Forecasting of Turkey's apparel exports using artificial neural network autoregressive models

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ABSTRACT – REZUMAT

Forecasting of Turkey's apparel exports using artificial neural network autoregressive models

Foreign trade is significant for open economies and has a critical place in the development of national economies in a globally competitive environment. Export has a key role as an important component in foreign trade transactions. In this study, Turkey's exports of HS-61 "Apparel and clothing accessories knitted or crocheted" and HS-62 "Apparel and clothing accessories not knitted or crocheted" products were examined. Turkey's exports of these HS codes to seven countries, which are mostly exported, EU27, OECD and the world were estimated for 2020–2025 using artificial neural networks (ANNs). The model was validated by measuring forecast errors (RMSE, MAE, and MAPE) to ensure that the model can recreate satisfactory results. The results reveal that the ANNs predicted the exports to the selected countries accurately. According to the findings from the NNAR (1,1) model, Turkey's exports of HS-61 coded products to Italy, the UK, France and EU-27 are expected to increase year-on-year from 2020 to 2025, while exports to the USA, Netherlands and Spain are expected to decrease. Exports from Turkey to Germany, the world and the OECD are projected to decrease first and then increase. In the NNAR (2,2) model, Turkey's exports to Italy, the UK and France are expected to increase year on year, while exports to other countries are generally estimated to decrease first and then increase. In the estimation made for the HS-62 product group with NNAR (1,1) model, it is predicted that TURKEY's exports to Italy, the USA, the UK, France and Spain will increase year by year from 2020 to 2025. It is estimated that TURKEY's exports to the Netherlands, Germany, World, OECD and EU-27 will decrease year by year in the same period. In the NNAR (2,2) model, it is predicted that TURKEY's exports to UK, France and Spain will increase year by year, while exports to EU-27, OECD and World will decrease. However, TURKEY's HS-62 exports to Italy, the USA, the Netherlands and Germany are expected to follow a fluctuating course.

***Keywords**: apparel industry, ready-made clothing sector, export, forecasting, artificial neural networks (ANNs)*

Prognoza exporturilor de îmbrăcăminte din Turcia folosind modele autoregresive ale rețelei neuronale artificiale

Comerțul exterior este semnificativ pentru economiile deschise și are un loc deosebit de important în dezvoltarea economiilor naționale într-un mediu competitiv la nivel global. Exportul are un rol cheie, ca o componentă importantă în tranzacțiile de comerț exterior. În acest studiu, au fost analizate exporturile Turciei de produse HS-61 „Îmbrăcăminte și accesorii de îmbrăcăminte tricotate sau croșetate" și HS-62 „Îmbrăcăminte și accesorii de îmbrăcăminte netricotate sau croșetate". Exporturile Turciei privind aceste coduri HS în șapte țări în care sunt în mare parte exportate, UE27, OCDE și global au fost estimate pentru perioada 2020–2025 folosind rețele neuronale artificiale (ANN). Modelul a fost validat prin măsurarea erorilor de prognoză (RMSE, MAE și MAPE) pentru a se asigura că modelul poate recrea rezultate satisfăcătoare. Rezultatele arată că ANN-urile au preconizat cu exactitate exporturile către țările selectate. Conform constatărilor modelului NNAR (1,1), exporturile Turciei de produse codificate HS-61 către Italia, Marea Britanie, Franța și UE-27 sunt de așteptat să crească de la an la an, din 2020 până în 2025, în timp ce exporturile către SUA, Olanda și Spania sunt de așteptat să scadă. Se estimează că exporturile Turciei către Germania, global și OCDE inițial vor scădea și apoi vor crește. În modelul NNAR (2,2), exporturile Turciei către Italia, Marea Britanie și Franța sunt de așteptat să crească de la an la an, în timp ce exporturile către alte țări sunt, în general, estimate inițial să scadă și apoi să crească. În estimarea făcută pentru grupa de produse HS-62 cu modelul NNAR (1,1), se preconizează că exporturile Turciei către Italia, SUA, Marea Britanie, Franța și Spania vor crește de la an la an, din 2020 până în 2025. Se estimează că exporturile Turciei către Olanda, Germania, global, OCDE și UE-27 vor scădea de la an la an în aceeași perioadă. În modelul NNAR (2,2), se preconizează că exporturile Turciei către Marea Britanie, Franța și Spania vor crește de la an la an, în timp ce exporturile către UE-27, OCDE și global vor scădea. Cu toate acestea, exporturile de HS-62 ale Turciei către Italia, SUA, Olanda și Germania sunt de așteptat să urmeze un curs fluctuant.

***Cuvinte-cheie**: industria de îmbrăcăminte, sectorul îmbrăcămintei de serie, export, prognoză, rețele neuronale artificiale (ANN)*

INTRODUCTION

In Turkey, the textile and clothing industry started to grow rapidly with the export-oriented development policy that was put into practice in 1980 and investments in the sector have increased since then. Today, the textile and clothing industry is one of the most important industries in terms of macro-economic magnitudes such as gross domestic product, share

in the manufacturing industry and industrial production, export, net foreign exchange inflow to the economy, employment, and investment [1]. In 2020, Turkey's ready-to-wear and apparel export share became 10.1% of total exports. 70.9% of sectoral exports were to the European Union countries. 11.8 billion dollars in exports were made to the top ten countries from Turkey to which the most ready-to-wear and apparel exports were made. The share of these ten countries in sectoral exports of 17.1 billion dollars was 68.6% [2]. The graphic of exports of HS-61 and HS-62 coded products to the examined seven countries, and to the groups are given in figures 1 and 2.

Foreign trade is crucial for open economies and plays a key role in the development of national economies in a globally competitive environment. Export is the most important component in foreign trade transactions as it has a driving force among economic growth, foreign exchange and capital input [3]. Economic growth is the increase in production capacity that causes an increment in income level and the output of a country. "Export-Oriented Growth Hypothesis" suggests that increases in exports will contribute to economic growth. According to this view, an increase in export affects economic growth by implying efficiency of resource allocation, economies of scale, productivity, increasing technological innovations, capital formation and employment [4]. From a micro perspective, if the effects of exports to companies are considered; the exporting firms can allocate the resources efficiently, full of their capacity, take the advantage of economical scale and increase their technological innovation provoked by the competition [5]. Therefore, finding an appropriate strategy and plan to get a smooth flow of international trade between countries is significant. To achieve this, forecasting the export and import of goods is the

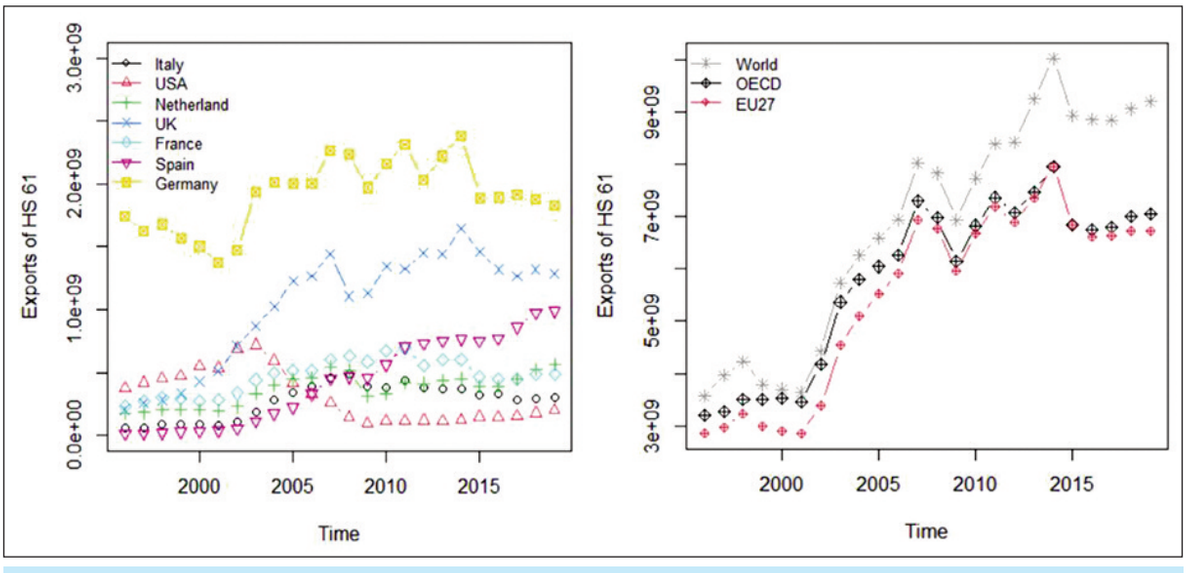

Fig. 1. Exports of HS-61

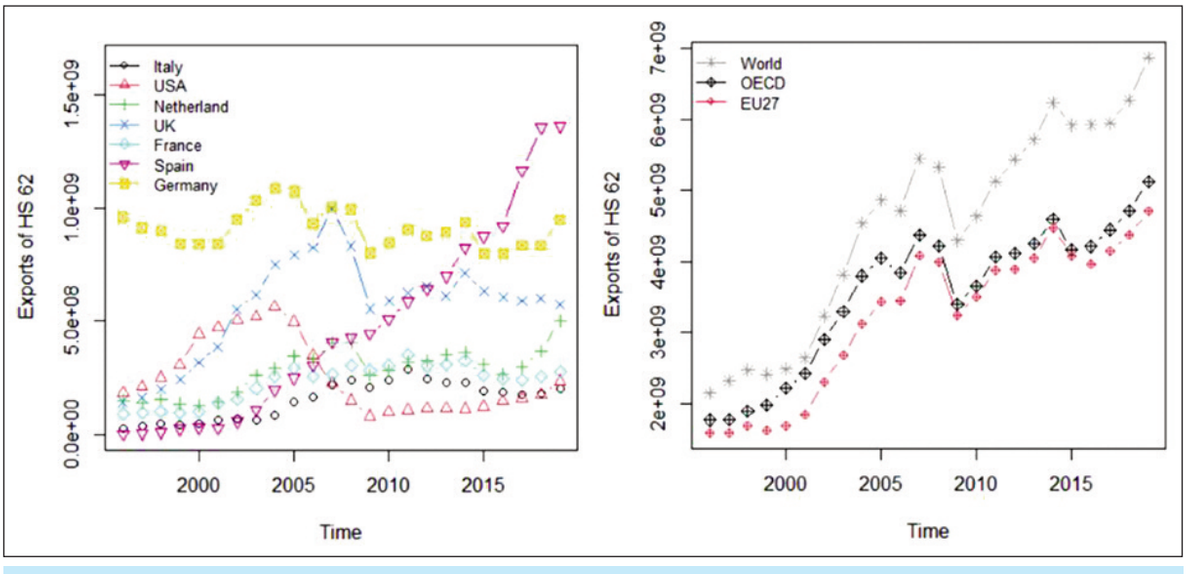

Fig. 2. Exports of HS-62

key point [6]. Particularly, examining trends of export and import is vital for developing countries. Proper estimation and forecasts create a clearer picture in the minds of decision-makers of nations, managers of companies and every individual and provide insight into the future. Thus, it can be possible to assess the situation, define policies, and measure the impact of potential decisions [7, 8]. For this reason, prediction takes the attention of the researchers. There are sectoral studies, in which estimates are made regarding the economical topics of countries and the activities of companies by using different techniques, in the literature.

Many studies predicted the sales of fashion manufacturers in the literature [9–13]. In all these studies, it was emphasized the need to plan properly and thus use the resources effectively, reduce costs, ad the importance of correct investment decisions. Again, for fashion production, there are some studies were conducted to estimate the trend of colours [14, 15].

There are several studies on forecasting the exports of some countries' textile and apparel industries.

Quanping and Xiaoyi proposed a hybrid model, that is composed of the GM (1,1) grey forecasting model and EMD method, to forecast the time series of textile export having seasonality characteristics for the period 2003–2011. The forecasting findings were better than the results of the direction prediction method [16].

Ozbek et al. forecasted the export of denim trousers in Turkey by using ANN and the autoregressive-integrated model of moving averages. The results revealed that the ANN model provides more accurate forecasting than the ARIMA model [17].

Xia et.al. predicted the next 3–5 years of apparel export in China by using GM (1,1) model. The model was verified with the data from 1999 to 2008. According to the results, forecasting accuracy was better and China's garment exports had the momentum of instant growth from 2011 to 2013 [18].

Xia et. al. used the Holt model to predict textile and garment export using data from 1992 to 2008. The result showed that the Holt model has a high prediction accuracy. They forecasted 2009–2010 exports to contribute by providing a series of adjustments of policies, and strategies for the relevant departments [19, 20].

Lu predicted the US total export of textile and apparel for the next ten years by using data from 1984 to 2014 via regression model and ARIMA model [21].

Ghosh studied the estimation of India's cotton export by using 63 monthly observations. The ARIMA model's results would be helpful for trade organizations to evaluate the volatility of the market structure. However, the study was limited to suggesting any policy because of the scarcity of secondary data sets [21].

In all these studies, export volumes were predicted with sufficient accuracy. The apparel industry is a driving force for the Turkish economy and it could not be met in a recent paper that forecasts the Turkish apparel export volume. Forecasting the export may contribute to the tracking of the development and change of the sector yearly. It can give an idea about the short-and long-term development trend of the sector. At the same time, the future of the export relationship with the top countries is also important. In this study, Turkey's apparel exports for 2020–2025 were estimated based on these countries. This research used the ANNs method for forecasting with time-series data.

MATERIAL AND METHOD

Neural network model for forecasting

Artificial neural networks (ANNs) are based on a mathematical model of the brain. ANNs are focused on non-linear relationships between the response variables and their predictors. In recent years, there has been increasing interest in the use of ANNs for forecasting and modelling [22]. Neural networks are used for complex non-linear forecasting. With time series data, lagged values of the time series can be used as inputs to a neural network, just as we used lagged values in a linear autoregression model. We call this a neural network autoregression or NNAR model [23]. (NNAR) forecasting model, which is relatively new to the Neural Network (NN) model and can be used in open-source software programs. Although artificial neural networks vary according to the applied network model, they have some advantages and disadvantages. Some of these advantages are [24]:

- The network can be trained again and again for system-appropriate solutions.
- They have learning abilities and learn with different learning algorithms.
- They can work with incomplete information.

The constraint arising from the disadvantage of the model is determining the appropriate network structure for the problem.

With all these advantages, the NNAR model was preferred because it provides flexibility in model assumptions compared to classical time series models.

This paper considers a neural network autoregression model (NNAR) with time series data for forecasting the export of "HS 61-apparel and clothing accessories knitted or crocheted" and "HS 62-apparel and clothing accessories not knitted or crocheted". This model uses inputs as lagged values of time-series data in a neural network model. Here, we consider a feed-forward network with one hidden layer and use the notation NNAR(p, k), p indicates lagged inputs, and k indicates nodes in the hidden layer. An example of the architecture of ANNs is shown in figure 3. In this example, the number of input variables is four and the number of nodes in one hidden layer is two.

To fit NNAR(p, k) model, we use the nnetar function in the forecast package of R [26]. In this paper, we consider NNAR(1,1) and NNAR(2,2) models to forecast the exporting of textiles in Turkey.

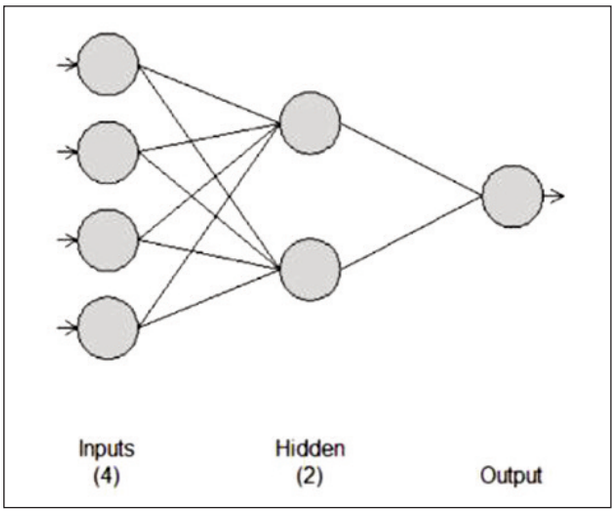

Fig. 3. The architecture of artificial neural network adopted from the nnforpackage of R [25]

Performance criteria

This paper compares forecast errors for NNAR(1,1) and NNAR(2,2) models. A forecast error is a difference between an observed value and its forecast. This forecast error can be represented as follows:

$$e_{T+h} = y_{T+h} - \hat{y}_{T+h} \quad (1)$$

where $\{y_1,\ldots,y_T\}$ is the training dataset and $\{y_{T+1}, y_{T+2},\ldots\}$ is the test dataset [23]. Therefore, we use accuracy measures as root mean square error (RMSE), mean absolute error (MAE) and mean absolute percentage error (MAPE). The formulation of the accuracy measures is as follows:

$$\text{RMSE} = \sqrt{\frac{1}{T}\sum_{t=1}^{T}(e_t)^2} = \sqrt{\text{mean}(e_t^2)} \quad (2)$$

$$\text{MAE} = \frac{1}{T}\sum_{t=1}^{T}|e_t| = \text{mean}|e_t| \quad (3)$$

$$\text{MAPE} = \frac{1}{T}\sum_{t=1}^{T}|p_t|, \quad p_t = \frac{100\,e_t}{y_t} \quad (4)$$

Here, residuals are computed on the training dataset while forecast errors are computed on the test dataset. In our study, we separate the available data into training and test data when selecting models. The training dataset is used to estimate the parameters of the NNAR models, and the test dataset is used to evaluate model accuracy. Therefore, the first 20 observations (1996–2015) are used for training dataset, and the last 4 observations (2016–2019) are used for testing the dataset. The lower values of RMSE, MAE and MAPE show the best model. The accuracy values for the MAPE criterion proposed by Lewis (1982) are given in table 1 [27].

RESULTS AND DISCUSSION

The results of training and testing, which are applied to the previous export series for the estimation of the HS-61 “Apparel and clothing accessories knitted or crocheted” coded product exports to selected countries and country groups of Turkey, are given in table 2. The training phase shows the prediction results for the observed dataset. According to the training results, it was seen that the Neural Networks NNAR(2,2) model performed better than the NNAR(1,1) model. To the MAPE value in the training results, only Italy and Spain have “Good accuracy” value, while the USA and other countries have “High accuracy” value. When the training results are examined in general, it is possible to say that NNAR(2,2) models have a better fit than NNAR(1,1) models.

After getting well-matched training results, the testing phase was started. The testing phase shows the estimation results for the unobserved data set. According to the results obtained for France, Italy and the OECD, the NNAR(2,2) models performed better than the NNAR(1,1) models. At the same time, France, Italy and the OECD showed “High accuracy” compliance concerning the MAPE value. For the USA and other countries, NNAR(1,1) test results have shown a better fit than NNAR(2,2). In comparison with MAPE values the USA, Netherlands and Spain have a “Good accuracy” and United Kingdom, Germany, World and EU27 have a “High accuracy”. Examining the MAPE value, only the NNAR(2,2) models of USA and Spain have achieved a "Reasonable accuracy" fit, while all the remaining models have "High accuracy and Good accuracy" values. In short, the models showed a good fit in making export estimations with respect to the Training and Testing results.

After the training and testing models display a good fit to data, Turkey's export forecasts for the HS-61 “Apparel and clothing accessories knitted or crocheted” product group to the relevant countries and country groups were given in table 3. To make a comparison with the export values of 2020 and to evaluate and control the estimation results obtained, the export estimation results for 2020 are shown in table 3. To make a comparison with the export values of 2020 and to evaluate and control the estimation results got, the export estimation results for 2020 are shown in table 3. Besides, the export values realized in 2019 and the percentage change in exports for both years compared to the previous year are given in the table. The export values used in the table and comments should be read as x$ 1,000.

The NNAR(2,2) model ($307,696) gave the forecast for exports to Italy for 2020 within the confidence interval and closer to the realized export value

Table 1

A SCALE OF JUDGMENT OF FORECAST ACCURACY				
MAPE	**<=10%**	**(10%–20%)**	**(20%–50%)**	**>=50%**
Forecasting ability	High accuracy	Good accuracy	Reasonable accuracy	Inaccurate

Table 2

COMPARISON RESULTS OF NNAR (1,1) AND NNAR (2,2) FOR HS-61 "APPAREL AND CLOTHING ACCESSORIES KNITTED OR CROCHETED"

Countries	Model	Training			Testing		
		RMSE	MAE	MAPE	RMSE	MAE	MAPE
Italy	NNAR (1,1)	34561788	28094843	13.20726	66989953	65084375	21.95834
	NNAR (2,2)	**30584223**	**23934885**	**10.28835**	**23735012**	**23519739**	**7.890762**
USA	NNAR (1,1)	64995608	42922670	12.26851	64995608	**42922670**	**12.26851**
	NNAR (2,2)	**26825831**	**17659415**	**5.634005**	**53694313**	53694190	28.64933
Netherlands	NNAR (1,1)	49411481	34890101	10.2399	**81774733**	**71238761**	**13.34776**
	NNAR (2,2)	**36034654**	**24713257**	**6.913815**	89189675	87754150	16.1407
UK	NNAR (1,1)	101956949	68602875	6.633984	**73228347**	**65207657**	**5.0993**
	NNAR (2,2)	**77826093**	**43559928**	**4.184797**	120561423	120100428	9.236127
France	NNAR (1,1)	52165809	41449828	8.816093	48031741	44717312	9.581438
	NNAR (2,2)	**43455567**	**28226764**	**5.917141**	**10270473**	**10250020**	**2.106736**
Spain	NNAR (1,1)	36465447	25247525	15.89645	**130919556**	**127981287**	**13.46383**
	NNAR (2,2)	**26111836**	**19319768**	**10.46842**	201166543	201165241	20.45058
Germany	NNAR (1,1)	156207617	132275343	6.957124	**70186797**	**62392473**	**3.313713**
	NNAR (2,2)	**100504414**	**85791475**	**4.325895**	87100889	83528573	4.521137
World	NNAR (1,1)	563002541	457193094	7.425661	**171159222**	**146826891**	**1.610776**
	NNAR (2,2)	**502806270**	**415876872**	**6.474047**	241429258	241174166	2.643452
OECD	NNAR (1,1)	426658400	364794364	6.442591	92400011	66027316	0.9659175
	NNAR (2,2)	**383944262**	**293484819**	**5.119292**	**51908276**	**51865762**	**0.738888**
EU27	NNAR (1,1)	442942343	364391623	7.227593	**180883660**	**176453982**	**2.642234**
	NNAR (2,2)	**377189581**	**273724951**	**5.250368**	258784934	258594128	3.847987

($267,913). Here, the 11% decrease in exports in 2020 should also be taken into account. In both models, HS-61 exports from Turkey to Italy are expected to increase gradually until 2025. For Turkey's exports to the USA, the estimated value ($181,480) by the NNAR (2,2) model is quite close to the actual value ($185,085). Despite the 12% increase in exports in 2019, it is possible to say that the estimation result is quite consistent, considering the 7% decrease in exports in 2020. While the 2021 forecast was $135,952 in the NNAR (1.1) model, it was estimated to decrease gradually to $132,561 in 2025. In the NNAR (2,2) model, it is predicted that it will decrease to $125,795 in 2022, but will be worth $133,843 by 2025.

Both models have estimated close to the value ($528,322) realized in Turkey's HS-61 exports to the Netherlands in 2020. However, in the NNAR (1,1) model, it is expected that exports will decline to $460,400 in 2025. In the NNAR (2,2) model, it is predicted that there will be sharp decreases in 2021 and 2022 and there will be an increase after 2023 and an export level of $477,055 in 2025.

For the United Kingdom, the NNAR (1.1) model estimated a value closer to the actual value than the NNAR (2,2) model. In both models, Turkey's HS-61 exports to the UK are predicted to increase steadily until 2025. Turkey's HS-61 exports to France decreased by 13% in 2020. Considering this situation, when the export value realized in 2020 is examined, it is seen that the estimation of the NNAR (2,2) model gives a closer result. In both models, Turkey's HS-61 exports to France are projected to increase slightly but steadily until 2025.

According to the forecast results for Spain, in 2020 both models produced results close to the realized value. However, in the NNAR (1,1) model, Turkey's HS-61 exports to Spain are predicted to decline slightly but gradually until 2025, while in the NNAR (2,2) model it is predicted to increase and fall later in 2021.

In the estimation of Turkey's HS-61 products exports to Germany, it is seen that the models gave close results to the realized value for 2020. However, in both models, there is an expectation of a decrease in exports until 2024. In 2025, while exports remain unchanged in the NNAR (1,1) model, an increase in exports is predicted in the NNAR (2,2) model.

When the estimations for Turkey's exports of HS-61 products to the world are examined, the NNAR (1,1) model gives a closer prediction of the real value for 2020, while this model predicts that exports will decrease until 2025. The NNAR (2,2) model, on the other hand, predicts that exports will increase again after a decline until 2023. When the results for the OECD are examined, it is possible to say that both models make close predictions for 2020. The NNAR (1,1) model predicts that Turkey's exports to

Table 3

FORECASTING RESULTS OF NNAR (1,1) AND NNAR (2,2) FOR HS-61 "APPAREL AND CLOTHING ACCESSORIES KNITTED OR CROCHETED"

Countries	Actual export (x$1,000) and rate of change (%)*		Model	Forecasting results (x$1,000)					
	2019	2020		2020	2021	2022	2023	2024	2025
Italy	301,937 (3)	267,913 (–11)	NNAR (1,1)	333,784	355,258	368,267	375,605	379,571	381,665
			NNAR (2,2)	307,696	310,848	312,485	313,329	313,767	313,998
USA	198,884 (12)	185,085 (–7)	NNAR (1,1)	150,562	135,952	133,134	132,654	132,574	132,561
			NNAR (2,2)	181,480	133,758	125,795	130,948	134,097	133,843
Netherlands	560,044 (7)	528,322 (–6)	NNAR (1,1)	481,363	466,381	462,189	460,918	460,523	460,400
			NNAR (2,2)	478,524	351,162	326,567	406,922	440,691	477,055
UK	1,284,497 (-3)	1,244,106 (-3)	NNAR (1,1)	1,328,640	1,347,005	1,354,165	1,356,883	1,357,904	1,358,287
			NNAR (2,2)	1,370,003	1,387,173	1,405,886	1,411,119	1,413,427	1,414,186
France	487,451 (0,4)	423,052 (–13)	NNAR (1,1)	518,623	543,585	560,912	571,567	577,580	580,797
			NNAR (2,2)	490,396	491,835	492,973	493,899	494,783	495,692
Spain	991,243 (2)	960,789 (–3)	NNAR (1,1)	988,560	986,679	985,358	984,429	983,775	983,314
			NNAR (2,2)	999,153	1,001,290	1,000,199	998,103	996,324	995,325
Germany	1,831,716 (–2)	1,733,117 (–5)	NNAR (1,1)	1,706,148	1,596,249	1,589,874	1,589,806	1,589,805	1,589,805
			NNAR (2,2)	1,754,138	1,651,575	1,592,173	1,560,993	1,559,441	1,560,801
World	9,200,636 (2)	8,387,723 (–9)	NNAR (1,1)	9,099,272	9,043,049	9,011,190	8,992,921	8,982,375	8,976,263
			NNAR (2,2)	9,129,243	9,071,424	9,052,013	9,050,847	9,053,317	9,054,846
OECD	7,039,566 (1)	6,645,923 (–6)	NNAR (1,1)	7,025,330	7,020,554	7,018,942	7,018,398	7,018,213	7,018,151
			NNAR (2,2)	7,044,887	7,045,462	7,045,511	7,045,514	7,045,514	7,045,514
EU27	6,716,491 (–0,1)	6,353,381 (–5)	NNAR (1,1)	6,825,027	6,869,651	6,887,236	6,894,047	6,896,667	6,897,672
			NNAR (2,2)	6,866,084	6,895,301	6,873,494	6,864,694	6,866,943	6,868,852

Note: * Export data taken from UN Comtrade (2021) database [28]. The authors calculated the change in exports.

the OECD will decrease slightly until 2025, while the NNAR (2,2) model predicts that it will increase slightly until 2023 and then remain stable. For EU-27, there is an expectation of an increase until 2025 in the NNAR (1,1) model, and a fluctuating course in close values after the increase in the NNAR (2,2) model in 2021.

In figure 4, the observed values and fitted results for Turkey's HS-61 exports to the world are given to show the fit of neural networks models for forecasting. The title of "HS Code 61" reflects the real values of Turkey's exports of the HS-61 product group to the world. The "Fitted data" title shows the fitted values of the NNAR (1,1) and NNAR (2,2) models. As can be seen here, HS Code 61 observed values are compatible with fitted data. In other words, neural networks models performed well in forecasting and export forecasts were made according to this fit.

It is seen in table 3 that Turkey's HS-61 exports to countries in 2020 declined. The decreasing trend in exports is under the influence of many factors. We can list the two most important reasons as follows. The first is the depreciation of the Turkish lira against foreign currencies, especially in 2019 and 2020. The second is that the COVID-19 pandemic conditions have had a negative impact on global trade. Inevitably, both situations will affect Turkey's exports in 2020. However, in the export estimation made under these conditions, it is very important that the export values realized in 2020 yielded results close to the estimated values. For example, while exports to the USA decreased by 7% in 2020, the actual export value was $185,085 and the NNAR (2,2) model estimated it at $181,480.

For the estimation of Turkey's HS-62 "Apparel and clothing accessories not knitted or crocheted" exports to selected countries and country groups, the results of the training and testing processes applied to Turkey's past export series to these countries and country groups are given in table 4.

According to the training results, it was seen that the NNAR (2,2) model achieved a better fit than the NNAR (1,1) model for all countries. Regarding the MAPE value in the training results, only Spain has the value of "Good accuracy", while all other countries have the value of "High accuracy". This shows that both models have achieved good performance.

After the training results achieved a good fit, the testing phase was started. Based on the findings, the NNAR (2,2) model for the United Kingdom and France, and the NNAR (1,1) model for other countries and country groups performed better and got a good fit with the series. According to the MAPE value, Italy, the USA, Netherlands, Spain and OECD showed

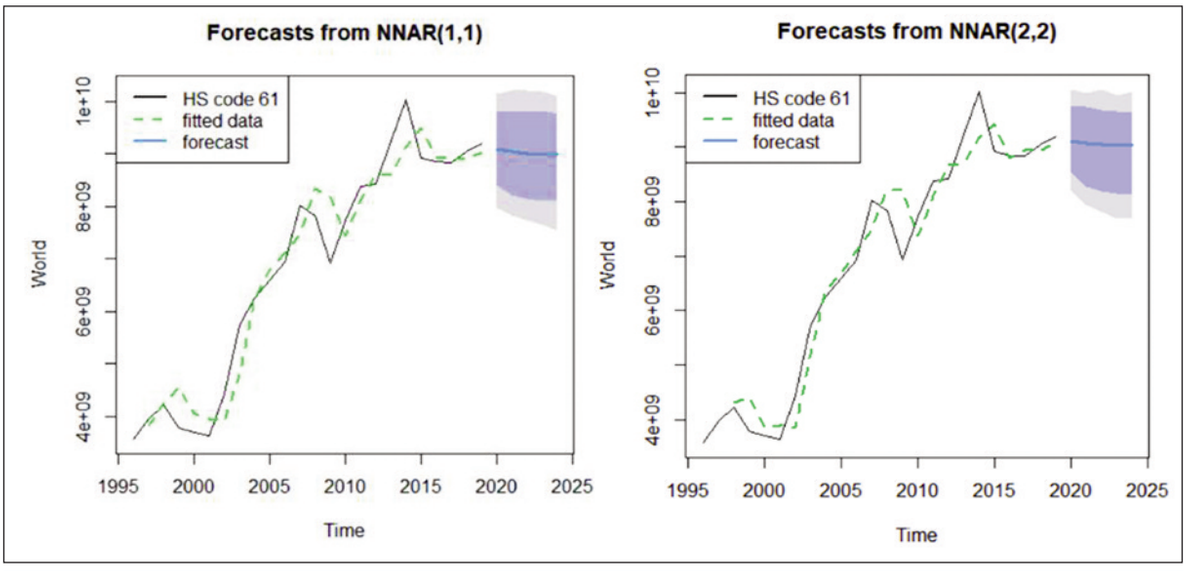

Fig. 4. Turkey's HS61 coded product export estimation to the world

Table 4

COMPARISON RESULTS OF NNAR (1,1) AND NNAR (2,2) FOR HS-62 "APPAREL AND CLOTHING ACCESSORIES NOT KNITTED OR CROCHETED"

Countries	Model	Training			Testing		
		RMSE	MAE	MAPE	RMSE	MAE	MAPE
Italy	NNAR (1,1)	20429519	15296331	11.83968	**31189243**	**28683437**	**15.78400**
	NNAR (2,2)	**17250409**	**11545844**	**9.087663**	32061554	30295198	16.09653
USA	NNAR (1,1)	63440814	46588829	20.1182	**37340604**	**29414934**	**13.9548**
	NNAR (2,2)	**17379058**	**12875438**	**6.044775**	54573686	48775284	22.42279
Netherlands	NNAR (1,1)	35075527	28182295	11.19503	**93447043**	**69688198**	**15.43911**
	NNAR (2,2)	**27006315**	**21028065**	**8.110915**	104761611	90301734	19.3544
UK	NNAR (1,1)	84453272	56282812	8.808795	73035142	71691724	12.24422
	NNAR (2,2)	**49350975**	**39183677**	**6.237545**	**56785809**	**53877665**	**9.255832**
France	NNAR (1,1)	22204518	16865527	7.328232	30955714	27496546	10.97946
	NNAR (2,2)	**21705080**	**15851835**	**6.850044**	**23194277**	**21879605**	**8.324111**
Spain	NNAR (1,1)	28862211	22610032	37.10514	**184219414**	**178629790**	**13.99512**
	NNAR (2,2)	**21310488**	**18173609**	**15.10049**	330335814	329393168	24.28814
Germany	NNAR (1,1)	69039535	55848010	6.106877	**52226114**	**49237465**	**5.55239**
	NNAR (2,2)	**35029667**	**28133448**	**3.173606**	59740375	58569034	6.517465
World	NNAR (1,1)	356872566	250654180	5.906928	**710185379**	**629096431**	**9.615673**
	NNAR (2,2)	**292905104**	**221547369**	**5.068071**	738219648	704930863	10.59872
OECD	NNAR (1,1)	233166527	150590086	4.255936	**652398425**	**601130786**	**12.35826**
	NNAR (2,2)	**135643361**	**77608831**	**2.015422**	1138142056	1013274516	20.18734
EU27	NNAR (1,1)	240862319	153833335	4.950147	**450925793**	**412278679**	**9.160216**
	NNAR (2,2)	**202477535**	**139782051**	**4.482708**	733533035	668668926	14.50173

"Good accuracy", while other countries showed a "High accuracy" fit. This displays that both models perform well to estimate Turkey's exports to selected countries.

Turkey's export values of HS-62 "Apparel and clothing accessories not knitted or crocheted" product group to the selected countries and country groups in 2019 and 2020 and its export's rate of change and HS-62 export forecast results from 2020 to 2025 are presented in table 5. As mentioned before, the real export values of 2020 have been tested for control. Thus, it is possible to compare the actual value in 2020 with the forecast results. In addition, exports in 2019 and the rate of change in exports compared to the previous year are also given in the table to monitor the course of exports better.

From the prediction results got, it is seen that Turkey's exports to Italy in 2020 in the HS-62 code

Table 5

FORECASTING RESULTS OF NNAR (1,1) AND NNAR (2,2) FOR HS-62 "APPAREL AND CLOTHING ACCESSORIES NOT KNITTED OR CROCHETED"

Countries	Actual export (x$1,000) and rate of change (%)*		Model	Forecasting results (x$1,000)					
	2019	2020		2020	2021	2022	2023	2024	2025
Italy	203,660 (12)	219,032 (8)	NNAR (1,1)	214,602	220,455	223,360	224,745	225,394	225,694
			NNAR (2,2)	225,051	231,799	229,305	227,296	226,329	225,936
USA	237,088 (36)	362,858 (53)	NNAR (1,1)	252,377	268,344	284,808	301,514	318,145	334,339
			NNAR (2,2)	355,807	459,335	503,091	517,175	515,917	508,676
Netherlands	500,040 (35)	619,928 (24)	NNAR (1,1)	375,975	363,103	359,932	359,059	358,812	358,741
			NNAR (2,2)	529,979	301,369	273,852	312,166	361,253	384,176
UK	573,419 (–4)	522,809 (–8)	NNAR (1,1)	620,786	654,320	676,411	690,243	698,620	703,588
			NNAR (2,2)	585,335	609,558	630,003	643,369	654,871	6,656,044
France	279,242 (9)	247,780 (–11)	NNAR (1,1)	287,073	289,992	291,016	291,367	291,487	291,528
			NNAR (2,2)	296,290	300,922	302,866	303,404	303,614	303,676
Spain	1,359,057 (0,4)	1,046,576 (–23)	NNAR (1,1)	1,421,826	1,463,700	1,489,919	1,505,650	1,514,841	1,520,124
			NNAR (2,2)	1,399,310	1,404,960	1,408,297	1,409,049	1,409,350	1,409,433
Germany	948,116 (14)	960,744 (1)	NNAR (1,1)	926,371	913,353	905,862	901,655	899,325	898,045
			NNAR (2,2)	1,023,649	1,033,922	901,067	887,999	868,142	873,015
World	6,871,159 (10)	6,600,585 (–4)	NNAR (1,1)	6,607,516	6,448,785	6,348,756	6,283,965	6,241,268	6,212,815
			NNAR (2,2)	6,878,794	6,877,840	6,875,970	6,874,545	6,873,621	6,873,051
OECD	5,128,781 (9)	5,073,618 (–1)	NNAR (1,1)	4,674,967	4,511,734	4,441,274	4,408,714	4,393,212	4,385,728
			NNAR (2,2)	7,011,919	9,664,157	9,917,357	9,907,495	9,904,198	9,904,075
EU27	4,706,070 (8)	4,533,935 (–4)	NNAR (1,1)	4,350,902	4,223,962	4,170,932	4,147,462	4,136,818	4,131,938
			NNAR (2,2)	4,483,861	4,323,926	4,237,345	4,192,936	4,170,274	4,158,637

Note: * Export data taken from UN Comtrade (2021) database [28]. The authors calculated the change in exports.

($219,032) are very close to the forecast produced by the NNAR (1,1) model. Turkey's HS-62 exports to Italy tend to increase by 2025. In exports to the USA ($362,858), it is seen that the NNAR (2,2) model gave results close to the actual export value. Considering that Turkey's HS-62 exports to the USA increased by 36% in 2019 and by approximately 53% in 2020, it is possible to say that the NNAR (2,2) model made a very accurate estimation. It is predicted that Turkey's exports to the USA will increase by 2023 and will begin to decrease in 2024.

The NNAR (2.2) model gave the closest estimate of Turkey's exports to the Netherlands. Increasing Turkey's exports to the Netherlands at high rates and growing decreasingly, may affect the forecast results. According to the NNAR (2,2) model, a decrease in exports to the Netherlands in 2021 and 2022, and then an increase is forecasted. Turkey's HS-62 exports to the UK decreased by 4% and 8% in 2019 and 2020, respectively. When the estimation results are examined, it is seen that the NNAR (2,2) model gave a closer result to the exports realized in 2020. In general, there is an expectation of an increase in HS-62 exports to the UK until 2025.

While the exports to France under the code HS-62 increased by 9% in 2019 compared to the previous year, they decreased by 11% in 2020. Considering the estimation results in this fluctuating course, it is seen that the NNAR (1,1) model's estimation is close to the actual export. There is an expectation of an increase, albeit slowly, until 2025. While there was a 0.4% increase in Turkey's HS-62 exports to Spain in 2019, there was a 23% decrease in 2020. After almost zero growth in exports in 2019, with the sudden decrease in 2020, the forecast result is close to the 2019 value, but it is far away from the 2020 value. An increase in exports is expected in the coming years.

In Turkey's estimation of HS-62 exports to Germany for 2020, NNAR (1,1) model's result was close to the value realized. Considering that, the export increase in 2019 was 14% and in 2020 was 1%, it is possible to conclude that there was a fluctuating course in the real export values. Therefore, it can be said that the forecast value is quite accurate.

When Turkey's HS-62 exports to country groups and the world are evaluated, it is seen that the NNAR (2,2) model for EU-27 and NNAR (1,1) model for the OECD and the World give results close to the realized values. Although Turkey's HS-62 exports, especially to the world, increased by 10% in 2019 and decreased by 4% in 2020, it is an important result that the 2020 forecast was realized very close to the real value. However, it is estimated that Turkey's

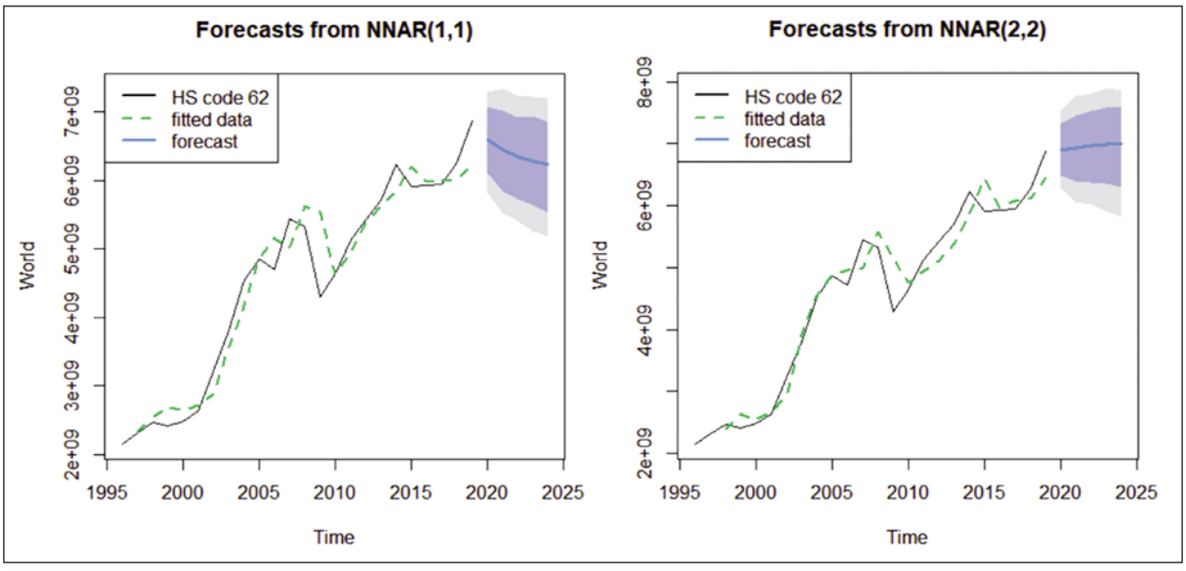

Fig. 5. HS-62 coded export forecast of Turkey to the world

HS-62 exports to the world will decrease gradually by 2025. Similar expectations are available for OECD and EU-27.

In figure 5, to see how Neural Networks models fit for forecasting, the fit status of the models for Turkey's HS-62 exports to the World yearly is shown. The title "HS Code 62" shows the real (observed) value of Turkey's export of HS-62 to the world. The title "Fitted data" shows the fitted values of the NNAR (1,1) and NNAR (2,2) prediction models. As seen here, the HS Code 62 observed values are consistent with the fitted values. In other words, Neural Networks models performed well in forecasting and export forecasts were made according to this fit.

In summary, compared with the 2020 realized values, it seems that in general, the estimates for HS-61 and HS-62 are within the confidence interval. However, in some cases, differences between the real and estimated values have been seen to open up. It has been said before that the reasons for this are the depreciation of TL against foreign currencies (the rise in the exchange rate) and the negative conditions created by the COVID-19 pandemic. Here, the declines in Turkey's HS-62 exports in 2020, excluding Italy, the USA and Netherlands, are noteworthy again. Both the depreciation of the TL and the impact of the pandemic conditions have affected Turkey's exports in 2020. However, in the export estimation made under these conditions, it was observed that the export values realized in 2020 gave results close to the estimation values. For example, while Turkey's HS-62 exports to France decreased by 11% in 2020, the NNAR (1,1) model estimated value ($287,073) is close to the actual value ($247,780). Again, Turkey's exports of the same product group to the USA increased by 53% and the estimated value was quite close to the actual export.

Here, besides the COVID-19 pandemic conditions, the depreciation of the domestic currency against foreign currencies in Turkey, especially in 2019 and 2020, is an issue that needs to be considered. Although there is a prevailing view in the economics literature that the depreciation of the domestic currency will increase exports [29], there are also studies suggesting that exchange rate volatility reduces exports [30–32]. This situation arises economically due to low short-term elasticity. It takes time for producers and consumers to adapt to this new situation. Producers may not increase their production capacity in a short time against the increasing demand or they may not make a new agreement since their commercial relations are based on contracts. In addition, exporters may delay their sales by anticipating that the exchange rates will rise even more. It is also difficult for consumers to change their tastes and habits in a short time [29, 33]. Many reasons like this may not increase or even decrease exports the first time when the local currency depreciates. Here, too, there may be a similar situation in Turkey's 2020 exports of both HS-61 and HS-62 product groups. However, after the harmonization process of producers and consumers, exports will continue in their normal course.

CONCLUSION

In this study, Turkey's exports to the countries and country groups to which it exports the most in the codes HS-61 "Apparel and clothing accessories knitted or crocheted" and HS-62 "Apparel and clothing accessories not knitted or crocheted" were discussed. Using the export data to these countries for 1996–2019, the 2020–2025 export values of Turkey in both product groups were estimated with Neural Networks models. Both HS-61 and HS-62 training and testing results have "Good accuracy" and "High accuracy" values according to MAPE value. In other words, it has been seen that Neural Networks models provide good results in estimating Turkey's apparel export values.

If we evaluate the findings for the HS-61 and HS-62 product groups separately, the estimation results for Turkey's exports to selected countries in the HS-61 product group can be summarized as follows; in the NNAR(1,1) model, Turkey's exports of HS-61 products to Italy, UK, France and EU-27 are expected to increase year-on-year from 2020 to 2025, while exports to USA, Netherlands and Spain are expected to decrease. However, first, a decrease and then an increase is foreseen in Turkey's exports to Germany, the World and the OECD. In the NNAR(2,2) model, while there is an expectation of an increase in Turkey's exports to Italy, the UK and France from year to year, it is estimated that exports to other countries first decrease and then increase.

The export forecast of Turkey's HS-62 product group to selected countries is as follows: In the NNAR(1,1) model, Turkey's exports to Italy, the USA, the UK, France and Spain are predicted to increase from year to year from 2020 to 2025. In the same period, Turkey's exports to the Netherlands, Germany, World, OECD and EU-27 are expected to decrease year by year. In the NNAR(2,2) model, while there is an expectation of an increase in exports to the UK, France and Spain from year to year, the opposite is expected in exports to EU-27, OECD and the World. However, a fluctuating course is expected in exports to Italy, the USA, the Netherlands and Germany.

It is expected that this study will contribute to future studies on forecasting the export of apparel and other industries. However, since forecasting is a concept related to the unseen and uncertain future, it also brings some limitations. There may be deviations from the estimation in case of situations such as shocks to be experienced in supply and demand, volatility in exchange rates, and economic and political instability. In this study, Turkey's exchange rate increases, especially in the last period, caused fluctuations in exports. In the economic literature, it is expected that exports will increase with the increase in exchange rates. However, exports may not increase or even decrease in the short run [30–32]. This is a concept related to the elasticities of supply and demand. If elasticities are low in the short run, exports do not increase, but on the contrary decrease (30). Factors caused this situation such as commercial agreements, the insufficient scale of production or the inability to change the tastes and preferences of the consumer in the short term. In future studies, new model trials can be made that consider such constraints.

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