detail that the impact of imports to China directly affected the export economy of countries around the world.

The latest economic data released by NBS shows that COVID-19 has become the largest shock to China's economy in recent history and such negative impacts are still ongoing. Economic sectors were hit by COVID-19 differentially (Zhang et al., 2020).

In addition to its awful cost in human lives, the COVID-19 outbreak is creating huge economic disruption, especially in the highly connected modern world, in which both trade and foreign investments are increasingly globalized and the majority of the population is urbanized (Liu, Lee, Lee, 2020).

To assess the possible impact of the coronavirus on the Italian financial market, not only the epidemiological profile of the virus is of great importance, but also its impact on the economy and investment. The feeling of uncertainty in the po-

sition of investors will affect the economy in various ways, such as a decrease in the participation of enterprises and households in the life of financial markets. Businesses may refrain from investing due to supply chain uncertainties and international and national clients. Households worried about exposure to the virus can cut spending on luxury goods. It should also be noted that health risk is a real economic risk associated with the payment of health insurance, which will lead to large costs in the country's economy as a whole and investors in particular (Daily FT, 2020; Igwe, 2020).

This will lead to a reduction in costs and, consequently, to a decrease in the rate of economic growth, which will also reduce the indicators of the country's stock market. Based on the above, if the impact of COVID-19 on the economy and stock markets is not properly understood and managed, this virus could completely disrupt the health sector or disrupt the economy of any country (AbdulAzeez, 2020), especially in the absence of a vaccine (Okhuese, 2020).

Kilic (2020) examined the effect of coronavirus on Borsa İstanbul sector returns using the event study method. According to the analysis results, negative abnormal returns were found in most of the indices.

Examining the impact of COVID-19 on stock markets, Zeren and Hızarcı (2020) included the countries of China, South Korea, Italy, France, Germany and Spain, where cases are frequently seen. Maki cointegration test was applied in the study where daily data between 23 January 2020 and 13 March 2020 were used. The findings reveal that the total number of deaths and all the exchanges examined act together in the long term, the total cases are in a cointegration relationship with the stock markets of China, South Korea and Spain, and the total number of cases is not cointegrated with the stock exchanges of Italy, France and Germany (Zeren, Hizarci, 2020).

Feng et al. (2020) tried to identify appropriate investment strategies with the philosophy of «thinking ahead of the curve» in order to achieve significant gains in the US stock markets and focused on the sectors that would be most benefited during this crisis. As a result of their analysis, researchers found that companies with more positive news than negative news yielded higher returns and suggested investors to invest in the stocks of a number of companies.

Yan et al. (2020) stated that during the epidemic periods, the markets reacted very quickly to the epidemic in the short term, but in the long term, the market corrected itself and rose.

4. Objectives of the Research

Therefore, the following tasks can be set:

— To conduct a theoretical study of the relationship between the overall mortality of COVID-19 and the country's stock markets;

— To develop and implement, based on available data, an economic and mathematical model that considers the relationship and strength of the relationship between virus-related mortality and stock market indicators;

— To generalise the results of the analysis in the form of proof or refutation of the research hypothesis.

The implementation of these tasks makes this work useful for such categories of researchers as economists, sociologists, political scientists, as well as for managers of public administration to predict the development of the economy as a result of the coronavirus epidemic.

5. The Research Goals

The purpose of this study is to investigate the relationship between the daily total mortality of COVID-19 and the daily total cases of COVID-19 with the stock markets of Italy, where COVID-19 is widely spread. Achieving this goal will reveal a very relevant and necessary relationship between coronavirus mortality and stock market indicators for the current period of global economic development. In the future, this will help predict the consequences of the coronavirus pandemic and develop measures for investors to overcome the severe stock market failures as soon as possible.

6. Research Methodology

Many studies have been exploring the relationship between epidemics and economic development. A wide variety of models are used. For example, Guptaa, Moyera and Stern (2020) use a multiple regression model, revealing the relationship between economic indicators and SARS incidence in Canada. Gormsen and Koijen (2020) use a linear model, highlighting the impact of coronavirus on the economy and the stock market.

But as of the date of this study, no in-depth research has been conducted that examines the relationship between COVID-19 and the economic variables that characterise the stock market in Italy as the most affected country by the pandemic. There are studies by Luo and Tsang (2020), Ruiz Estrada et al. (2020), in which researchers try to interpret the possible consequences of the current state of the virus for the economy and the stock market in particular.

In this study, we discussed an economic and mathematical model that allows changes in the

Table 1

Correlation coefficients between X_i and Y_j

	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Y_8	Y_9	Y_{10}	Y_{11}
X_1	–0.635	–0.622	–0.119	–0.703	0.178	–0.582	–0.565	–0.499	–0.298	–0.482	–0.643
X_2	–0.495	–0.482	–0.096	–0.569	0.298	–0.418	–0.417	–0.404	–0.140	–0.399	–0.515
X_3	–0.774	–0.766	–0.288	–0.778	–0.343	–0.809	–0.754	–0.622	–0.690	–0.601	–0.742
X_4	0.172	0.165	–0.067	0.221	–0.267	0.129	0.121	0.122	–0.007	0.157	0.178

Source: created using Gretl statistical software.

level, trend, and independent variables due to the structure of the series. In the course of the study, the selected model is evaluated for each possible structural break and statistical data are obtained from the unit error test applied to the residuals.

The present research attempts to identify the relationship between COVID-19 and stock markets with empirical data on Italy using time series analysis, and this reveals the original side of the work. The following sections of the study include the econometric method, data and empirical conclusions, and the conclusions section, which discusses these conclusions and presents suggestions for future research.

6. Research Model

The source data are presented by the daily prices of the indices of the Italian stock exchange FTSE / MIB 40 (Y_1), INVIT40 (Y_2), FTIT1300 (Y_3), FTIT8000 (Y_4), FTIT4000 (Y_5), FTIT2000 (Y_6), FTIT5700 (Y_7), FTIT0001 (Y_8), FTIT9000 (Y_9), FTIT6000 (Y_{10}), FTIT7000 (Y_{11}) from 17 February 2020 to 30 April 2020.

FTSE / MIB 40 (Y_1): Futures on the FTSE MIB — June '20, Futures on the FTSE MIB — June '20.

INVIT40 (Y_2): Investing.com Italy 40.

FTIT1300 (Y_3): FTSE Italia All Share Chemicals.

FTIT8000 (Y_4): FTSE Italia All Share Financials.

FTIT4000 (Y_5): FTSE Italia All Share Health Care.

FTIT2000 (Y_6): FTSE Italia All Share Industrials.

FTIT5700 (Y_7): FTSE Italia All Share Travel & Leisure.

FTIT0001 (Y_8): FTSE Italia Oil & Gas.

FTIT9000 (Y_9): FTSE Italia Technology.

FTIT6000 (Y_{10}): FTSE Italia Telecommunications.

FTIT7000 (Y_{11}): FTSE Italia Utilities.

Factor variables are:

X_1 — Number of cases of coronavirus (COVID-19), people.

X_2 — Number of recoveries from coronavirus, people.

X_3 — Number of deaths from coronavirus, people.

X_4 — Mortality from coronavirus among those who have it, %.

Using the Gretl statistical software, we will build significant econometric models of the impact of morbidity and mortality rates of the Italian population from coronavirus on the key indices of the Italian stock exchange (Babeshko, 2018; Boldyrevskiy, 2017; Ismagilov, Kadochnikova, 2018; Kremer, 2019).

8. Results

First, it is necessary to analyse the correlation between the features. Table 1 presents the results of calculating the correlation coefficients between the explanatory factors and the resulting variables.

5 % critical values (bilateral) = 0.2732 for n = = 52. Significant correlation coefficients are highlighted in colour (Table 1).

Correlation coefficients show that the death rate from coronavirus among the sick does not have a statistically significant relationship with the price of the Italian stock exchange indices. The number of deaths from coronavirus is statistically significantly correlated with all the key indices of the stock exchange.

It is also worth noting that the price of the FTIT1300 index depends only on the number of deaths, but not on the number of sick and recovered, unlike the FTSE/MIB 40, INVIT40, FTIT8000, FTIT2000, FTIT5700, FTIT0001, FTIT6000, FTIT7000 indices.

Factors X_1, X_2, and X_3 are significantly interrelated with each other, which indicates the collinearity of factors and will lead to unreliability of coefficient estimates when constructing a multiple regression model.

The analysis of paired models of the dependence of key indices of the Italian stock exchange on the number of sick, recovered and dead was conducted using the least squares method, based on which tests were performed to verify the feasibility of Gauss-Markov conditions using Gretl tools:

— heteroskedasticity of residues — White test;

— autocorrelation of residues — Darbin-Watson test;

— normality of the distribution of residues.

Table 2

Paired linear models Y_j from X_1

J	Index	Regression equation	Relevance *b*	Significance of the model	R^2
1	FTSE/MIB 40	$Y = 20915.846 - 0.046\ X_1$	yes	yes	0.403
2	INVIT40	$Y = 2041.192 - 0.004\ X_1$	yes	yes	0.386
3	FTIT1300	$Y = 12827.175 - 0.003\ X_1$	no	no	0.014
4	FTIT8000	$Y = 11205.847 - 0.033\ X_1$	yes	yes	0.495
5	FTIT4000	$Y = 194633.241 + 0.069\ X_1$	no	no	0.032
6	FTIT2000	$Y = 30297.162 - 0.066\ X_1$	yes	yes	0.338
7	FTIT5700	$Y = 33787.933 - 0.097\ X_1$	yes	yes	0.319
8	FTIT0001	$Y = 13257.405 - 0.024\ X_1$	yes	yes	0.249
9	FTIT9000	$Y = 84952.837 - 0.091\ X_1$	yes	yes	0.089
10	FTIT6000	$Y = 10927.650 - 0.013\ X_1$	yes	yes	0.232
11	FTIT7000	$Y = 38940.496 - 0.070\ X_1$	yes	yes	0.414

Source: created using Gretl statistical software.

Table 3

Paired linear models Y_j from X_2

J	Index	Regression equation	Relevance *b*	Significance of the model	R^2
1	FTSE/MIB 40	$Y = 20059.294 - 1.454\ X_2$	yes	yes	0.245
2	INVIT40	$Y = 1957.895 - 0.139\ X_2$	yes	yes	0.233
3	FTIT1300	$Y = 12775.447 - 0.097\ X_2$	no	no	0.009
4	FTIT8000	$Y = 10624.905 - 1.090\ X_2$	yes	yes	0.323
5	FTIT4000	$Y = 193355.557 + 4.731\ X_2$	yes	yes	0.089
6	FTIT2000	$Y = 28894.478 - 1.927\ X_2$	yes	yes	0.175
7	FTIT5700	$Y = 31809.212 - 2.913\ X_2$	yes	yes	0.174
8	FTIT0001	$Y = 12843.804 - 0.780\ X_2$	yes	yes	0.163
9	FTIT9000	$Y = 82051.621 - 1.752\ X_2$	no	no	0.020
10	FTIT6000	$Y = 10702.935 - 0.452\ X_2$	yes	yes	0.159
11	FTIT7000	$Y = 37687.972 - 2.283\ X_2$	yes	yes	0.265

Source: created using Gretl statistical software.

The simulation results are presented in Tables 2, 3 and 4.

The data in Table 2 show that two models of the dependence of the Italian stock exchange indices on the number of patients with coronavirus are not statistically significant with 95 % reliability.

The dependence of the FTIT8000 index on the number of patients with COVID-19 is the highest — 49.5 % of the variation in the price of the index for the period from 17 February 2020 to 30 April 2020 is due to the variation in the number of cases.

Table 4

Paired linear Y_j models from X_3

J	Index	Regression equation	Relevance *b*	Significance of the model	R^2
1	FTSE/MIB 40	$Y = 21738.880 - 8.581\ X_3$	yes	yes	0.598
2	INVIT40	$Y = 2124.039 - 0.837\ X_3$	yes	yes	0.587
3	FTIT1300	$Y = 13081.496 - 1.099\ X_3$	yes	yes	0.083
4	FTIT8000	$Y = 11588.542 - 5.633\ X_3$	yes	yes	0.605
5	FTIT4000	$Y = 205796.127 - 20.612\ X_3$	yes	yes	0.118
6	FTIT2000	$Y = 32126.071 - 14.099\ X_3$	yes	yes	0.655
7	FTIT5700	$Y = 36167.853 - 19.886\ X_3$	yes	yes	0.568
8	FTIT0001	$Y = 13720.910 - 4.540\ X_3$	yes	yes	0.387
9	FTIT9000	$Y = 92306.624 - 32.653\ X_3$	yes	yes	0.476
10	FTIT6000	$Y = 11190.487 - 2.575\ X_3$	yes	yes	0.361
11	FTIT7000	$Y = 39944.814 - 12.444\ X_3$	yes	yes	0.551

Source: created using Gretl statistical software.

The value of R^2 for all models of Table 2 does not exceed 0.5 (50 %), which indicates a low share of the variance explained by the models in the total price variance of the Italian stock exchange indices.

The data in Table 3 show that two models of the dependence of the Italian stock exchange indices on the number of coronavirus recovered are not statistically significant with 95 % reliability. The value of R^2 for all models does not exceed 0.5 (50 %), which indicates a low proportion of the variance explained by the models in the total price variance of the Italian stock exchange indices.

It is worth noting that a statistically significant positive relationship is observed only in the FTIT4000 index of the number of patients recovered from the coronavirus.

All paired linear models of the dependence of the Italian stock exchange indices on the number of deaths are statistically significant with a 95 % probability, as are the regression coefficients of the models characterising the negative relationship between the variables: an increase in the number of deaths from coronavirus leads to a decrease in the price of the indices.

Of the 33 pair linear models under study, a determination coefficient of more than 0.5, which is optimal, was found only in 6 models characterising the dependence of the Italian stock exchange indices on the number of deaths from coronavirus (Table 4).

An analysis of these six models showed:

— The type of dependence and the Ramsey test (p-value < 0.05) confirm the presence of a nonlinear dependence between the signs (hyperbolic);

— All model coefficients, including constants, are statistically significant;

— The test for the normality of the distribution of residues (p-value > 0.05) shows that the residues of all six models obey the normal distribution law;

— Darbin-Watson statistics DW < d_L = 1.5 at $\alpha = 0.05$, $n = 52$, and $m = 1$, respectively, there is a positive autocorrelation of residues;

— White test for heteroskedasticity (p-value < 0.05) confirmed the presence of heteroskedasticity in the remains of two models: Y_4 from X_3, Y_7 from X_3.

The economic meaning of the regression coefficients of the four models, the remains of which are homoscedastic, is that, ceteris paribus, with an increase in the number of deaths from coronavirus in Italy by 1 person:

— decrease in the price of the FTSE / MIB 40 index by 8.581 points on average;

— decrease in the price of the INVIT40 index by 0.837 points on average;

— decrease in the price of the FTIT2000 index by 14.099 points on average;

— FTIT7000 index price reduction by 12.444 points on average.

The mean absolute percentage forecast error (MAPE) for the dependence of the FTSE / MIB 40 index on the number of deaths was 9 %, the INVIT40 index was 9.1 %, the FTIT2000 index was 8.5 %, and the FTIT7000 index was 7.5 %. The mean absolute percentage forecast errors do not exceed 10 %, indicating a high accuracy of forecasting.

Thus, the dependence of the Italian stock exchange indices on the number of patients, recovered and died from the coronavirus is recognised as statistically significant. The most suitable for forecasting are the paired linear regression models of the FTSE / MIB 40, INVIT40, FTIT2000, FTIT7000 stock exchange indices from the number of deaths from COVID-19 in Italy.

9. Discussion

Therefore, in this research, the goal was to investigate the relationship between daily total COVID-19 mortality and daily total COVID-19 cases with the stock markets of Italy, where COVID-19 is widely spread. Accordingly, an economic and mathematical model was used that considers the dependence and strength of the relationship between virus-related mortality and stock market indicators.

While the existence of a relationship is found between the daily total death rate from COVID-19 and the entire Italian stock market, a relationship was also found between the daily total death rate and some stock indicators in particular. Accordingly, the increase in population mortality affects all investors, while the hearing of the case, but the absence of death did not affect some stock markets in some countries. Given that stock markets do not act according to the efficient market hypothesis and tend to follow behavioural financial theories, it is clear that investors in the Italian stock markets are not psychologically affected by the implementation of cases. From the results of this study, it is clear that investors have started to suffer from deaths in Italy, and these trends will continue while the Italian population continues to die from the virus.

A careful study of the results shows that the dates of structural changes in the Italian stock market coincided with the beginning of March 2020, when the effect of the COVID-19 virus began to be seriously felt in Italy. During these dates,

there was a significant increase in the number of people who died from COVID-19, and this situation is considered in the results of this analysis as a structural gap that confirms the hypothesis of the study.

Based on the data obtained, it becomes clear that the country's stock market, studied through the indicator of the daily total death of COVID-19, shows a high dependence on mortality from coronavirus. On the other hand, it is understood that there is a long-term relationship between COVID-19 daily total cases and the Italian stock market. This was confirmed by calculations using the econometric model, according to which the research hypothesis was confirmed that the number of deaths from coronavirus is statistically significantly interconnected with all key Italian stock exchange indices. In particular, the price of FTIT1300 index depends only on the number of deaths, but not on the number of sick and recovered, unlike the indices FTSE / MIB 40, INVIT40, FTIT8000, FTIT2000, FTIT5700, FTIT0001, FTIT6000, FTIT7000. The highest dependence on the number of patients with COVID-19 is observed for the FTIT8000 index. The pairwise linear regression models of the stock exchange indices most suitable for forecasting were also identified — namely: FTSE / MIB 40, INVIT40, FTIT2000, FTIT7000 of the number of deaths from COVID-19 in Italy. These models can be used in further research and in building forecasts for the development of the stock market.

Thus, in this study of econometrics, it is possible to identify the direction of relationships and cause-and-effect relationships between the variables considered.

As a result, the severe economic losses due to the pandemic in Italy indicate that with the end of COVID-19, world monetary and commodity flows will be redistributed and world trade will give new signals of movement. So, the research hypothesis put forward at the initial stage was confirmed.

10. Conclusions and Suggestions

Therefore, given that the number of COVID-19 cases and the number of deaths increased day by day in line with the results, it is clear that investing in the stock market is not the right option for investors. The fact that this is one of the new studies that reveals the relationship between the death rate of an individual country from COVID-19 and stock markets with empirical findings determines the novelty of the study. However, the fact that the article is based on limited data does not provide clear conclusions about what results will occur in the future.

The results, which will be obtained with a wider dissemination of data, will reveal the possible consequences of the pandemic for stock markets and the economy with clearer conclusions. However, the fact that macroeconomic variables such as gross domestic product, trade openness, and unemployment are not measured at daily frequencies does not yet allow empirical research to identify the relationship between these variables and COVID-19. If the pandemic continues, future research with a new model that takes these variables into account will present important economic conclusions to policy makers. Therefore, this study is also very useful for researchers, economists and political scientists studying the consequences and impact of COVID-19.

In addition, the results of this research are of great interest to investors. Therefore, it is possible to develop specific recommendations and suggestions for this group of users. Investing in gold markets, which are seen as a safe haven in all financial markets, can be seen as a logical choice for investors. With the increasing spread of COVID-19, businesses started operating on the Internet, and this process may gradually expand. Cryptocurrencies such as bitcoin, the most widely used cryptocurrency in the world, can be considered as another financial tool for investment. In addition, to minimise the risk, turning to derivative products will also be one of the right options. Another correct investment option in this extraordinary situation would be to turn to country markets where COVID-19 cases are relatively low.

It is necessary to note the importance of the results of this study for public authorities and financial regulation. Based on the research findings, the following measures can be recommended: stimulating local companies, diversifying the economy, implementing flexible exchange rate regime in order to improve the situation in the financial market and attract more investors to the Italian stock exchange.

Further research may focus on the construction of more complex econometric models to assess the impact of coronavirus morbidity and mortality rates, as well as the development of prognostic models to assess the future impact of COVID-19 morbidity and mortality on the development of the stock exchange. In this case, paired linear regression models of stock exchange indices most suitable for forecasting that were identified during this study can be used: namely, FTSE / MIB 40, INVIT40, FTIT2000, FTIT7000 of the number of deaths from COVID-19 in Italy.

In the future, these results will help predict the consequences of the coronavirus pandemic and

develop measures for investors to quickly overcome the resulting severe stock market failures. The study recommends the regulators to pursue social and economic policies such as a stable political environment, incentives for local companies, diversification of the economy, a flexible exchange rate regime in order to improve the situation in the financial market and attract more investors to the Italian stock exchange. In addition, alternative investment directions are offered for investors working on the stock exchange during the coronavirus pandemic.

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