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Implementation of Exponential Smoothing in Forecasting the Export Value Price of Oil and Gas in Indonesia

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Abstract

This study aims to predict the value of oil and gas export prices in Indonesia using exponential smoothing. Exponential smoothing was applied because the data analysis revealed that the data consisted of trends and seasonal components. This study uses secondary data obtained from the website of the Central Bureau of Statistics of the Republic of Indonesia, covering the value of oil and gas exports in Indonesia every month from January 2010 to March 2022. The study obtained the exponential smoothing parameters, including $\alpha = 0.5153984$, $\beta = 0.06410119$, and $\gamma = 0.7137603$, with a seasonal length of $L = 12$. The forecast for the next five periods in millions of US$: April 2022 (1111.765), May 2022 (1250.465), June 2022 (1405.016), July 2022 (1447.510), and August 2022 (1452.984).

Keywords: forecasting; export value price; oil and gas; exponential smoothing.

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1. Introduction

The act of selling goods or services from one country to other countries is known as exports. A country that produces a significant amount of goods or services and has fulfilled demand within the country is capable of engaging in export activities. Exporting goods or services can contribute to a country's economic growth by generating foreign exchange, which is a medium of international payment transactions, such as US Dollars (US$), gold, securities, and others. By expanding export activities, a country can create new market opportunities abroad, leading to increased investment and employment opportunities for the local community. In Indonesia, export commodities are classified into two categories: oil and gas exports and non-oil and gas exports. The former includes oil products, natural gas, mining products, and other items, whereas the latter encompasses goods and services that are not related to oil and gas.

Indonesia's oil and gas export value data are time series data that exhibit fluctuations (Ahmar, Botto-Tobar, Rahman, & Hidayat, 2022). The value of exports may decrease because of a trade balance deficit, where the value of imports exceeds that of exports. This is considered an intervention in the time-series data. Additionally, changes in the exchange rate of the rupiah against the US dollar can influence the value of exports, particularly oil and gas exports. When the rupiah weakens, the volume of oil and gas exports may increase, as these commodities are not reliant on imported raw materials, leading to a lower selling price compared to other countries. This situation can subsequently impact national economic growth.

To overcome the oil and gas export deficits in Indonesia, planning and improvement measures are required. Short- or long-term planning can serve as a reference for steps that must be taken to prevent a lack of oil and gas exports in the future. This planning can be achieved by estimating the value of future oil and gas exports using a forecasting method that is highly accurate (Hayati et al. 2021). The results of this forecasting method can be used as a basis for planning strategies by interested parties, particularly the National Export Development Agency (BPEN) and Ministry of Trade

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(Yulisa et al. 2023).

Forecasting is a crucial aspect of decision making that relies heavily on historical data analyzed through specific methods. One commonly used method for forecasting is the exponential smoothing model, which depends heavily on the pattern of past data movements (Jonnius, 2018).

The exponential smoothing method is a continuous improvement procedure in forecasting that utilizes the latest observations (Makridakis & Hibon, 2000; Muchayan, 2019). This method is based on the concept of constructing a forecast of future values as a weighted average of past observations, with more recent observations having a greater weight value in determining the forecast. The exponential smoothing method is a relatively straightforward and effective approach for forecasting (Irwan, Abdy, Karwingsi, & Ahmar, 2023).

Therefore, it is crucial to conduct research on forecasting the value of Indonesia's oil and gas exports every month from March 2010 to March 2020 using the exponential smoothing model.

2. Methods

The research data utilized in this study were secondary data obtained from the website of the Central Bureau of Statistics of the Republic of Indonesia. The data span January 2010 to March 2022 and pertain to the value of oil and gas exports in Indonesia on a monthly basis. The analysis used in this study involved Triple Exponential Smoothing.

The Triple Exponential Smoothing method is a time-series forecasting technique that utilizes three smoothing equations to estimate trend, seasonality, and randomness, and each equation has its own smoothing parameter (α, β, γ) set between 0 and 1. The forecast value can be calculated using the formula proposed by Makridakis, Wheelwright, and McGee (1992).

Overall Smoothing:

$$S_t = \alpha\left(\frac{X_t}{I_{t-L}}\right) + (1-\alpha)(S_{t-1} + b_{t-1})$$

Trend smoothing:

$$b_t = \gamma(S_t - S_{t-1}) + (1-\gamma)b_{t-1}$$

Seasonal smoothing:

$$I_t = \beta(\frac{X_t}{S_t}) + (1-\beta)I_{t-L}$$

Forecast:

$$F_{t+m} = (S_t + b_t m)I_{t-L+m}$$

$$F_{t+m} = \left(\left(\alpha\left(\frac{X_t}{I_{t-L}}\right) + (1-\alpha)(S_{t-1} + b_{t-1})\right) + \left(\left(\gamma(S_t - S_{t-1}) + (1-\gamma)b_{t-1}\right)m\right)\right)\left(\beta(\frac{X_{t-L+m}}{S_{t-L+m}}) + (1-\beta)I_{t-2L+m}\right)$$

dengan :

X_t = actual data at time t,
S_t = data smoothing value,
S_{t-1} = previous period smoothing value,
b_t = trend smoothing
b_{t-1} = previous period trend smoothing,
I_t = seasonal smoothing,
I_{t-1} = previous period seasonal smoothing,
α = exponential parameter for data smoothing with values between 0 and 1,
β = exponential parameter for trend smoothing with value between 0 and 1,
γ = exponential parameter for seasonal smoothing with a value between 0 and 1,
F_{t+m} = forecasting value,

m = time period to be forecasted,
L = seasonal length.

3. Result and Discussions

To accurately forecast the data, the initial step is to present a time-series plot of the data. The time-series plot of the price of oil and gas exports in Indonesia is shown in Figure 1.

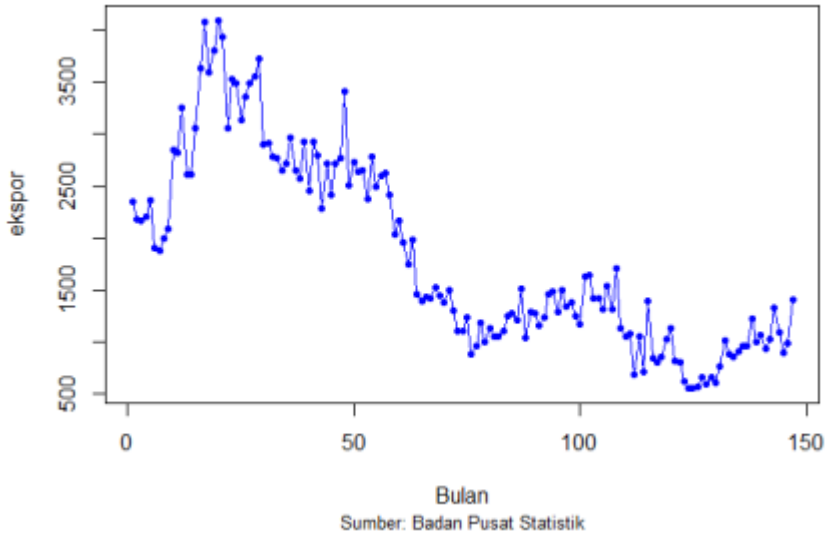

Figure 1. Time series plot of the price of oil and gas export value in Indonesia

As shown in Figure 1, the export value of oil and gas in Indonesia fell from USD 2500 million to USD 1500 million. The trend is downward and stable, which warrants the application of Triple Exponential Smoothing, also known as Winter Exponential Smoothing or Holt-Winters method.

To better understand the characteristics of time-series data (trend, seasonality, and randomness), a data decomposition process was conducted. Decomposition plots are used to separate the time-series data into distinct patterns and identify each component separately, which helps in forecasting data with trends and seasonal influences. The data may exhibit a complex pattern, such as increases, fluctuations, and irregularities, making it difficult to model them all at once. Therefore, it is necessary to divide the data into four components: trend, seasonal, cyclic fluctuations (stationary), and random, as shown in Figure 2.

```
> decompose(data.ts)
$x
        Jan    Feb    Mar    Apr    May    Jun    Jul    Aug    Sep    Oct    Nov
2010 2344.9 2175.3 2168.6 2204.6 2369.3 1901.5 1881.4 1993.5 2082.9 2841.9 2816.4
2011 2615.0 2612.5 3061.8 3628.3 4072.8 3591.0 3802.5 4091.6 3931.0 3062.7 3522.8
2012 3142.6 3355.5 3486.1 3560.7 3724.9 2899.7 2919.7 2783.0 2770.5 2650.6 2717.1
2013 2653.7 2567.6 2928.3 2452.1 2926.2 2800.4 2282.6 2720.5 2414.7 2715.2 2766.8
2014 2501.7 2729.1 2641.3 2651.4 2375.7 2786.0 2496.3 2598.2 2622.6 2413.2 2035.4
2015 1959.0 1753.4 1988.9 1458.2 1392.7 1439.9 1421.8 1530.9 1453.6 1379.6 1497.0
2016 1108.0 1113.3 1239.3  891.7  958.0 1187.4  998.6 1138.6 1061.5 1055.9 1103.0
2017 1278.6 1208.6 1516.2 1036.2 1294.4 1276.3 1165.0 1233.6 1455.0 1488.2 1295.8
2018 1342.7 1388.8 1256.1 1178.8 1633.1 1646.7 1416.5 1423.7 1320.2 1545.3 1312.9
2019 1131.3 1050.8 1077.4  688.1 1054.2  714.1 1400.5  842.9  803.0  860.0 1033.7
2020  815.3  805.2  617.4  562.1  560.9  567.4  660.4  599.6  667.3  614.5  762.2
2021  883.8  860.6  907.9  962.4  968.4 1232.1 1009.6 1066.8  932.8 1025.3 1332.4
2022  901.2  994.8 1405.1

        Dec
2010 3259.3
2011 3485.0
2012 2966.9
2013 3405.1
2014 2168.0
```

```
2015 1299.5
2016 1250.2
2017 1496.5
2018 1706.8
2019 1133.3
2020 1018.8
2021 1093.4
2022

$seasonal
            Jan         Feb         Mar         Apr         May         Jun         Jul
2010  -97.40542  -89.34746   34.45557 -104.37057   80.06807   19.32072  -55.00930
2011  -97.40542  -89.34746   34.45557 -104.37057   80.06807   19.32072  -55.00930
2012  -97.40542  -89.34746   34.45557 -104.37057   80.06807   19.32072  -55.00930
2013  -97.40542  -89.34746   34.45557 -104.37057   80.06807   19.32072  -55.00930
2014  -97.40542  -89.34746   34.45557 -104.37057   80.06807   19.32072  -55.00930
2015  -97.40542  -89.34746   34.45557 -104.37057   80.06807   19.32072  -55.00930
2016  -97.40542  -89.34746   34.45557 -104.37057   80.06807   19.32072  -55.00930
2017  -97.40542  -89.34746   34.45557 -104.37057   80.06807   19.32072  -55.00930
2018  -97.40542  -89.34746   34.45557 -104.37057   80.06807   19.32072  -55.00930
2019  -97.40542  -89.34746   34.45557 -104.37057   80.06807   19.32072  -55.00930
2020  -97.40542  -89.34746   34.45557 -104.37057   80.06807   19.32072  -55.00930
2021  -97.40542  -89.34746   34.45557 -104.37057   80.06807   19.32072  -55.00930
2022  -97.40542  -89.34746   34.45557

            Aug         Sep         Oct         Nov         Dec
2010    1.43584  -34.13083  -12.42436   19.04193  238.36580
2011    1.43584  -34.13083  -12.42436   19.04193  238.36580
2012    1.43584  -34.13083  -12.42436   19.04193  238.36580
2013    1.43584  -34.13083  -12.42436   19.04193  238.36580
2014    1.43584  -34.13083  -12.42436   19.04193  238.36580
2015    1.43584  -34.13083  -12.42436   19.04193  238.36580
2016    1.43584  -34.13083  -12.42436   19.04193  238.36580
2017    1.43584  -34.13083  -12.42436   19.04193  238.36580
2018    1.43584  -34.13083  -12.42436   19.04193  238.36580
2019    1.43584  -34.13083  -12.42436   19.04193  238.36580
2020    1.43584  -34.13083  -12.42436   19.04193  238.36580
2021    1.43584  -34.13083  -12.42436   19.04193  238.36580
2022

$trend
           Jan       Feb       Mar       Apr       May       Jun       Jul
2010        NA        NA        NA        NA        NA        NA 2347.8875
2011 2951.4458 3118.9125 3283.3375 3369.5417 3408.1750 3447.0125 3478.4000
2012 3468.6417 3377.3333 3274.4542 3208.9292 3158.1875 3103.0292 3061.0708
2013 2734.7958 2705.6458 2688.2167 2676.0833 2680.8458 2701.1750 2713.1000
2014 2674.7458 2678.5542 2682.1208 2678.2000 2635.1417 2553.1208 2478.9625
2015 1982.3792 1893.1375 1799.9583 1708.1833 1642.6833 1584.0625 1512.4167
2016 1239.0417 1205.0625 1172.3792 1142.5542 1112.6500 1094.1792 1099.2333
2017 1191.7750 1202.6667 1223.0208 1257.4292 1283.4750 1301.7708 1314.7042
2018 1392.1708 1410.5708 1412.8750 1409.6375 1412.7292 1422.2042 1422.1583
2019 1202.7750 1177.9083 1132.1583 1082.0542 1041.8667 1006.3375  969.2750
2020  802.6375  761.6625  745.8708  729.9875  708.4458  692.3625  690.4458
2021  859.3833  893.4000  923.9292  952.1083  992.9833 1019.8500 1023.6833
2022        NA        NA        NA
           Aug       Sep       Oct       Nov       Dec
2010 2377.3583 2432.7917 2529.3292 2659.6292 2801.0042
2011 3531.3417 3579.9792 3594.8417 3577.5292 3534.2292
2012 3007.8708 2951.8000 2882.3667 2802.8958 2765.4792
2013 2713.4958 2708.2667 2704.6125 2689.9792 2666.4417
2014 2415.6958 2347.8583 2270.9583 2180.2833 2083.2375
2015 1450.2875 1392.3833 1337.5458 1295.8292 1267.1958
2016 1110.3125 1125.8208 1143.3792 1163.4167 1181.1375
2017 1324.8833 1321.5542 1316.6583 1336.7125 1366.2583
2018 1399.2667 1377.7375 1349.8458 1305.2792 1242.3000
2019  945.8750  916.4750  892.0583  866.2542  839.5875
2020  695.6083  710.0208  738.8042  772.4625  817.1375
2021 1030.0000 1056.3083        NA        NA        NA
2022

$random
            Jan         Feb         Mar         Apr         May         Jun
```

```
2010          NA          NA          NA          NA          NA          NA
2011 -239.040417 -417.065038 -255.993069  363.128901  584.556931  124.666780
2012 -228.636251   67.514128  177.190265  456.141401  486.644431 -222.649887
2013   16.309583  -48.698372  205.627765 -119.612766  165.286098   79.904280
2014  -75.640417  139.893295  -75.276402   77.570568 -339.509735  213.558446
2015   74.026249  -50.390038  154.486098 -145.612766 -330.051402 -163.483220
2016  -33.636251   -2.415038   32.465265 -146.483599 -234.718069   73.900113
2017  184.230416   95.280795  258.723598 -116.858599  -69.143069  -44.791554
2018   47.934583   67.576628 -191.230569 -126.466932  140.302765  205.175113
2019   25.930416  -37.760872  -89.213902 -289.583599  -67.734735 -311.558220
2020  110.067916  132.884962 -162.926402  -63.516932 -227.613902 -144.283220
2021  121.822083   56.547462  -50.484735  114.662234 -104.651402  192.929280
2022          NA          NA          NA
            Jul         Aug         Sep         Oct         Nov         Dec
2010 -411.478201 -385.294174 -315.760840  324.995189  137.728901  219.930037
2011  379.109299  558.822493  385.151660 -519.717311  -73.771099 -287.594963
2012  -86.361535 -226.306674 -147.169174 -219.342311 -104.837766  -36.944963
2013 -375.490701    5.568326 -259.435840   23.011856   57.778901  500.292537
2014   72.346799  181.068326  308.872493  154.666022 -163.925266 -153.603296
2015  -35.607368   79.176660   95.347493   54.478522  182.128901 -206.061629
2016  -45.624035   26.851660  -30.190007  -75.054811  -79.458599 -169.303296
2017  -94.694868  -92.719174  167.576660  183.966022  -59.954432 -108.124129
2018   49.350965   22.997493  -23.406674  207.878522  -11.421099  226.134204
2019  486.234299 -104.410840  -79.344174  -19.633978  148.403901   55.346704
2020   24.963465  -97.444174   -8.590007 -111.879811  -29.304432  -36.703296
2021   40.925965   35.364160  -89.377507          NA          NA          NA
2022

$figure
 [1]  -97.40542  -89.34746   34.45557 -104.37057   80.06807   19.32072  -55.00930
 [8]    1.43584  -34.13083  -12.42436   19.04193  238.36580

$type
[1] "additive"

attr(,"class")
[1] "decomposed.ts"
```

Figure 2 is composed of 4 parts, and it is evident that the price of oil and gas export value in Indonesia has a downward trend pattern with seasonal fluctuations at specific times.

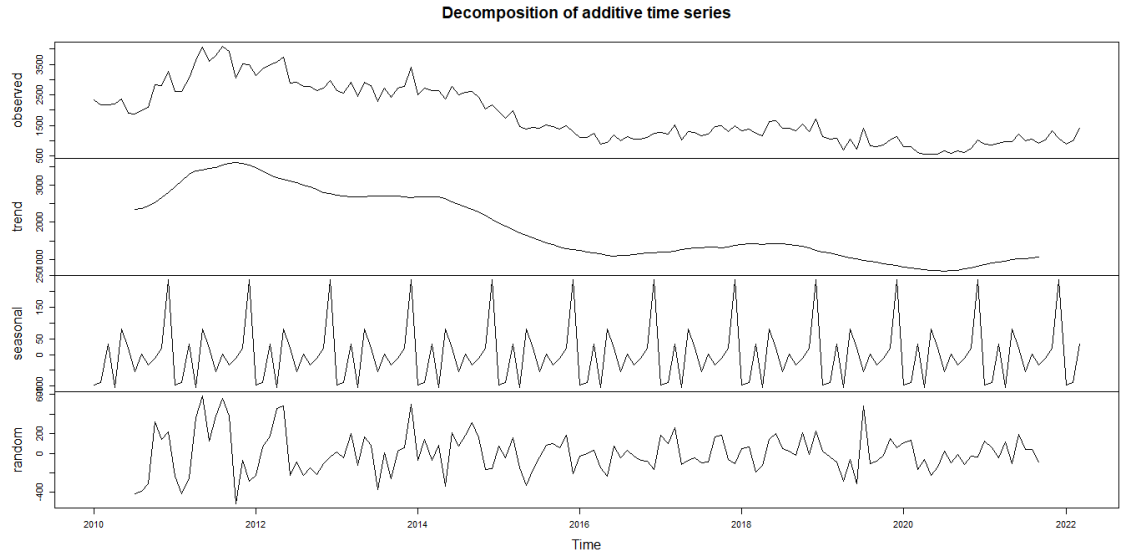

Figure 2. Decomposition plot of the price value of oil and gas exports in Indonesia

After reviewing the triple exponential smoothing data using the forecast package in R Software, the results of the analysis are shown in the following output:

```
> data.ts <- ts(datanya,start = c(2010,1),frequency = 12)

> triplexpo <- HoltWinters(data.ts, gamma = NULL, beta = NULL, alpha = NULL, s
easonal = "additive")

Holt-Winters exponential smoothing with trend and additive seasonal component.

Call:
HoltWinters(x = data.ts, alpha = NULL, beta = NULL, gamma = NULL, seasonal = "
additive")

Smoothing parameters:
 alpha: 0.5153984
 beta : 0.06410119
 gamma: 0.7137603
```

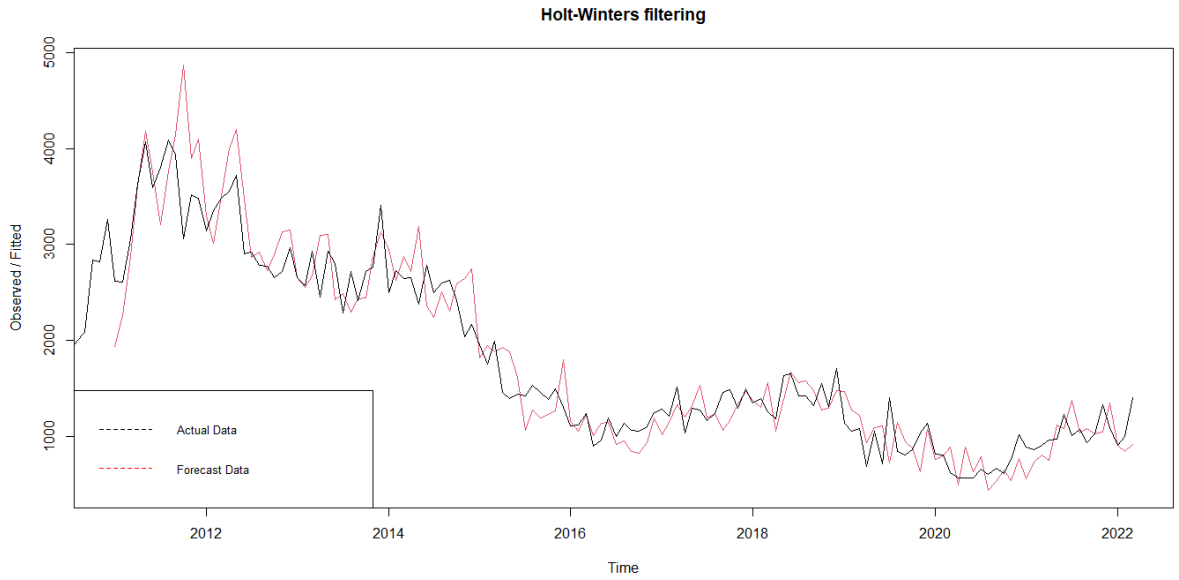

Figure 3. Plot of fitted data with actual data.

The triple exponential smoothing analysis revealed that the exponential smoothing parameters are α = 0.5153984, β = 0.06410119, and γ = 0.7137603, with the seasonal length L equal to 12. The equation for triple exponential smoothing is as follows:

$$F_{t+m} = \left(\left(\alpha\left(\frac{X_t}{I_{t-12}}\right)+(1-\alpha)(S_{t-1}+b_{t-1})\right)+\left((\gamma(S_t-S_{t-1})+(1-\gamma)b_{t-1})m\right)\right)\left(\beta(\frac{X_{t-12+m}}{S_{t-12+m}})+(1-\beta)I_{t-24+m}\right)$$

The following step involves data forecasting, which is carried out using the data for the next five periods: April, May, June, July, and August 2022.

```
> ramalan <- forecast(triplexpo, h=5)
> ramalan
         Point Forecast    Lo 80    Hi 80    Lo 95    Hi 95
Apr 2022       1111.765 702.6045 1520.925 486.0081 1737.521
May 2022       1250.465 783.8107 1717.120 536.7786 1964.152
Jun 2022       1405.016 881.2119 1928.820 603.9268 2206.105
Jul 2022       1447.510 866.4851 2028.534 558.9093 2336.110
Aug 2022       1452.984 814.4011 2091.568 476.3555 2429.613
```

Table 1. Five Period Forward Forecasting Results of the price of oil and gas export value in Indonesia

Months	Forecast (Million US$)
April 2022	1111.765
May 2022	1250.465
June 2022	1405.016
July 2022	1447.510
August 2022	1452.984

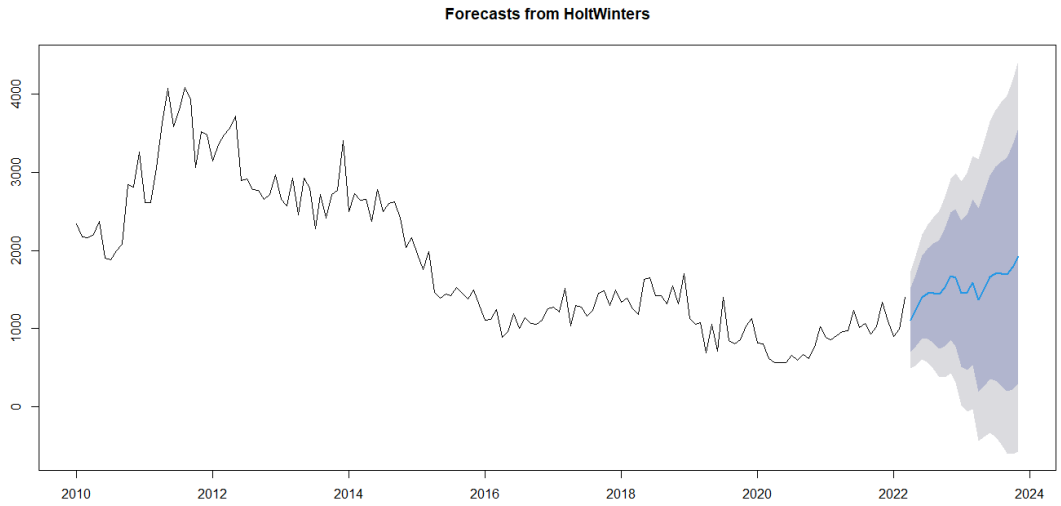

Figure 4. Plot of forecasting data.

According to the forecasting results depicted in Figure 4, it is anticipated that the prices of oil and gas exports in Indonesia will escalate in the upcoming period. These projections offer exporters insights and guidance.

4. Conclusions

The use of the Holt-Winters triple exponential smoothing method for forecasting the price of oil and gas export value in Indonesia yields:

(1) Using the values α = 0.5153984, β = 0.06410119, and γ = 0.7137603, the smoothing equations $S_t = 0.5153984X_t + \left(0.4846016\left(S_{t-1} + b_{t-1}\right)\right)I_{t-12}$ and $I_t = 0.06410119\mathrm{X}_t + 0.93589881\left(\mathrm{I}_{t-12}S_t\right)$, as well as the trend equation $b_t = 0.7137603(S_t - S_{t-1}) + 0.2862397b_{t-1}$, are applied. The forecasting equation:

$$F_{t+m} = \left(\left(0.5153984X_t + \left(0.4846016\left(S_{t-1} + b_{t-1}\right)\right)I_{t-12}\right) + \left(0.7137603(S_t - S_{t-1}) + 0.2862397b_{t-1}\right)m\right) \times 0.06410119\mathrm{X}_{t-12+m} + 0.93589881\left(\mathrm{I}_{t-24-m}S_{t-12+m}\right)$$

was then used to generate the forecast.

(2) The forecasted results for the next five periods in millions of US$ are as follows: April 2022 (1111.765), May 2022 (1250.465), June 2022 (1405.016), July 2022 (1447.510), and August 2022 (1452.984). These results suggest that the prices of oil and gas exports in Indonesia will rise in the coming period.

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