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Araştırma Makalesi Research Article

EFFECTS OF THE COVID-19 PANDEMIC ON TURKISH NATURAL STONE INDUSTRY: A GREY FORECASTING MODEL

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Keywords
Turkish Natural Stone, Export, Covid-19 Pandemic, Grey Forecast Model.

Abstract
When the indicators in recent years are examined in the developing and renewed economic environment in Turkey, it is seen that the momentum of the natural stone industry and its share in total mining exports have increased steadily. However, the Covid-19 pandemic in 2020, which affected the whole world, also affected the Turkish natural industry. Within the scope of this study, the export values of the Turkish natural stone industry on a monthly and yearly basis were evaluated both before the pandemic and during the pandemic. Export figures for 2020 and 2021 were tried to be estimated using the Gray Forecast model. With the effect of the Covid-19 pandemic, natural stone export figures for 2020 fell behind 2019 in February, March, April and May. With the normalization process in June, July and Months, normalization started in export figures and exceeded the export values of 2019 in September, October, November and December. In 2020, which was entered with great hopes, it was not possible to reach the targeted figures this year due to the pandemic. In addition, Also, export values for 2020 and 2021 were predicted using a GM (1,1) grey forecasting model, which is a method frequently used in uncertainty cases. 2020 and 2021 export values were estimated by using the GM (1,1) gray forecasting model, which is a method frequently used in uncertainty situations. It has been seen that the model can be used reliably to predict natural stone export figures. In the following years, some assessments and recommendations have been made that may make the Turkish natural stone industry stronger in the following years on issues such as health management of crises and adaptation to the current situation if such outbreaks are replicated in the global world economy.

COVİD-19 PANDEMİSİNİN TÜRK DOĞAL TAŞ SEKTÖRÜNE ETKİLERİ: BİR GRİ TAHMİN MODELİ

Anahtar Kelimeler
Türk Doğal Taşı, İhracat, Covid-19 Pandemisi, Gri Tahmin Modeli.

Öz
Türkiye'de gelişen ve yenilenen ekonomik ortamda son yıllardaki göstergeler incelendiğinde, doğal taş sektörünün ivmesinin ve toplam madencilik ihracatı içindeki payının istikrarlı bir şekilde arttığı görülmektedir. Ancak 2020 yılında tüm dünyayı etkisi altına alan Covid-19 salgını, Türkiye doğal taş endüstrisini de etkilemiştir. Bu çalışma kapsamında hem pandemi öncesi hem de pandemi döneminde Türkiye doğal taş sektörünün aylık ve yıllık olarak ihracat değerleri değerlendirilmiştir. 2020 ve 2021 yılına ait ihracat rakamları Gri Tahmin modeli kullanılarak tahmin edilmeye çalışılmıştır. Türkiye maden ihracatının %50'lik kısmını Doğal Taş ihracatı oluşturmaktadır. Covid-19 pandemisinin etkisiyle 2020 yılı doğal taş ihracat rakamları Şubat, Mart, Nisan ve Mayıs aylarında 2019 yılının gerisinde kalmıştır. Haziran, Temmuz ve Ağustos aylarında normalleşme süreci ile birlikte ihracat rakamlarında normalleşme başlamış ve Eylül, Ekim, Kasım ve Aralık

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aylarında 2019 yılı ihracat değerlerinin aşmıştır. Büyük umutlarla girilen 2020 yılında pandemi nedeniyle bu yıl hedeflenen rakamlara ulaşmak mümkün olmamıştır. Ayrıca belirsizlik durumlarında sıklıkla kullanılan bir yöntem olan GM (1,1) gri tahmin modeli kullanılarak 2020 ve 2021 ihracat değerleri tahmin edilmiştir. Modelin doğal taş ihracat rakamlarını tahminde güvenilir olarak kullanılabileceği görülmüştür. İlerleyen yıllarda krizlerin sağlıklı yönetimi ve bu tür salgınların küresel dünya ekonomisinde tekrarlanması halinde mevcut duruma uyum gibi konularda önümüzdeki yıllarda Türkiye doğal taş sektörünü daha güçlü kılabilecek bazı değerlendirmeler ve önerilerde bulunulmuştur.

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1. Introduction

The effects of changes occurring in the world due to globalization are very rapid. The consequences of political developments, economic crises, wars, and epidemics occurring at the national level as a result of globalization in the world exceed the borders of the country and reach countries that are not bordering. Economically dependent, economically dependent countries or foreign-dependent countries are adversely affected by such events due to their fragile economies. Developing countries such as Turkey should be economically strong because they are affected by developments on a global scale. The road to power in the global world is also through economic growth. Developing countries, which consider economic growth as a goal, both enrich and develop by using their natural resources (Başol et al., 2005; Ekincioğlu and Akbay, 2021).

The wide range of raw materials in the natural stone industry increases its competitiveness in global markets with block and processed plate productions using modern production methods and contributes about $2 billion to the country's economy every year.

As of 2019, the share of mining in Turkey's total exports was 2.60% ($4.3 billion) and the share of natural stone exports in total mining exports was 43.74% ($1.86 billion) (TİM, 2020). When the data of recent years are examined in the developing and renewed economic environment in Turkey, the momentum of the natural stone industry is obvious. Therefore, to maintain the momentum and stability achieved, all scenarios should be prepared and underlined what awaits the industry (Ekincioğlu and Akbay, 2021). However, this paper tries to answer the following research questions:

- How can the extraordinary situations on natural stone industry be modelled?
- Today, Covid-19 pandemic also affected all industries on a global scale in 2020. So, can it be investigated what effect the pandemic has had on the natural stone industry?
- Can a new model be developed under uncertainty with a time-series-based approach to achieve these effects using Turkey export data until 2020 to 2021?
- Which method/s can be selected for clarifying the uncertainty?

Within the scope of this study, the development of the industry in recent years and the impact of the Covid-19 pandemic affecting the whole world on a global scale in 2020 were examined. In addition, 2020 and 2021 export values were estimated with GM (1,1) grey forecasting model, which is a method frequently used in uncertainty cases, and some evaluations and recommendations were made that could make Turkey's natural stone industry stronger.

The rest of the paper is organized as follows. The analysis of the before Covid-19 pandemic Turkish natural stone export is given with the global views in Section 2. Then, the effects of the Covid-19 pandemic on the natural stone export values of Turkey are given with numerical analysis on the year 2020 in Section 3. The establishing the grey forecasting models and their results are presented with error analysis on the year 2021 in Section 4. Finally, our conclusions are presented by combining the actual and future analysis of the Covid-19 effects as a big crisis in the last section.

2. Before Covid-19 Pandemic Turkish Natural Stone Export

Natural stones are easy to process, resistant to environmental conditions and their aesthetic appearance has been effective in their use throughout history. With the development of technology, the processing of hard rocks that cannot be processed, the increasing ability of rocks to give plates, and the rapid increase of the needs of the construction industry have made the natural stone industry the engine of mining in the world and our country (Adıgüzel and Şengüler, 2019; Ekincioğlu and Akbay, 2021).

There are approximately 2500 licensed natural quarries in the industry and 1500 of them are actively working. Approximately 200 large facilities and approximately 9000 medium and small enterprises and workshops operate in the industry, including SME. Approximately 180000 workers and 5000 technical staff are employed in the industry (TCKB, 2018). The natural stone industry has high added value compared to other industries. It is among the industries that bring net foreign currency to the country as a result of its market. In other industries with high added value, a ratio of 10% to 30% of the foreign currency revenue after exports remains in the country, while all the foreign currency obtained from exports in the natural stone industry remains in the country (Kocaman, 2006; Adıgüzel and Şengüler, 2019; Ekincioğlu and Akbay, 2021).

When the natural stone trade volume of our country between 2013 and 2019 is examined, it is seen that it varies between 41% and 49%. In other words, nearly half of our country's mining exports, which are very rich in underground resources, are natural stone exports (Table 1). Since 2013, Turkish natural stone exports have ranged from 1.74-2.2 billion dollars and the lowest exports have been observed in 2015, 2016, and 2020 (Figure 1). During these years, there has been a decrease in both mining exports and natural stone exports. However, it is seen that the decrease in natural stone exports is less than the decrease in total mining exports. The decrease in 2015 and 2016 was due to the fact that the People's Republic of China cut its incentives to the construction industry during this period. The reason for the decrease in 2020 is the negative, diminutive, narrowing effect of the Covid-19 pandemic on the country's economies and world trade (Ekincioğlu and Akbay, 2021).

Table 1. Turkish natural stone and mining exports values according to the years (IMIB, 2020)

Year	Mining Export		Natural Stone Export		Natural Stone Export/Mining Export %
	$\times 10^6$ tonnes	$\times 10^9$ $	$\times 10^6$ tonnes	$\times 10^9$ $	
2013	22.31	5.03	8.44	2.22	44.14
2014	21.21	4.64	7.37	2.13	45.85
2015	20.14	3.90	6.52	1.91	48.94
2016	20.43	3.79	6.52	1.81	47.67
2017	24.70	4.69	7.94	2.05	43.69
2018	26.33	4.56	7.46	1.91	41.83
2019	27.15	4.31	7.14	1.86	43.24
2020	27.88	4.27	6.46	1.74	40.75

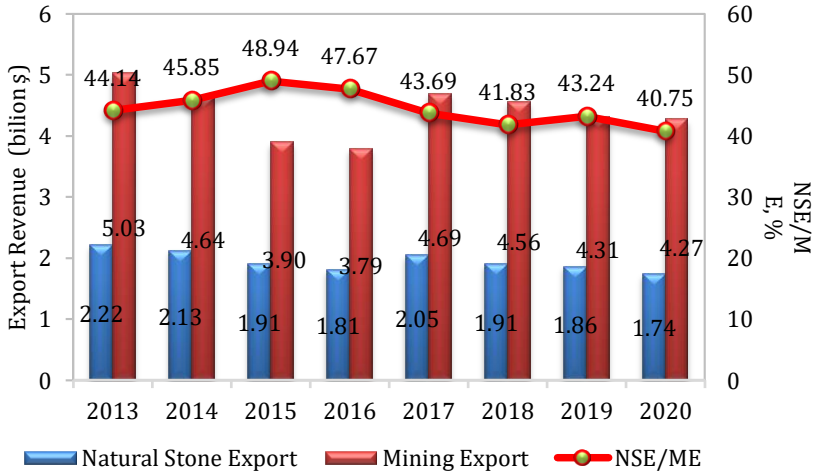

Figure 1. Turkish natural stone-mining export value and natural stone exports/mining exports ratio (NSE/ME, %) (Ekincioğlu and Akbay, 2021)

The decrease in export rates for 2015, 2016, and 2020 has been included in the table as an indication of how risky it is for the industry to adhere to the single market. In terms of the following years, a possible economic or political crisis in the People's Republic of China, where Turkey exports a very large part of its natural stone exports, or the Chinese government restricting natural stone imports or stopping its imports completely, the Turkish natural stone industry will be adversely affected. As a matter of fact, this scenario occurred in late 2019 with the Covid-19 pandemic that occurred in Wuhan, People's Republic of China, was effective all over the world in 2020. The largest share of Turkey's total natural stone exports has remained unchanged in recent years to the People's Republic of China (Table 2) (Ekincioğlu and Akbay, 2021).

Table 2. Export rates by countries (FOB) (%) (IMIB, 2020)

Countries	2013	2014	2015	2016	2017	2018	2019	2020
People's Republic of China	44.17	38.94	38.16	40.41	46.18	40.55	37.27	31.09
United States of America	13.41	15.22	17.03	15.96	14.37	15.69	15.34	18.72
Saudi Arabia	4.27	5.20	5.96	6.61	5.11	5.55	6.73	8.02
India	2.09	2.61	3.30	3.05	4.15	4.73	4.93	3.54
Israel	1.70	1.88	2.21	2.65	2.63	3.17	3.52	4.37
France	0.00	2.37	2.30	2.50	2.53	2.91	3.32	3.88
Iraq	5.17	5.28	4.26	3.95	3.11	3.27	3.43	3.61
Australia	1.12	1.50	1.64	1.72	1.75	2.09	2.13	2.43
United Arab Emirates	2.02	2.23	2.57	2.69	2.57	2.83	2.13	2.09
Other countries	26.05	24.77	22.57	20.46	17.6	19.21	21.2	22.25

The United States follows the People's Republic of China. Following these two countries, the total of natural stone exports to Saudi Arabia, India, Israel, and other countries lags far behind natural stone exports to the People's Republic of China. The People's Republic of China in block exports and the United States in processed product exports are two important markets for the natural stone industry. When Figures 2 and 3 are examined, the first place in the total export amount is the People's Republic of China (min. %47.36 – max. %59.15), but its share in total natural stone exports is higher due to higher value-added processed plate exports to the United States. (min. %13.41 - max. %17.13). These figures clearly prove the importance of high value-added product exports for the Turkish economy (Ekincioğlu and Akbay, 2021).

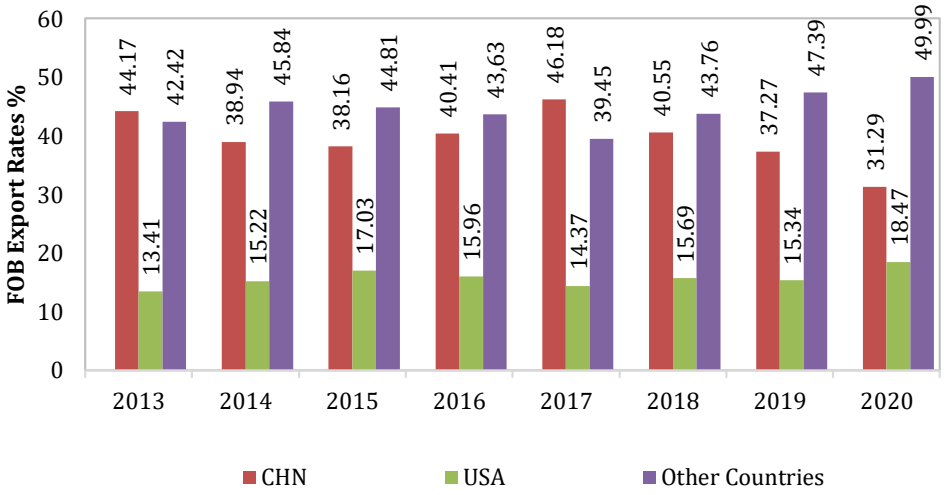

Figure 2. Country shares (FOB) (%) in total natural stone export revenues (Ekincioğlu and Akbay, 2021)

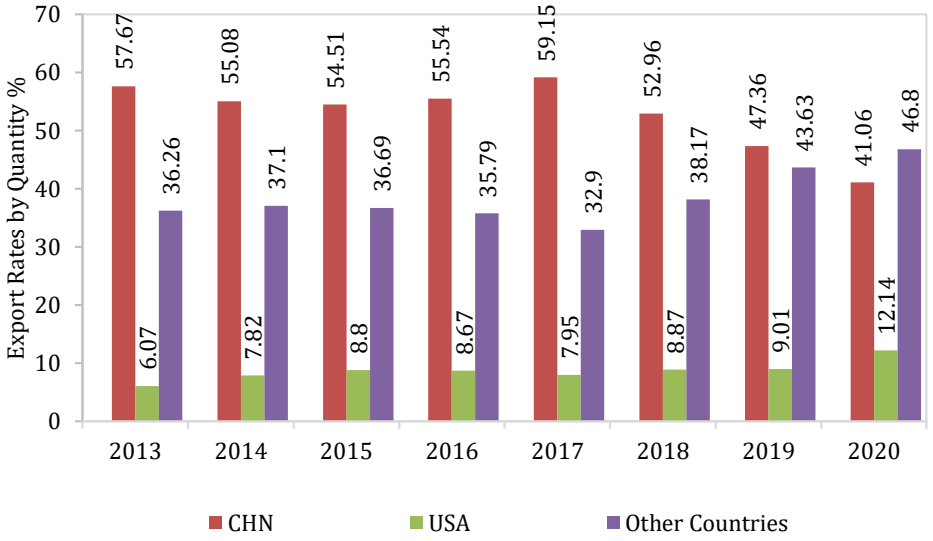

Figure 3. Country shares in total natural stone exports (billion tonnes) (%) (Ekincioğlu and Akbay, 2021)

3. Turkish Natural Stone Export Impact of the Covid-19

How the figures for 2020 belonging to the People's Republic of China and the United States, the two largest markets in the natural stone export market for Turkey, raw blocks and processed products, have changed is given in Table 3. The numbers given in red font in the table represent the decreases in export figures. When the data are examined, it is seen that the natural stone export figures to the People's Republic of China, the center of the pandemic that emerged in December 2019, decreased by around 50% from February 2020. According to the People's Republic of China, natural stone export figures to the United States, where the pandemic reached later, decreased slightly in February 2020, but the decrease in the amount of exports was not felt much on the revenue side due to the rising dollar exchange rate. It is seen that the export figures to the United States have fallen significantly in May 2020. When we look at the data for June 2020, it is seen that the sales amounts close to the data of June 2019 last year were formed although the impact of the pandemic continues to accelerate in the People's Republic of China and United States. This has been interpreted as a strong signal that natural stone exports for Turkey begin the normalization process by June. However, the number of cases that started to increase again in the Covid-19 pandemic, which took effect all over the world in July, has troubled shrinking economies. This situation has led to a continued decline in exports to the People's Republic of China, which operates with high stocks in the natural stone market, takes very drastic measures against the pandemic, and makes closures. Export figures to the United States, whose economy has been severely shrinking, which has started to normalize early due to the election period, and where the measures are not implemented very strictly according to the world as a whole, continued to increase. Natural stone exports to the People's Republic of China decreased by 21% in total in 2020, while exports to the United States increased by 22% (Table 3) (Ekincioğlu and Akbay, 2021).

Table 3. People's Republic of China and United States export data for 2019-2020 (IMIB, 2020)

	2019				2020				% Change			
	China		USA		China		USA		China		USA	
Months	Amount	FOB	Amount	FOB	Amount	FOB	Amount	FOB	Amount	FOB	Amount	FOB
	×103	×106 $	×103	×106 $	×103	×106 $	×103	×106 $	%	%	%	%
January	289.1	56.1	50.9	22.0	290.6	58.6	48.7	44277	1	4	-4	2
Februa	153.6	44436	47.1	44367	74.4	44211	49.6	44398	-52	-48	5	5
March	181.6	35.2	51.8	44217	101.9	44336	57.4	44463	-44	-42	11	18
April	299.1	62.2	54.3	44461	221.5	45.4	49.5	44306	-26	-27	-9	-11
May	437.6	91.3	67.8	31.2	181.7	36.6	46.6	44394	-58	-60	-31	-43
June	210.3	45.1	40.9	44272	192.4	39.1	67.3	44373	-9	-13	64	54
July	357.5	75.2	61.9	44254	280.7	57.7	79.6	32.1	-21	-23	28	18
August	285.4	60.6	48.7	44429	212.3	43.6	63.2	44373	-26	-28	30	22
Septem	309.6	64.7	54.4	44371	293.7	60.3	77.4	44439	-5	-7	42	29
Octobe	299.7	62.2	55.5	44464	246.6	51.2	83.0	35.0	-18	-18	50	35
Novem	298.7	61.6	54.9	44433	304.1	61.9	87.5	34.2	2	0.5	61	33
Decem	259.9	51.8	55.2	44372	257.1	50.2	75.9	31.9	-1	-3	38	25
Total	3382.1	604.8	643.4	286	2657	540.2	785.7	325.2	-21	-11	22	14

Figures 4 and 5 show total natural stone export figures monthly. When the last seven years are examined, it is seen that the natural stone export figures reached their lowest level in February but reached their highest level during the year, both with the opening of the quarries depending on the seasonal effect in May and with the effect of the International İzmir Natural Stone and Technology fair held every year in March. However, with the pandemic effect of 2020, it was seen that natural stone exports were at their lowest level during the year in May. When we look at the data for June 2020, it is seen that the figures were above the sales amounts (tonnes) of June 2019 last year. It is seen that this upward trend continues to spread throughout the year in direct proportion to the normalization process all over the world. It is thought that the amount of exports expected to occur in May 2020 but could not be

realized due to the pandemic had a positive effect on the figures in the remaining six months of 2020 as "Hidden May Export Amount" (Ekincioğlu and Akbay, 2021).

Table 4. Natural stone exports on a monthly basis by year (FOB million $) (IMIB, 2020)

Months	2013	2014	2015	2016	2017	2018	2019	2020
January	169.10	197.28	137.35	129.40	128.64	150.85	139.06	151.48
February	114.54	128.85	114.62	103.81	118.23	119.46	115.52	108.17
March	132.58	147.41	117.07	127.94	138.37	139.39	122.26	116.20
April	184.56	203.57	175.93	168.57	182.96	172.23	160.16	117.96
May	231.87	222.65	183.60	173.36	219.84	197.70	215.49	101.51
June	205.64	201.99	199.40	167.87	199.18	166.48	114.09	134.60
July	223.37	183.71	185.48	128.14	173.72	177.11	184.71	176.14
August	179.21	163.59	168.87	186.69	201.41	142.79	150.80	134.75
September	207.74	191.08	150.79	153.18	152.35	157.71	168.55	172.76
October	183.72	150.87	155.89	161.15	182.65	176.55	167.89	180.45
November	199.31	160.88	159.81	156.82	190.58	167.57	164.57	179.51
December	190.74	176.34	157.44	148.59	160.16	140.45	161.15	163.48
Total	2222.38	2128.22	1906.25	1805.52	2048.09	1908.29	1864.25	1737.01

Table 5. Natural stone exports of Turkey on a monthly basis by year ($\times 10^3$ tonnes) (IMIB, 2020)

Months	2013	2014	2015	2016	2017	2018	2019	2020
January	660	716	440	475	476	594	553	573
February	399	406	338	325	426	444	410	328
March	463	453	330	431	503	506	437	386
April	707	699	590	609	730	668	630	437
May	982	811	642	625	853	796	845	395
June	798	709	721	593	794	651	435	494
July	843	664	622	448	673	685	717	662
August	655	577	586	691	778	562	580	498
September	772	707	561	595	593	626	653	668
October	704	531	532	603	718	704	629	667
November	754	544	576	594	753	683	641	721
December	699	553	578	529	638	542	610	640
Total	8436	7370	6516	6518	7935	7461	7140	6469

4. Grey Prediction Model

Grey System Theory (GST) was proposed by Professor J. Deng in 1982 with titled as “Control Problems of Grey Systems” that was the first study in this field. The GST applications were started to use for many real-life systems such as social, economic, and technical systems since 1989 (Deng, 1989). On the other hand, the GST has many research fields as clustering, incidence analysis, relational analysis, system modelling, decision making, input-output analysis, control process etc. (Liu and Lin, 2006). According to progress of GST, it has applied as an effective and powerful tool in many of the academic and industrial studies are scientific and technological, industrial, mechanical, robotics, mechatronics, transportation, financial, military systems on transforming of cybernetics and, also natural events and sources as meteorological, agricultural, ecological, hydrological, geological, biomedical, mining etc. under grey uncertainties (Liu et al., 2016; Liu, Yang, Forrest, 2017).

Grey system modelling (GM) is a prediction tool using the historical data at least four. GM (1,1) denotes a one-order one-variable grey difference prediction model. Then, the GM (1,1) model has more advantages over the traditional prediction methods. It does not need to any distribution and statistical sample. In addition, it uses an Accumulation Generation Operator (AGO) for smoothing the randomness on the primitive data and an Inverse Accumulation Generation Operator (IAGO) for finding the predicted values (Liu, Yang, Forrest, 2017; Yang et al.,

2018). In the recent scientific literature, grey prediction and forecasting methods are applied in many studies both theoretical and practical modelling (Hsu and Chen, 2003; Ding et al., 2018; Akay and Atak; 2007; Kayacan et al., 2010; Aydemir et al., 2013; Hamzaçebi and Es, 2014; Wei et al., 2019; Liu and Xie, 2019; Carmona-Benítez and Nieto; 2020; Zhu et al., 2021).

4.1. The GM (1,1) Modelling

The modelling process of GM (1,1) is given as follows (Liu et al., 2017; Yang et al., 2018):
Step 1. Conduct the original time series data

$$X^{(0)} = \{x^{(0)}(1), x^{(0)}(2), \dots, x^{(0)}(n)\} \quad [1]$$

where $x^{(0)}(t) \geq 0,\ t = 1,2, \dots, n$.
Step 2. Establish the 1-AGO (first-order accumulating generation operator) time series data

$$X^{(1)} = \{x^{(1)}(1), x^{(1)}(2), \dots, x^{(1)}(n)\} \quad [2]$$

where $x^{(1)}(t) = \sum_{t=1}^{n} x^{(0)}(t),\ t = 1,2, \dots, n$.
Step 3. Obtain the $Z^{(1)}$ row data that is called mean sequence of $X^{(1)}$ generated by by consecutive neighbors

$$Z^{(1)} = \{z^{(1)}(2), z^{(1)}(3), \dots, z^{(1)}(n)\} \quad [3]$$

where $z^{(1)}(t) = \alpha \cdot x^{(1)}(t) + (1-\alpha) \cdot x^{(1)}(t-1),\ t = 2, \dots, n$, $\alpha = 0.5$ in general as the even form of model GM (1, 1). The original form of grey prediction equation is given as a difference equation:

$$x^{(0)}(t) + a \cdot x^{(1)}(t) = b \quad [4]$$

Then, after the Step 3, the original form of GM (1,1) is represented as the even form of GM (1,1) model that is given as follows:

$$x^{(0)}(t) + a \cdot z^{(1)}(t) = b \quad [5]$$

where $\hat{a} = [a, b]^T$ parameter values are estimated using the least square method which satisfies

$$\hat{a} = (B^T B)^{-1} B^T Y \quad [6]$$

where

$$B = \begin{bmatrix} -z^{(1)}(2) & 1 \\ -z^{(1)}(3) & 1 \\ \vdots & \vdots \\ -z^{(1)}(n) & 1 \end{bmatrix}, Y = \begin{bmatrix} x^{(0)}(2) \\ x^{(0)}(3) \\ \vdots \\ x^{(0)}(n) \end{bmatrix} \quad [7]$$

Step 4. Obtain the accumulating prediction equation as a time response function.

$$\hat{x}^{(1)}(t) = (x^{(0)}(1) - \frac{b}{a}) \cdot e^{-a \cdot (t-1)} + \frac{b}{a}, t = 1,2, \dots, n. \quad [8]$$

Step 5. Obtain the prediction equation using 1-IAGO (first-order inverse accumulating generation operator).

$$\hat{x}^{(0)}(t) = (1 - e^{a}) \cdot (x^{(0)}(1) - \frac{b}{a}) \cdot e^{-a \cdot (t-1)}, t = 1,2, \dots, n. \quad [9]$$

4.2. Error Analysis

The prediction and/or forecasting studies need to be compared with the higher imprecision level. So, essential accuracy measurement approaches which are the Mean Squared Error (MSE), the mean absolute error (MAE), and the Mean Absolute Percentage Error (MAPE) are the most widely used. However, according to Chatfield (1988), MSE and MAE can often be major variations in the scale of the observations between the different time series so that a few series with large values can dominate the comparisons. At this phase, MAPE is mostly employed method as needing the unit free measures. The forecasting error at time (e_t) can be defined as follows (Goodwin and Lawton, 1999):

$$e_t = A_t - F_t, t = 1,2, \dots, n \quad [10]$$

where A_t is the actual observation value and F_t is also the forecasted/predicted value for period t. Thus, the Percentage Error (PE) and the Absolute Percentage Error (APE) can be calculated as respectively.

$$PE_t = \frac{A_t - F_t}{A_t} \cdot 100 \quad [11]$$

$$APE_t = \left|\frac{A_t - F_t}{A_t}\right| \cdot 100 \quad [12]$$

So, the MAPE calculation is given as follows in Equation 13.

$$MAPE = \frac{\sum_{t=1}^{n} APE_t}{n} = \frac{\sum_{t=1}^{n} \left|\frac{A_t - F_t}{A_t}\right| \cdot 100}{n} \quad [13]$$

In addition, Makridakis (1993) has presented some disadvantages of MAPE value, for a greater APE, the equal errors above the actual observation than those below the actual value. So, the modified APE (Makridakis,1993) and the smoothed APE (O'Connor et al., 1997) are developed respectively. However, in this study, besides using MAPE, for residual correction, posterior error ratio (C) are also used to test the accuracy of GM (1, 1). The posterior error ratio (C) can be calculated as (Yang et al., 2018):

$$C = S_e / S_x \quad [14]$$

where S_e is the residual standard deviation and S_e is the data standard deviation are given as follows:

$$S_e = \sqrt{\frac{1}{n}\sum_{t=1}^{n}(e^0(t) - e)^2} \quad [15]$$

$$S_x = \sqrt{\frac{1}{n}\sum_{t=1}^{n}(x^0(t) - x)^2} \quad [16]$$

Consequently, the adequacy levels of prediction accuracy for GM (1,1) are classified with four levels to MAPE and C measures in Table 6 which is modified from Lewis (1982) and Yang et al. (2018).

Table 6. Adequacy levels of prediction accuracy for GM (1,1)

Prediction accuracy grades	MAPE	C
1 Excellent	≤ 10	≤ .35
2 Qualified	≤ 20	≤ .50
3 Barely Qualified	≤ 50	≤ .65
4 Unqualified	> 50	> .65

4.3. Computational Results

In this paper, the Covid-19 pandemic effects on the natural stone export values of Turkey from Table 1 in 2020 and grey forecasting model to 2021 are examined by showing model accuracy evaluations in Table 7. Two forecasting models are developed which are titled as Grey Model 1 (GM1) and Grey Model 2 (GM2). GM1 model has established by the years of 2013-2019 row data and then, for the year of 2020, the predict values are obtained by monthly using Equation 17 with 7.88 MAPE value of the whole model.

$$\frac{dx}{dt} - 0.0124253 * x = 6788.2876659 \quad [17]$$

On the other hand, GM2 model has been established by the years 2013-2020 row data including pandemic year, and then, for the year of 2021, the forecast values are obtained by monthly using Equation 18 with 3.34 MAPE value of the whole model. The observed total value of export for the years 2013-2020 is obtained as 57845 $\times 10^3$ tonnes and the predicted total value of export for the years 2013-2020 is also obtained as 55912.55$\times 10^3$ tonnes.

$$\frac{dx}{dt} + 0.0025317 * x = 7142.5154436 \quad [18]$$

Table 7. Computational results on a monthly basis by year ($\times 10^3$ tonnes)

	Grey Model 1			Grey Model 2	
Months	**Observed 2020**	**Predicted 2020**	**APE (%)**	**Forecasted 2021**	
January	573	569.32	0.64	541.99	
February	328	399.71	21.86	371.56	
March	386	454.26	17.68	423.86	
April	437	673.90	54.21	612.42	
May	395	807.87	104.52	718.59	
June	494	683.79	38.42	627.52	
July	662	676.66	2.22	641.89	
August	498	644.23	29.36	595.14	
September	668	655.57	1.86	625.10	
October	667	643.06	3.59	614.59	
November	721	661.10	8.31	636.09	
December	640	603.50	5.70	578.47	
Total	6469	7472.97	288.38	6987.22	
		$MAPE^{2020}$	24.03		
		$MAPE^{MODEL1}$	7.88	$MAPE^{MODEL2}$	3.34
		C	0.23		

According to Table 7, GM1 model has been included the pandemic effects. The months of Feb-Jun and Aug have a very large deviation. So, the prediction results for the year of 2020 are obtain the 24.03 MAPE value against the whole model which has 7.88 MAPE value for the years of 2013-2019. The GM1 results show that the pandemic effects are very disruptive on the natural stone export values in grey highlighted cells. Then, GM2 model deals with forecasting values that are given in Table 7 and Figure 4 for the year 2021.

Within the scope of the study, an export forecast was made for 2021 using data from 2013-2020 and given in Table 7. When the estimated export figures for 2020 are examined, it is seen that the impact of the pandemic, which started in December 2019, began to affect the export figures expected to be as of February and started to fall below the expected values for 2020. The difference was 72000 tonnes for February, 68000 tonnes in March, 237000 tonnes in April, and 413000 tonnes in May. Although there was a decrease in the difference between June and July due to the effect of the normalization process in June, it was 146000 tonnes in August. With the export normalization process that did not occur in the first eight months of 2020, export figures were formed above the forecast values by spreading over the last four months.

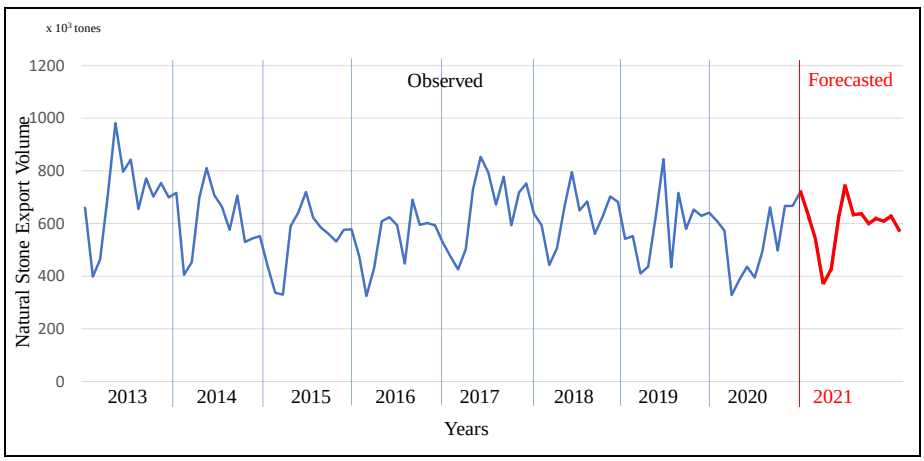

Figure 4. The observed (2013-2020) and forecasted data (2021)

The forecasted data has obtained from GM2 model using Equation 18 and for the year 2021, it is important to continue the Covid-19 pandemic times and their effects on the industries. So, GM2 model has 3.34 MAPE value that is excellent forecasting accuracy with 0.23 C value from Tables 6-7.

5. Discussion and Conclusion

As is known, the Covid 19 pandemic was first seen in the People's Republic of China and affected both the People's Republic of China and all countries, especially our country, with which it has a trade relationship. The two countries most affected by the pandemic in the world were the People's Republic of China and the United States. The People's Republic of China, which covers 32% in exports, and the United States, which has a 15% share, account for 52% of our natural stone exports. Turkish natural stone industry has been greatly affected by the fact that the People's Republic of China and the United States, are the central two countries of the pandemic. When the export figures for 2020 are analyzed, it is seen that the highest loss occurred in May. In this period, there was a decrease of 52% in exports to the People's Republic of China and 31% in exports to the USA. In the rest of the year, the figures that emerged with the normalization process were higher than the previous year.

When the Covid-19 pandemic process and the export figures for 2020 are examined, it is clear that a period of memorization has been entered for the coming years. Turkey, which entered 2019 successfully, has negatively affected the natural stone industry, as the industry has remained dependent on the two countries to date and these countries are the countries most affected by the pandemic. Considering that the GM (1,1) forecasts for 2021 with excellent accuracy are below 2019, it is thought that future planning should be made in managerial decisions.

It will be through institutionalization that Turkish natural stone companies can be more competitive both in the country and in the world market. The way to have a stronger structure before the pandemics, political, etc. that may occur after this will be through institutionalization. There are a few companies in the industry that make an effort in this regard and try to gain brand value, and they have begun to get rewarded for their steps in this process. It has been understood during the pandemic that it is no longer possible to catch up with the future with classical commercial methods. Digital fairs and digital showcases will play an important role in achieving greater goals. Companies should participate in such fairs and prepare the necessary technology infrastructure. The pandemic process has shown that, as in other industries, new markets must be found, and alternatives must be created in the natural stone industry. As observed in this difficult period, the industry is affected as much as the rate at which your biggest buyer is affected by any crisis. Dividing the risk with alternative markets will strengthen the industry economically.

It is thought that the Turkish natural stone industry will enter the coming years stronger with the review of the issues that are tried to be emphasized in this study. Increasing the number of companies that have completed their institutionalization and branding in the light of science and technology and reaching new markets with new distance marketing techniques will make the industry less affected by any crisis. As a further research, the roadmap of the sector should be updated every year by developing these forecasting models and making new forecasts every year.

Conflict of Interest

No conflict of interest was declared by the authors.

References

Adgüzel, M., Şengüler, M., 2019. Investigation of Turkish Marble Sector and its Competitive Power. Third Sector Social Economic Review, 54 (3), 1530-1546.

Akay, D., Atak, M., 2007. Grey prediction with rolling mechanism for electricity demand forecasting of Turkey. Energy, 32 (9), 1670-1675.

Aydemir, E., Bedir, F., Ozdemir, G., 2013. The Grey System Approaches for Demand Forecasting. Journal of Trends in Development of Machinery and Associated Technology, 17 (1), 105-108.

Başol, K., Durman, M., Çelik, M.Y., 2005. Leading of Development Process; Natural Process. Journal of Social Sciences and Humanities Researches, 14, 61-71.

Carmona-Benítez, R.B., Nieto, M.R., 2020. SARIMA damp trend grey forecasting model for airline industry. Journal of Air Transport Management, 82, 101736.

Chatfield, C., 1988. Apples, oranges and mean squared error. International Journal of Forecasting, 4, 515–518.

Deng, J., 1989. Introduction to grey system theory. Journal of Grey System, 1, 1-24.

Ding, S., Hipel, K.W., Dang, Y.G., 2018. Forecasting China's electricity consumption using a new grey prediction model. Energy, 149, 314-328.

Ekincioğlu, G., Akbay, D., 2021. Değerlendirme: 2020 Yılı Türkiye Doğal Taş Sektörü. Türkiye 11. Uluslararası Mermer ve Doğal Taş Kongresi ve Sergisi, 10-11 Aralık 2021, s. 127-136, Diyarbakır.

Goodwin, P., Lawton, R., 1999. On the asymmetry of the symmetric MAPE. International Journal of Forecasting, 15 (4), 405-408.

Hamzaçebi, C., Es, H.A., 2014. Forecasting the annual electricity consumption of Turkey using an optimized grey model. Energy, 70, 165-171.

Hsu, C.C., Chen, C.Y., 2003. Applications of improved grey prediction model for power demand forecasting. Energy Conversion and management, 44 (14), 2241-2249.

IMIB (Istanbul Mineral Exporters Association), 2021, Mineral Export Reports by Product Groups or Countries on a Monthly Basis, available at: https://www.IMIB.org.tr/tr/raporlar/ihracat-istatistikleri (accessed 01 March 2021)

Kayacan, E., Ulutaş, B., Kaynak, O., 2010. Grey system theory-based models in time series prediction. Expert systems with applications, 37 (2), 1784-1789.

Kocaman, F., 2006. Natural Stone Sector and Marketing Strategies, Master Thesis, Dumlupınar University, Kütahya, Turkey.

Lewis, C.D., 1982. Industrial and business forecasting methods, London: Butterworths.

Liu, S., Lin, Y., 2006. Grey Information, London: Springer-Verlag.

Liu, S., Yang, Y., Forrest, J., 2017. Grey Data Analysis: Methods, Models and Applications, Singapore: Springer.

Liu, S., Yang, Y., Xie, N.F., 2016). New progress of grey system theory in the new millennium. Grey Systems: Theory and Application, 6 (1), 2-31.

Liu, X., Xie, N., 2019. A nonlinear grey forecasting model with double shape parameters and its application. Applied Mathematics and Computation, 360, 203-212.

Makridakis, S., 1993. Accuracy measures: theoretical and practical concerns. International Journal of Forecasting, 9, 527–529.

O'Connor, M., Remus, W., Griggs, K., 1997. Going up-going down: how good are people at forecasting trends and changes in trends? Journal of Forecasting, 16, 165–176.

TCKB (TR Ministry of Development), 2018. Eleventh Development Plan (2019-2023) Mining Policies Specialization Commission Report, Ankara, Turkey, Kb: 3041 - JMC: 822.

Wei, B.L., Xie, N.M., Yang, Y.J., 2019. Data-based structure selection for unified discrete grey prediction model. Expert Systems with Applications, 136, 264-275.

Yang, X., Zou, J., Kong, D., Jiang, G., 2018. The analysis of GM (1, 1) grey model to predict the incidence trend of typhoid and paratyphoid fevers in Wuhan City, China. Medicine, 97 (34), e11787.

Zhu, X., Dang, Y., Ding, S., 2021. Forecasting air quality in China using novel self-adaptive seasonal grey forecasting models. Grey Systems: Theory and Application, 11 (4), 596-618.