Предсказание продаж товара

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In [4]:
```
from clickhouse_driver import Client
import pandas as pd
import csv
import matplotlib.pyplot as plt
import numpy as np
from statsmodels.tsa.seasonal import seasonal_decompose
from statsmodels.tsa.stattools import adfuller
import statsmodels.api as sm

import statsmodels.tsa.api as tsa
from statsmodels.graphics.tsaplots import plot_acf, acf, plot_pacf, pacf
from statsmodels.tsa.stattools import acf, q_stat, adfuller
from scipy.stats import probplot, moment

import pmdarima.arima
import warnings
from statsmodels.tools.sm_exceptions import ConvergenceWarning
warnings.simplefilter('ignore', ConvergenceWarning)

from catboost import CatBoostRegressor
from datetime import date, datetime, timedelta
from sklearn.metrics import make_scorer, mean_squared_error
from sklearn.model_selection import train_test_split
from sklearn.model_selection import TimeSeriesSplit

from joblib import Parallel, delayed

%matplotlib inline
plt.style.use('ggplot')
from tensorflow import keras
```

In [5]:
```
from google.colab import drive
drive.mount('/content/drive')
```

```
Mounted at /content/drive
```

In [6]:
```
#PATH = 'Datasets/imprice/' # local
PATH = '/content/drive/MyDrive/DataScience/imprice/' # colab
```

Постановка задачи

Требуется провести анализ данных и сделать предсказания продаж в штуках на последующую неделю для товара `7d185936-7a60-11eb-ba7f-4a6a34607ded`.

Загрузка данных

Загрузим датасеты из файлов.

In [21]:
```
products = pd.read_csv(PATH + 'products.csv')
sales = pd.read_csv(PATH + 'sales.csv')
stocks_items = pd.read_csv(PATH + 'stocks_items.csv')
stocks_on_days = pd.read_csv(PATH + 'stocks_on_days.csv')
warehouse = pd.read_csv(PATH + 'warehouse.csv')
```

Посмотрим на загруженные датасеты и предвариельно проанализируем данные, с которыми в дальнейшем буде работать.

Импортируем датасеты для товара `7d185936-7a60-11eb-ba7f-4a6a34607ded` .

In [22]:
```
products
```

Out[22]:

	item_id	brand_id	name
0	7d185936-7a60-11eb-ba7f-4a6a34607ded	a2c5d335-815e-11eb-ba83-4a6a34607ded	NaN

В таблице `products` мы ожидаемо получили одну строку с идентификатором бренда, соответствующим нашему товару. Для наших целий этот датасет не пригодится.

In [23]:
```
sales.head(5)
```

Out[23]:

	date	warehouse_id	item_id	order_number	price	quantity	amount
0	2021-01-04 00:00:00	01ffab2c-3c70-11ec-ba95-4a6a34607ded	7d185936-7a60-11eb-ba7f-4a6a34607ded	3547355649947603906	0.00	1	59.99
1	2021-01-04 00:00:00	01ffab2c-3c70-11ec-ba95-4a6a34607ded	7d185936-7a60-11eb-ba7f-4a6a34607ded	4908248033917346488	0.00	1	59.99
2	2021-01-04 00:00:00	01ffab2c-3c70-11ec-ba95-4a6a34607ded	7d185936-7a60-11eb-ba7f-4a6a34607ded	1134184689814738432	0.00	1	59.99
3	2021-01-04 00:00:00	bb818041-3c6f-11ec-ba95-4a6a34607ded	7d185936-7a60-11eb-ba7f-4a6a34607ded	765388806314934293	0.00	1	59.99
4	2021-01-04 00:00:00	d91c6b6b-50f4-11ec-ba96-4a6a34607ded	7d185936-7a60-11eb-ba7f-4a6a34607ded	1561687768297015768	59.99	1	59.99

В таблице **`sales`** содержатся данные о продажах. А именно:

- `date` - дата продажи
- `warehouse_id` - идентификатор склада,
- `item_id` - идентификатор нашего товара,
- `order_number` - номер заказа,
- `price` - цена единицы товара,
- `quantity` - количество единиц товара в заказе,
- `amount` - стоимость заказа (цена, умноженная на количество единиц товара в заказе),
- `sebes` - себестоимость единицы товара

In [24]:
```
stocks_items
```

Out[24]:

	stock_id	item_id	quantity
0	4787ce96-7a69-11eb-ba7f-4a6a34607ded	7d185936-7a60-11eb-ba7f-4a6a34607ded	15
1	126055b5-2c17-11ec-ba94-8141c2516b9e	7d185936-7a60-11eb-ba7f-4a6a34607ded	2
2	01ffab2c-3c70-11ec-ba95-4a6a34607ded	7d185936-7a60-11eb-ba7f-4a6a34607ded	3
3	708b9941-3c6f-11ec-ba95-4a6a34607ded	7d185936-7a60-11eb-ba7f-4a6a34607ded	6
4	bb818041-3c6f-11ec-ba95-4a6a34607ded	7d185936-7a60-11eb-ba7f-4a6a34607ded	1
5	e1627618-3c6f-11ec-ba95-4a6a34607ded	7d185936-7a60-11eb-ba7f-4a6a34607ded	5
6	f6e80261-3c6f-11ec-ba95-4a6a34607ded	7d185936-7a60-11eb-ba7f-4a6a34607ded	-2
7	d24bc91d-50f4-11ec-ba96-4a6a34607ded	7d185936-7a60-11eb-ba7f-4a6a34607ded	-2
8	e523eaae-50f4-11ec-ba96-4a6a34607ded	7d185936-7a60-11eb-ba7f-4a6a34607ded	6
9	ed86c36a-50f4-11ec-ba96-4a6a34607ded	7d185936-7a60-11eb-ba7f-4a6a34607ded	6

В таблице **`stocks_items`** содержится информация о балансе товара на складах.

- `stock_id` - идентификатор склада,
- `item_id` - идентификатор нашего товара,
- `quantity` - количество единиц товара на складе

На двух складах баланс в штуках нашего товара отрицательный. Предположительно, это может быть связано с логистическими особенностями, например, товар куплен с этого склада, но еще на него не поступил. Либо имеет место ошибка при подсчете изначального баланса или что-то в этом роде.

In [25]:
```
stocks_on_days.tail(5)
```

Out[25]:

	date	stock_id	item_id	start_day	finish_day
4255	2022-01-09 00:00:00	e1627618-3c6f-11ec-ba95-4a6a34607ded	7d185936-7a60-11eb-ba7f-4a6a34607ded	5	5
4256	2022-01-09 00:00:00	f6e80261-3c6f-11ec-ba95-4a6a34607ded	7d185936-7a60-11eb-ba7f-4a6a34607ded	-2	-2
4257	2022-01-09 00:00:00	d24bc91d-50f4-11ec-ba96-4a6a34607ded	7d185936-7a60-11eb-ba7f-4a6a34607ded	-2	-2
4258	2022-01-09 00:00:00	e523eaae-50f4-11ec-ba96-4a6a34607ded	7d185936-7a60-11eb-ba7f-4a6a34607ded	6	6
4259	2022-01-09 00:00:00	ed86c36a-50f4-11ec-ba96-4a6a34607ded	7d185936-7a60-11eb-ba7f-4a6a34607ded	6	6

В таблице **`stocks_on_days`** содержится информация об изменении баланса товара на складах.

- `date` - дата изменения записи,
- `stock_id` - идентификатор склада,
- `start_day` - количество единиц товара на начало дня,
- `finish_day` - количество единиц товара на конец дня

2022-01-09 на двух складах мы видим отрицательные балансы, соответствующие данным из предыдущей таблицы. Возможно, дальнейший анализ позволит предполжить причину.

In [26]:
```
warehouse
```

Out[26]:

	id	name
0	4787ce96-7a69-11eb-ba7f-4a6a34607ded	31
1	126055b5-2c17-11ec-ba94-8141c2516b9e	29
2	708b9941-3c6f-11ec-ba95-4a6a34607ded	30
3	bb818041-3c6f-11ec-ba95-4a6a34607ded	36
4	e1627618-3c6f-11ec-ba95-4a6a34607ded	32
5	f6e80261-3c6f-11ec-ba95-4a6a34607ded	13
6	01ffab2c-3c70-11ec-ba95-4a6a34607ded	43
7	0ad8892d-3c70-11ec-ba95-4a6a34607ded	2
8	d24bc91d-50f4-11ec-ba96-4a6a34607ded	10
9	d91c6b6b-50f4-11ec-ba96-4a6a34607ded	17
10	e523eaae-50f4-11ec-ba96-4a6a34607ded	11
11	ed86c36a-50f4-11ec-ba96-4a6a34607ded	40
12	6e1c3edd-50f7-11ec-ba96-4a6a34607ded	38
13	77155156-50f7-11ec-ba96-4a6a34607ded	22

В таблице **`warehouse`** содержится информация о соответствии идентификатора склада имени склада.

- `id` - идентификатор склада,
- `name` - имя склада

Предобработка данных

Сначала проанализируем данные в каждой таблице отдельно. Нас в основном будут интересовать две таблицы: `sales` и `stocks_on_days` , т.к. в них есть информация по дням. Сразу преобразуем поле `date` в дату в обоих датасетах.

In [27]:

```
sales.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 7881 entries, 0 to 7880
Data columns (total 8 columns):
 #   Column        Non-Null Count  Dtype  
---  ------        --------------  -----  
 0   date          7881 non-null   object 
 1   warehouse_id  7881 non-null   object 
 2   item_id       7881 non-null   object 
 3   order_number  7881 non-null   uint64 
 4   price         7881 non-null   float64
 5   quantity      7881 non-null   int64  
 6   amount        7881 non-null   float64
 7   sebes         7881 non-null   float64
dtypes: float64(3), int64(1), object(3), uint64(1)
memory usage: 492.7+ KB
```

In [28]:

```
sales['date'] = pd.to_datetime(sales['date'], format='%Y-%m-%d')
```

In [29]:

```
stocks_on_days.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 4260 entries, 0 to 4259
Data columns (total 5 columns):
 #   Column      Non-Null Count  Dtype 
---  ------      --------------  ----- 
 0   date        4260 non-null   object
 1   stock_id    4260 non-null   object
 2   item_id     4260 non-null   object
 3   start_day   4260 non-null   int64 
 4   finish_day  4260 non-null   int64 
dtypes: int64(2), object(3)
memory usage: 166.5+ KB
```

Преобразуем `date` в дату.

In [30]:

```
stocks_on_days['date'] = pd.to_datetime(stocks_on_days['date'], format='%Y-
```

Таблица `sales`

In [31]:

```
sales.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 7881 entries, 0 to 7880
Data columns (total 8 columns):
 #   Column        Non-Null Count  Dtype
---  ------        --------------  -----
 0   date          7881 non-null   datetime64[ns]
 1   warehouse_id  7881 non-null   object
 2   item_id       7881 non-null   object
 3   order_number  7881 non-null   uint64
 4   price         7881 non-null   float64
 5   quantity      7881 non-null   int64
 6   amount        7881 non-null   float64
 7   sebes         7881 non-null   float64
dtypes: datetime64[ns](1), float64(3), int64(1), object(2), uint64(1)
memory usage: 492.7+ KB
```

In [32]:
```
sales.describe()
```

Out[32]:

	order_number	price	quantity	amount	sebes
count	7.881000e+03	7881.000000	7881.000000	7881.000000	7881.000000
mean	9.327293e+18	29.018286	1.215962	73.103140	62.887013
std	5.398734e+18	30.190997	0.565779	34.144389	57.869118
min	2.034849e+15	0.000000	1.000000	41.000000	46.810000
25%	4.602076e+18	0.000000	1.000000	59.990000	53.500000
50%	9.384644e+18	0.000000	1.000000	59.990000	53.500000
75%	1.403695e+19	59.990000	1.000000	59.990000	53.500000
max	1.844082e+19	72.890000	20.000000	1199.400000	428.000000

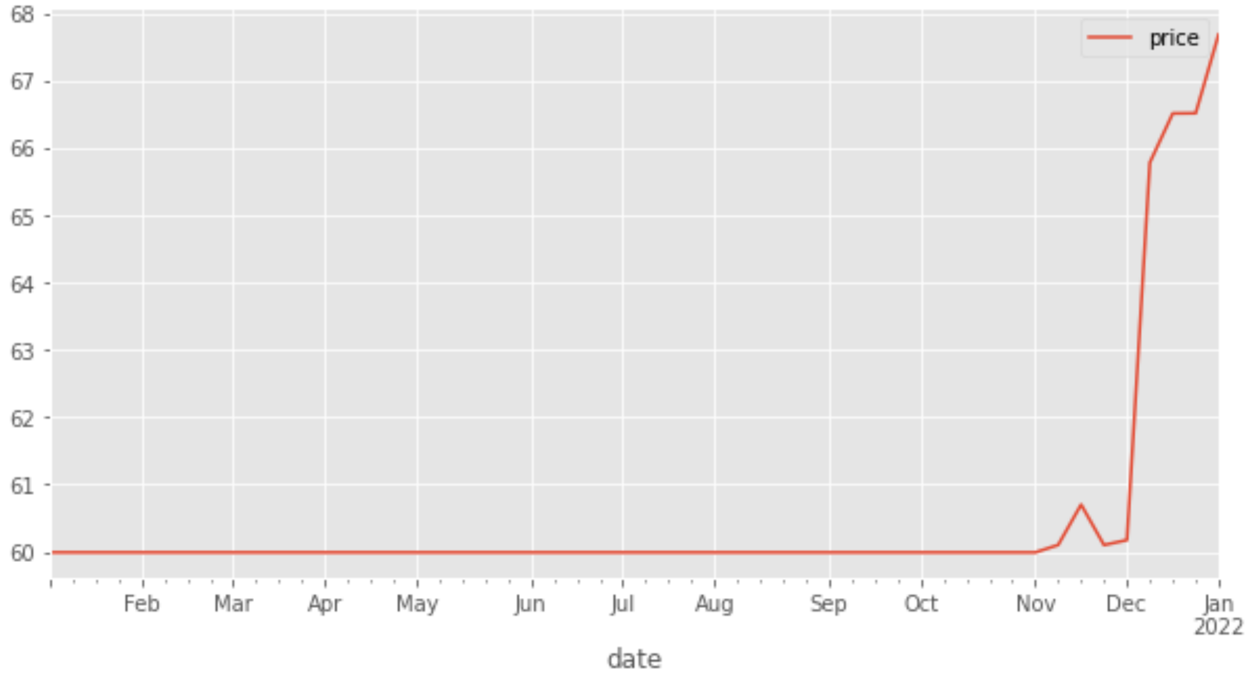
Усредненный пользователь заказывает 1.2 нашего товара. При этом 1.2 * 29 не равно 73. Видимо, с какой-то из этих колонок что-то не так. Медианное значение цены - 0, то есть в нашем датасете по меньшей мере половина строк, где товар бесплатен, что странно.

In [33]:
```
sales['price'].value_counts()
```

Out[33]:
```
0.00     4092
59.99    3653
72.89      90
64.99      46
Name: price, dtype: int64
```

Так и есть - в нашем датасете 4092 записи, где товар стоит 0. Это скорее всего ошибка в данных. Хорошо, что для задачи прогнозирования продаж в штуках цена товара нам не понадобится. Однако мы можем приблизительно проследить, как менялась цена за единицу товара.

In [34]:
```
sales[sales['price'] != 0].pivot_table(index=('date'),\
                                    values=('price'), aggfunc='mean').resample('1W
                    .plot(grid=True, figsize=(10, 5),style='-');
```



Итак, с ноября цена за единицу товара начинает расти.

Сгруппируем данные по номеру заказа и посмотрим суммарное количество единиц товара в одном заказе.

In [35]:
```
sales.groupby('order_number')['quantity'].value_counts().sort_values(ascend
```

Out[35]:
```
order_number         quantity
6731018479413670002  1           5
1672391227775584346  1           5
113212051826480409   1           4
2305051651363929932  1           3
9940791630401677462  1           3
                                ..
6304597147929193647  1           1
6303587684150998541  2           1
6301763020603510346  2           1
6296363353016666437  1           1
9385861019613057384  1           1
Name: quantity, Length: 7739, dtype: int64
```

Итак, одна строка в нашем датасете не соответствует одному заказу, т.к. есть строки с одинаковым номером заказа. Посмотрим на один из них.

In [36]:
```
sales[sales['order_number'] == 6731018479413670002]
```

Out[36]:

	date	warehouse_id	item_id	order_number	price	quantity	amount
5323	2021-06-29	ed86c36a-50f4-11ec-ba96-4a6a34607ded	7d185936-7a60-11eb-ba7f-4a6a34607ded	6731018479413670002	59.99	1	41.99
5324	2021-06-29	ed86c36a-50f4-11ec-ba96-4a6a34607ded	7d185936-7a60-11eb-ba7f-4a6a34607ded	6731018479413670002	59.99	1	59.99
5325	2021-06-29	ed86c36a-50f4-11ec-ba96-4a6a34607ded	7d185936-7a60-11eb-ba7f-4a6a34607ded	6731018479413670002	59.99	1	41.99
5326	2021-06-29	ed86c36a-50f4-11ec-ba96-4a6a34607ded	7d185936-7a60-11eb-ba7f-4a6a34607ded	6731018479413670002	59.99	1	41.99
5327	2021-06-29	ed86c36a-50f4-11ec-ba96-4a6a34607ded	7d185936-7a60-11eb-ba7f-4a6a34607ded	6731018479413670002	59.99	1	41.99

В один день с одного и того же склада было добавлено в заказ 5 единиц товара. Причем поштучно. При этом мы изначально предполагали, что 'amount' есть произведение цены товара на количество товара - это явно прослеживалось по некоторым строкам, где 'quantity' больше 1. Однако здесь эта закономерность не работает в четырех из пяти случаев. Следовательно, можно предположить три варианта: первый - строки в датасете по какой-то причине задублированы, второй - счётчик количества товаров в одном заказе по какой-то причине не всегда работает, третий - количество в каждой строке это покупка вне зависимости от номера заказа.

Чтобы отбросить пару предположений, посмотрим, есть ли среди заказов такие, в которых количество в одной строке больше 1.

In [37]:

```
sales[sales['quantity']>1].groupby('order_number')['quantity'].value_count
```

Out[37]:
```
order_number          quantity
1129619448496512795 5  2          2
1730941216231673741 0  2          2
4049899956522145911    4          2
1023225050455825080 0  2          2
5797787849689655 84    2          2
1679969382972181959 3  2          2
2102220760535183504    2          2
1096084460980853483 9  3          2
1144011807144174995 7  2          2
2318083237555896309    2          2
1308545200483054307 3  2          2
7110878873487874671    2          2
7102228416989677268    2          2
9175776159446999722    2          2
2676459181329578499    2          2
1083940588807702367 5  2          2
1057456506420152601 6  2          2
1510957634445775749 3  2          2
6894026867048799798    2          2
1835552876047231542 0  2          2
1310799616417822319    2          2
1734804568586959735 6  4          2
5235063407714053795    2          2
4737158851813872577    2          2
1397436151991953240 4  2          2
1252473983503668059 7  2          1
1255908165882123151 8  2          1
1254564049840282507 4  2          1
1253783697884214094 1  2          1
1253068377164700309 4  3          1
Name: quantity, dtype: int64
```

У нас есть несколько таких заказов. Посмотрим на некоторые из них.

In [38]:
```
sales[sales['order_number'] == 4049899956522145911]
```

Out[38]:

	date	warehouse_id	item_id	order_number	price	quantity	amount
335	2021-01-15	126055b5-2c17-11ec-ba94-8141c2516b9e	7d185936-7a60-11eb-ba7f-4a6a34607ded	4049899956522145911	0.0	4	239.96
336	2021-01-15	126055b5-2c17-11ec-ba94-8141c2516b9e	7d185936-7a60-11eb-ba7f-4a6a34607ded	4049899956522145911	0.0	4	239.96

In [39]:
```
sales[sales['order_number'] == 10960844609808534839]
```

Out[39]:

	date	warehouse_id	item_id	order_number	price	quantity	amou
5272	2021-06-28	01ffab2c-3c70-11ec-ba95-4a6a34607ded	7d185936-7a60-11eb-ba7f-4a6a34607ded	10960844609808534839	0.0	3	179.!
5273	2021-06-28	01ffab2c-3c70-11ec-ba95-4a6a34607ded	7d185936-7a60-11eb-ba7f-4a6a34607ded	10960844609808534839	0.0	3	179.!

In [40]:

```
sales[sales['order_number'] == 13974361519919532404]
```

Out[40]:

	date	warehouse_id	item_id	order_number	price	quantity	amoun
5613	2021-07-13	d24bc91d-50f4-11ec-ba96-4a6a34607ded	7d185936-7a60-11eb-ba7f-4a6a34607ded	13974361519919532404	59.99	2	119.9!
5614	2021-07-13	d24bc91d-50f4-11ec-ba96-4a6a34607ded	7d185936-7a60-11eb-ba7f-4a6a34607ded	13974361519919532404	59.99	2	119.9!

Вряд ли проблема в счетчике количества единиц товара в одном заказе. Иначе мы могли бы увидеть для одного заказа нечто вроде двух строк с разным 'quantity'. Так же маловероятно, что пользователь сначала купил 4 единицы товара, а затем подумал, что ему не хватает, и заказал ещё 4 единицы. Поэтому логично всё же заключить, что записи задублированы. Возможно, логгирование завязано на не самое удачное событие. Например, на кнопку "Оплатить заказ", а не на подтверждение оплаты. Посмотрим, сколько всего у нас повторяющихся строк.

In [41]:

```
sales.duplicated().sum()
```

Out[41]: 131

Удалим эти строки.

In [42]:

```
sales = sales.drop_duplicates().reset_index(drop=True)
```

Рассмотрим оставшиеся заказы с большим количеством строк, чем 1.

In [43]:

```
sales['order_number'].value_counts()[sales['order_number'].value_counts() >
```

Out[43]:
```
785214136477173422      2
16590744060919034086    2
6731018479413670002     2
735175590017064594      2
1670133850376295321     2
1182413268119596500     2
175523352856087190      2
2918464380085550324     2
532907036741686853      2
1128963427423366634     2
14146929096356632958    2
8129142197681254166     2
6345548677911873275     2
348314697940896314      2
9586599714543904593     2
9028684352588784015     2
Name: order_number, dtype: int64
```

Таких заказов немного, поэтому рассмотрим каждый индивидуально.

In [44]:
```
sales[sales['order_number'].isin(\
            sales['order_number'].value_counts()[sales['order_number'].valu
```

Out[44]:

	date	warehouse_id	item_id	order_number	price	quantity	amou
617	2021-01-23	e1627618-3c6f-11ec-ba95-4a6a34607ded	7d185936-7a60-11eb-ba7f-4a6a34607ded	6345548677911873275	0.00	2	119.(
618	2021-01-23	e1627618-3c6f-11ec-ba95-4a6a34607ded	7d185936-7a60-11eb-ba7f-4a6a34607ded	6345548677911873275	0.00	1	59.!
653	2021-01-24	126055b5-2c17-11ec-ba94-8141c2516b9e	7d185936-7a60-11eb-ba7f-4a6a34607ded	1670133850376295321	0.00	1	59.!
654	2021-01-24	126055b5-2c17-11ec-ba94-8141c2516b9e	7d185936-7a60-11eb-ba7f-4a6a34607ded	1670133850376295321	0.00	1	59.
744	2021-01-26	e1627618-3c6f-11ec-ba95-4a6a34607ded	7d185936-7a60-11eb-ba7f-4a6a34607ded	175523352856087190	0.00	1	59.
745	2021-01-26	e1627618-3c6f-11ec-ba95-4a6a34607ded	7d185936-7a60-11eb-ba7f-4a6a34607ded	175523352856087190	0.00	1	59.
1756	2021-02-21	ed86c36a-50f4-11ec-ba96-4a6a34607ded	7d185936-7a60-11eb-ba7f-4a6a34607ded	9028684352588784015	59.99	1	59.
		ed86c36a-	7d185936-				

1757	2021-02-21	50f4-11ec-ba96-4a6a34607ded	7a60-11eb-ba7f-4a6a34607ded	9028684352588784015	59.99	1	59.
1763	2021-02-22	126055b5-2c17-11ec-ba94-8141c2516b9e	7d185936-7a60-11eb-ba7f-4a6a34607ded	9586599714543904593	0.00	1	59.9
1764	2021-02-22	126055b5-2c17-11ec-ba94-8141c2516b9e	7d185936-7a60-11eb-ba7f-4a6a34607ded	9586599714543904593	0.00	1	59.9
1843	2021-02-24	d24bc91d-50f4-11ec-ba96-4a6a34607ded	7d185936-7a60-11eb-ba7f-4a6a34607ded	1182413268119596500	59.99	1	59.
1844	2021-02-24	d24bc91d-50f4-11ec-ba96-4a6a34607ded	7d185936-7a60-11eb-ba7f-4a6a34607ded	1182413268119596500	59.99	1	59.9
2715	2021-03-23	e1627618-3c6f-11ec-ba95-4a6a34607ded	7d185936-7a60-11eb-ba7f-4a6a34607ded	532907036741686853	0.00	2	119.0
2716	2021-03-23	e1627618-3c6f-11ec-ba95-4a6a34607ded	7d185936-7a60-11eb-ba7f-4a6a34607ded	532907036741686853	0.00	1	59.8
3572	2021-04-26	01ffab2c-3c70-11ec-ba95-4a6a34607ded	7d185936-7a60-11eb-ba7f-4a6a34607ded	1128963427423366634	0.00	1	59.
3573	2021-04-26	01ffab2c-3c70-11ec-ba95-4a6a34607ded	7d185936-7a60-11eb-ba7f-4a6a34607ded	1128963427423366634	0.00	1	59.4
4542	2021-05-30	ed86c36a-50f4-11ec-ba96-4a6a34607ded	7d185936-7a60-11eb-ba7f-4a6a34607ded	14146929096356632958	59.99	2	119.9
4625	2021-06-03	01ffab2c-3c70-11ec-ba95-4a6a34607ded	7d185936-7a60-11eb-ba7f-4a6a34607ded	14146929096356632958	0.00	1	59.9
4998	2021-06-19	126055b5-2c17-11ec-ba94-8141c2516b9e	7d185936-7a60-11eb-ba7f-4a6a34607ded	735175590017064594	0.00	1	59.0
4999	2021-06-19	126055b5-2c17-11ec-ba94-8141c2516b9e	7d185936-7a60-11eb-ba7f-4a6a34607ded	735175590017064594	0.00	2	119.3

5229	2021-06-29	ed86c36a-50f4-11ec-ba96-4a6a34607ded	7d185936-7a60-11eb-ba7f-4a6a34607ded	6731018479413670002	59.99	1	41.
5230	2021-06-29	ed86c36a-50f4-11ec-ba96-4a6a34607ded	7d185936-7a60-11eb-ba7f-4a6a34607ded	6731018479413670002	59.99	1	59.
5454	2021-07-09	708b9941-3c6f-11ec-ba95-4a6a34607ded	7d185936-7a60-11eb-ba7f-4a6a34607ded	348314697940896314	0.00	1	59.
5455	2021-07-09	708b9941-3c6f-11ec-ba95-4a6a34607ded	7d185936-7a60-11eb-ba7f-4a6a34607ded	348314697940896314	0.00	1	59.
5579	2021-07-17	6e1c3edd-50f7-11ec-ba96-4a6a34607ded	7d185936-7a60-11eb-ba7f-4a6a34607ded	16590744060919034086	59.99	2	119.
5580	2021-07-17	6e1c3edd-50f7-11ec-ba96-4a6a34607ded	7d185936-7a60-11eb-ba7f-4a6a34607ded	16590744060919034086	59.99	1	59.
5886	2021-08-03	126055b5-2c17-11ec-ba94-8141c2516b9e	7d185936-7a60-11eb-ba7f-4a6a34607ded	2918464380085550324	0.00	1	64.
5887	2021-08-03	126055b5-2c17-11ec-ba94-8141c2516b9e	7d185936-7a60-11eb-ba7f-4a6a34607ded	2918464380085550324	0.00	1	64.
6170	2021-08-24	ed86c36a-50f4-11ec-ba96-4a6a34607ded	7d185936-7a60-11eb-ba7f-4a6a34607ded	8129142197681254166	59.99	1	59.
6171	2021-08-24	ed86c36a-50f4-11ec-ba96-4a6a34607ded	7d185936-7a60-11eb-ba7f-4a6a34607ded	8129142197681254166	59.99	1	59.
7084	2021-11-08	708b9941-3c6f-11ec-ba95-4a6a34607ded	7d185936-7a60-11eb-ba7f-4a6a34607ded	785214136477173422	0.00	1	59.
7085	2021-11-08	708b9941-3c6f-11ec-ba95-4a6a34607ded	7d185936-7a60-11eb-ba7f-4a6a34607ded	785214136477173422	0.00	1	59.

Рассмотрение показало, что возможны три варианта:

1. Разные даты, разные склады, разное количество.

In [45]:
```
sales[sales['order_number'] == 14146929096356632958]
```

Out[45]:

	date	warehouse_id	item_id	order_number	price	quantity	amou
4542	2021-05-30	ed86c36a-50f4-11ec-ba96-4a6a34607ded	7d185936-7a60-11eb-ba7f-4a6a34607ded	14146929096356632958	59.99	2	119.!
4625	2021-06-03	01ffab2c-3c70-11ec-ba95-4a6a34607ded	7d185936-7a60-11eb-ba7f-4a6a34607ded	14146929096356632958	0.00	1	59.!

Если бы не половина датасета с нулевой ценой, можно было бы предположить возврат единицы товара покупателем и отгрузку нового товара со склада. Но мы не знаем этого. Также можно предположить, что 2021-05-30 товара на складе не хватило, и была отгрузка одной единицы товара 2021-06-03. Мы можем проверить, сколько единиц товара было на начало и конец дня на складе 2021-05-30, чтобы проверить эту версию.

In [46]:
```
stocks_on_days[(stocks_on_days['date'] == '2021-05-30') & (stocks_on_days[
```

Out[46]:

	date	stock_id	item_id	start_day	finish_day
1928	2021-05-30	ed86c36a-50f4-11ec-ba96-4a6a34607ded	7d185936-7a60-11eb-ba7f-4a6a34607ded	12	8

Похоже, версию с доотгрузкой можно отбросить. Однако, мы не знаем, могло ли произойти задвоение номера заказа от разных покупателей, когда они заказывали товар с разных складов. Оставим обе записи.

1. Одинаковые даты, одинаковые склады, разное количество:

In [47]:
```
sales[sales['order_number'] == 532907036741686853]
```

Out[47]:

	date	warehouse_id	item_id	order_number	price	quantity	amount
2715	2021-03-23	e1627618-3c6f-11ec-ba95-4a6a34607ded	7d185936-7a60-11eb-ba7f-4a6a34607ded	532907036741686853	0.0	2	119.66
2716	2021-03-23	e1627618-3c6f-11ec-ba95-4a6a34607ded	7d185936-7a60-11eb-ba7f-4a6a34607ded	532907036741686853	0.0	1	59.84

Мы не знаем, уменьшилось ли количество единиц в заказе или увеличилось, и следовательно мы не знаем, какие записи удалять и удалять ли. Оставим без изменения, т.к. их всё равно немного.

1. Одинаковые даты, одинаковые склады, одинаковое количество, разная стоимость с отличием на 0.01 (округление). Рассматриваем как дубль:

In [48]:

```
sales[sales['order_number'] == 1128963427423366634]
```

Out[48]:

	date	warehouse_id	item_id	order_number	price	quantity	amount
3572	2021-04-26	01ffab2c-3c70-11ec-ba95-4a6a34607ded	7d185936-7a60-11eb-ba7f-4a6a34607ded	1128963427423366634	0.0	1	59.51
3573	2021-04-26	01ffab2c-3c70-11ec-ba95-4a6a34607ded	7d185936-7a60-11eb-ba7f-4a6a34607ded	1128963427423366634	0.0	1	59.50

Индексы 653, 744, 1756, 1763, 1843, 3573, 5229, 5454, 5887, 6171, 7085 удаляем.

In [49]:

```
sales = sales[sales.index.isin(\
        (653, 744, 1756, 1763, 1843, 3573, 5229, 5454, 5887, 6171, 7085))=
        .reset_index(drop=True)
```

In [50]:

```
sales['order_number'].value_counts()[sales['order_number'].value_counts() >
```

Out[50]:

```
14146929096356632958    2
16590744060919034086    2
532907036741686853      2
6345548677911873275     2
735175590017064594      2
Name: order_number, dtype: int64
```

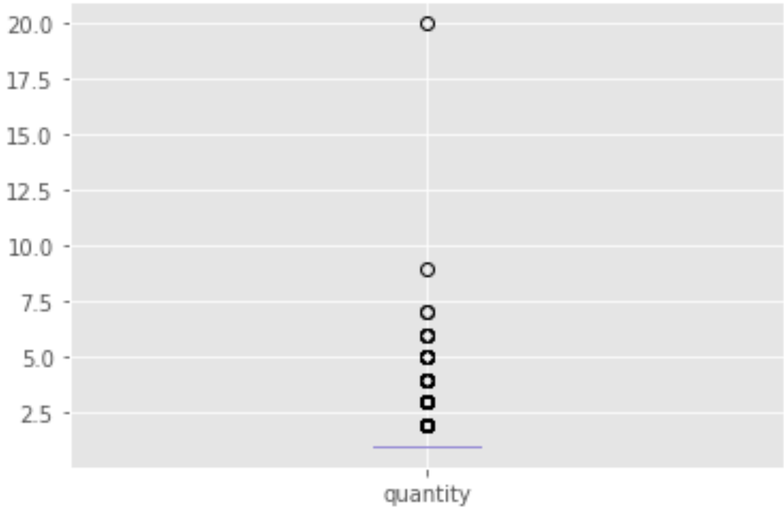
Посмотрим, сколько в датасете строк с разным количеством товара.

In [51]:
```
sales['quantity'].value_counts()
```

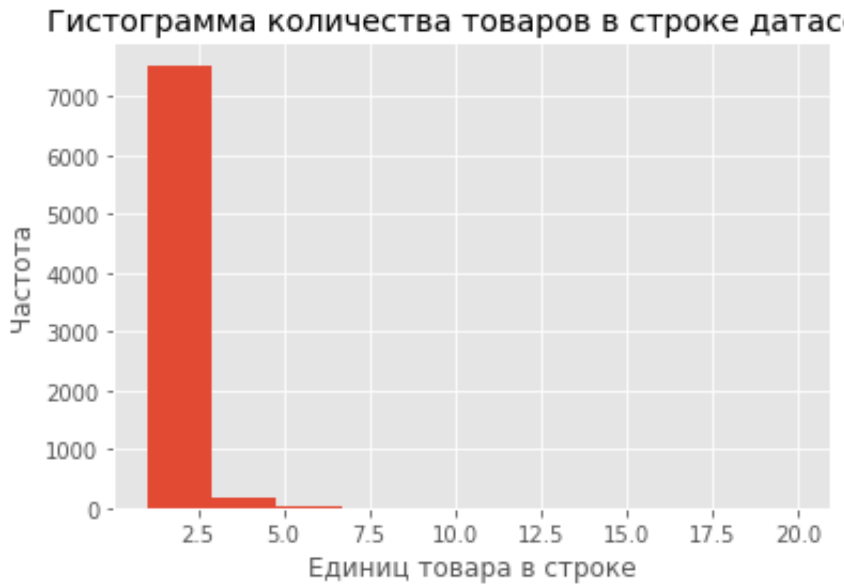
Out[51]:
```
1     6368
2     1169
3      149
4       35
5        9
6        5
7        2
20       1
9        1
Name: quantity, dtype: int64
```

Чаще всего встречаются строки с одной единицей товара, но есть и случаи, когда их 9 или 20.

In [52]:
```
sales.boxplot(column=['quantity']);
```



In [53]:
```
plt.title('Гистограмма количества товаров в строке датасета')
plt.xlabel('Единиц товара в строке')
plt.ylabel('Частота')
plt.hist(sales['quantity'], bins=10);
```

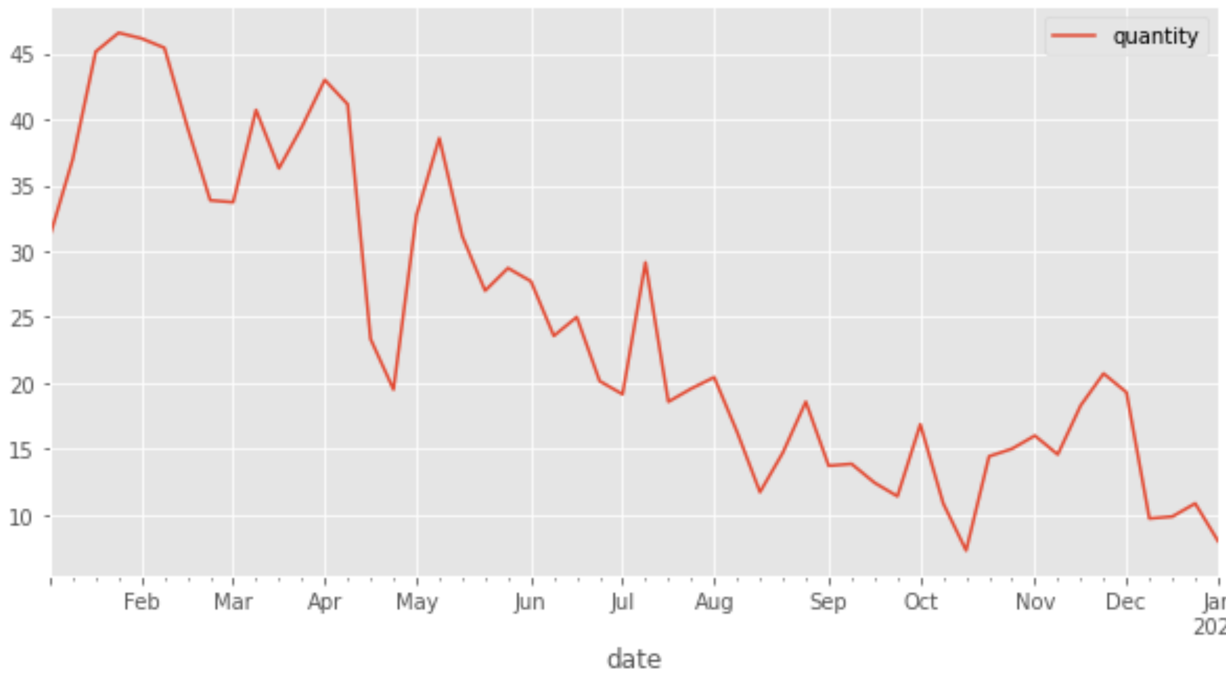


Очевидно, что количество единиц товара от 3 и более настолько редки, что их следует рассматривать, как выбросы. Оставим в датасете только те продажи, количество единиц товара в которых меньше 3.

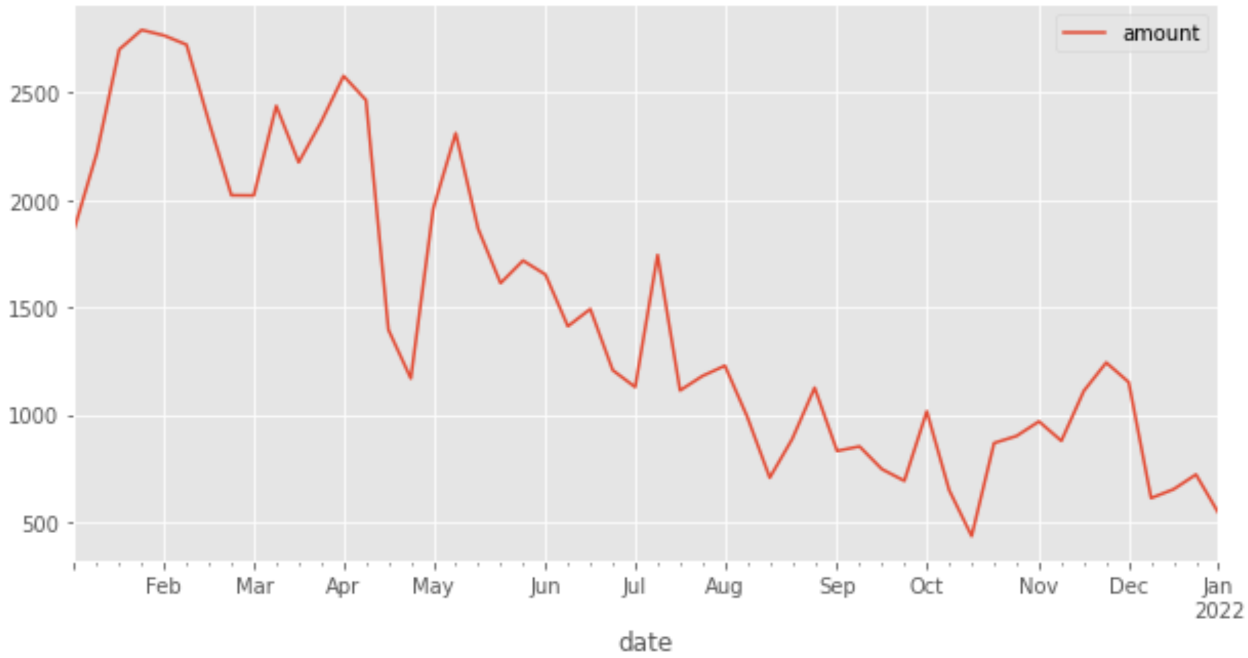
In [54]:
```
sales = sales[sales['quantity'] < 3]
```

Просуммируем количество проданных единиц товара по дням, затем ресемплируем по среднему за неделю, и построим график.

In [55]:
```
sales.pivot_table(index=('date'),\
                                   values=('quantity'), aggfunc='sum').resample('
                       .plot(grid=True, figsize=(10, 5),style='-');
```



In [56]:
```
sales.pivot_table(index=('date'),\
                              values=('amount'), aggfunc='sum')\
                              .resample('1W').mean()\
                  .plot(grid=True, figsize=(10, 5),style='-');
```



Судя по графикам очевидна зависимость между 'amount' и 'quantity'.

Таблица `stocks_on_days`

In [57]:
```
stocks_on_days.columns
```

Out[57]:
```
Index(['date', 'stock_id', 'item_id', 'start_day', 'finish_day'], dtype='ob
ject')
```

В датасете `sales` наблюдения начинаются 2021-01-04:

In [58]:
```
min(sales['date'])
```

Out[58]:
```
Timestamp('2021-01-04 00:00:00')
```

Поэтому из `stocks_on_days` мы удалим все записи до этой даты.

In [59]:
```
stocks_on_days = stocks_on_days[stocks_on_days['date'] >= '2021-01-04']
```

In [60]:
```
stocks_on_days.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 3793 entries, 467 to 4259
Data columns (total 5 columns):
 #   Column      Non-Null Count  Dtype
---  ------      --------------  -----
 0   date        3793 non-null   datetime64[ns]
 1   stock_id    3793 non-null   object
 2   item_id     3793 non-null   object
 3   start_day   3793 non-null   int64
 4   finish_day  3793 non-null   int64
dtypes: datetime64[ns](1), int64(2), object(2)
memory usage: 177.8+ KB
```

In [61]:

```
stocks_on_days.describe()
```

Out[61]:

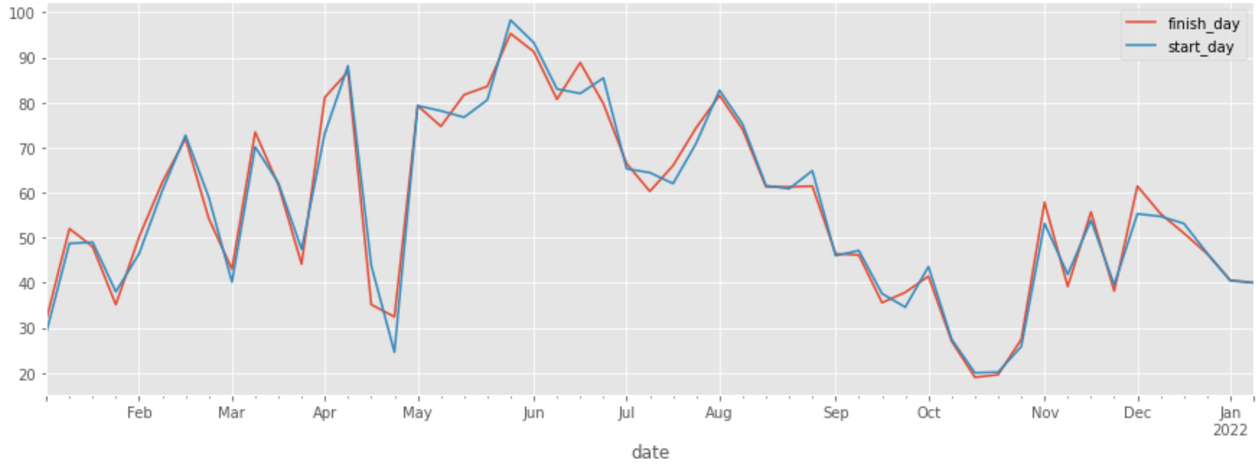
	start_day	finish_day
count	3793.000000	3793.000000
mean	5.533087	5.557342
std	5.474001	5.469993
min	-2.000000	-2.000000
25%	1.000000	1.000000
50%	4.000000	4.000000
75%	8.000000	8.000000
max	45.000000	45.000000

Мы уже отмечали, что в датасете `stocks_on_days` присутствуют записи с отрицательным балансом. В среднем на складах присутствует около 5,5 единиц товара.

Построим график количества товара в среднем за неделю.

In [62]:

```
stocks_on_days.pivot_table(index=('date'),\
                            values=('start_day', 'finish_day'), aggfunc='su
                .plot(grid=True, figsize=(15, 5),style='-');
```



Товар появляется на складах в начале января 2021, в апреле наблюдается уменьшение количества единиц товара, в июне наблюдается пик количества, к октябрю товар раскупают быстрее, чем пополняют склады. Затем количество увеличивается и колеблется в диапозоне 40-60 шт. до конца наблюдений.

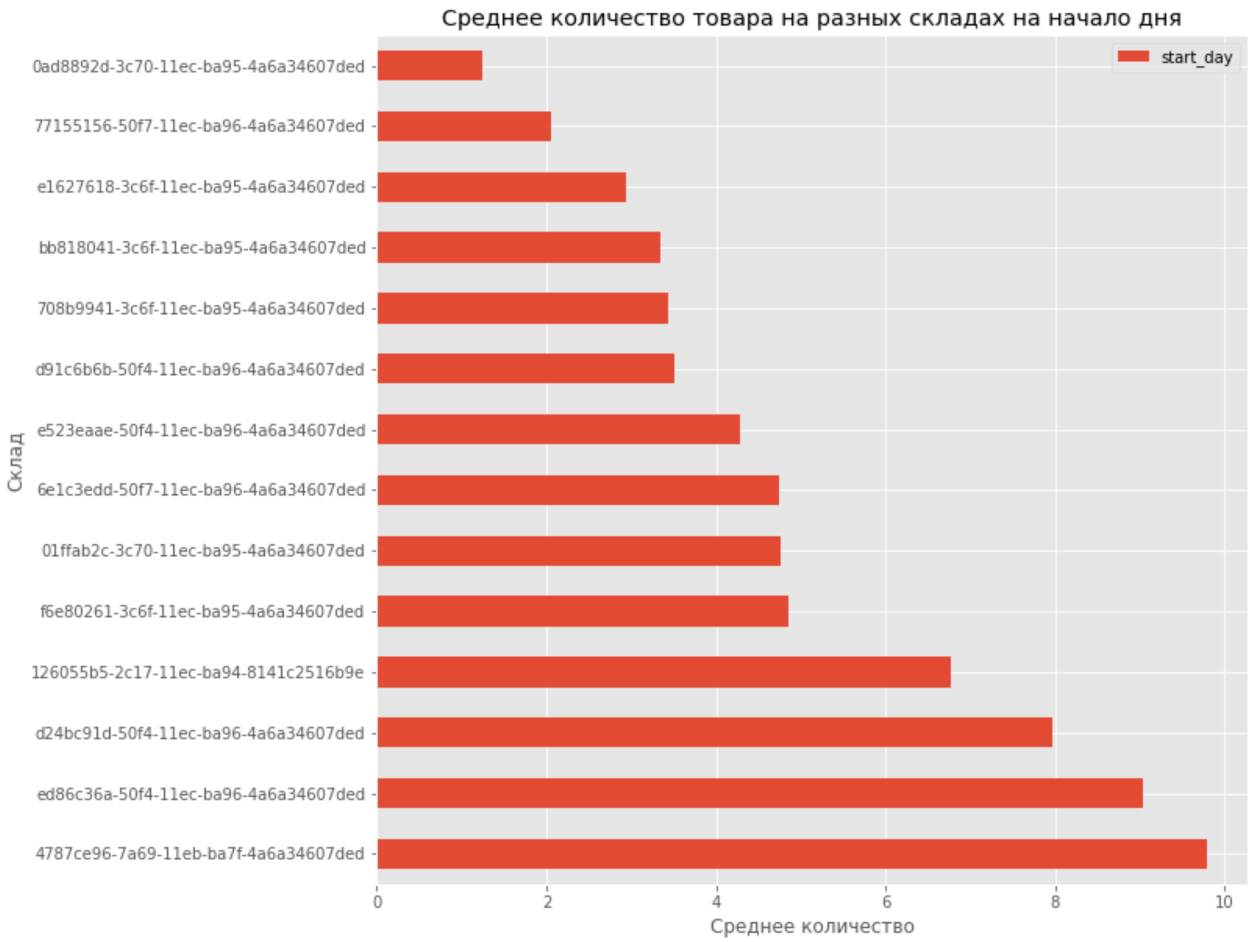
Посмотрим, какое количество товара в среднем лежит на разных складах.

In [63]:

```
# Функция строит горизонтальный бар по сводной таблице
def grouped_barh(df, index, value, aggfunc, title, xlabel, ylabel, top=50)
    df.pivot_table(index=index,\
                                values=value, aggfunc=aggfunc).sort_values
                                .head(top)\
                                .plot(kind='barh', grid=True, figsize=(10,
    plt.title(title)
    plt.xlabel(xlabel)
    plt.ylabel(ylabel)
    plt.show()
```

In [64]:

```
grouped_barh(stocks_on_days, 'stock_id', 'start_day', 'mean', \
             'Среднее количество товара на разных складах на начало дня',
```



Эта информация может косвенно говорить о том, насколько велик склад (или точка магазина), либо о популярности данного товара в разных районах/городах/регионах.

Исследовательский анализ данных

В дальнейшем мы скорее всего будем работать только с зависимостью количества продаж в день от времени. Но на данном этапе исследуем обе таблицы `sales_q` и `stocks_on_days_q` .

In [65]:

```
sales_q = sales.drop(columns=['warehouse_id', 'item_id', 'order_number', 'p
```

In [66]:

```
sales_q = sales_q.groupby('date').sum()
sales_q
```

Out[66]:

date	quantity
2021-01-04	9
2021-01-05	35
2021-01-06	30
2021-01-07	33
2021-01-08	38
...	...
2021-12-26	11
2021-12-27	7
2021-12-28	6
2021-12-29	11
2021-12-30	8

353 rows × 1 columns

In [67]:

```
stocks_on_days.groupby('date').sum()
```

Out[67]:

date	start_day	finish_day
2021-01-04	0	20
2021-01-05	20	45
2021-01-06	45	23
2021-01-07	23	47
2021-01-08	47	20
...	...	...
2022-01-05	40	40
2022-01-06	40	40
2022-01-07	40	40
2022-01-08	40	40
2022-01-09	40	40

371 rows × 2 columns

Так как графики 'start_day', 'finish_day' в `stocks_on_days` похожи, оставим для анализа только 'finish_day'. Таким образом мы получим информацию о количестве единиц товара, оставшихся на складах после завершения продаж (и поставок) в этот же день. Если бы мы оставили 'start_day', это бы по сути соответствовала результату продаж на предыдущий день.

In [68]:
```
stocks_on_days_q = stocks_on_days.drop(columns=['stock_id', 'item_id', 'sta
```

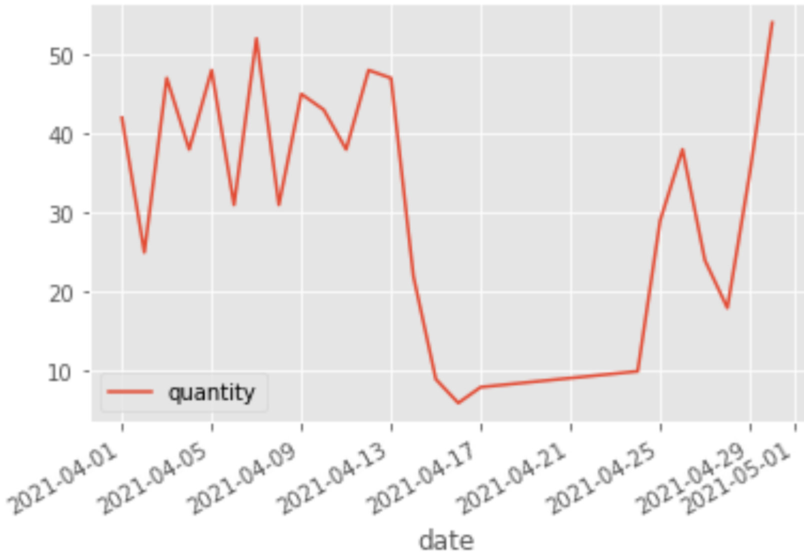
In [69]:
```
stocks_on_days_q = stocks_on_days_q.groupby('date').sum()
stocks_on_days_q
```

Out[69]:

	finish_day
date	
2021-01-04	20
2021-01-05	45
2021-01-06	23
2021-01-07	47
2021-01-08	20
...	...
2022-01-05	40
2022-01-06	40
2022-01-07	40
2022-01-08	40
2022-01-09	40

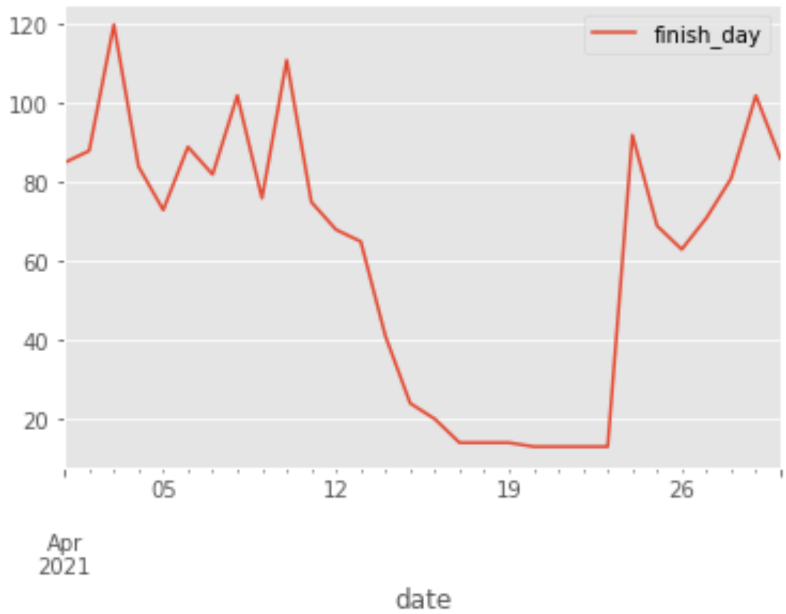
371 rows × 1 columns

In [70]:
```
sales_q.loc['2021-04'].plot();
```



In [71]:

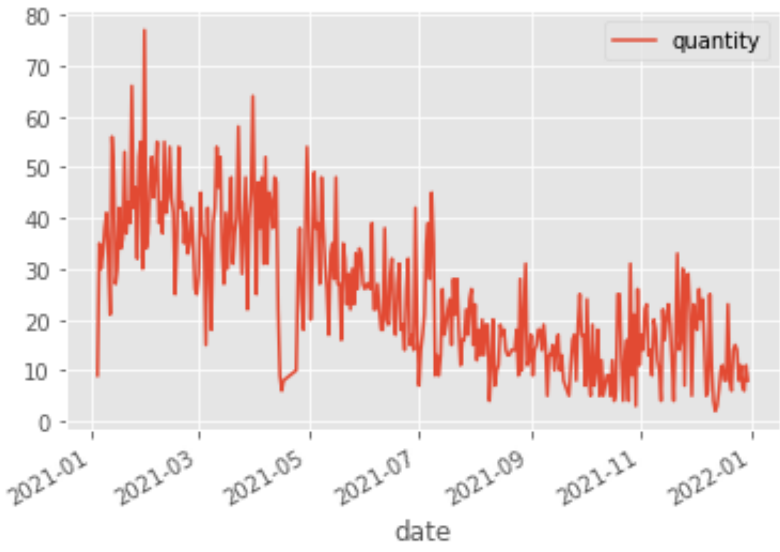
```
stocks_on_days_q.loc['2021-04'].plot();
```



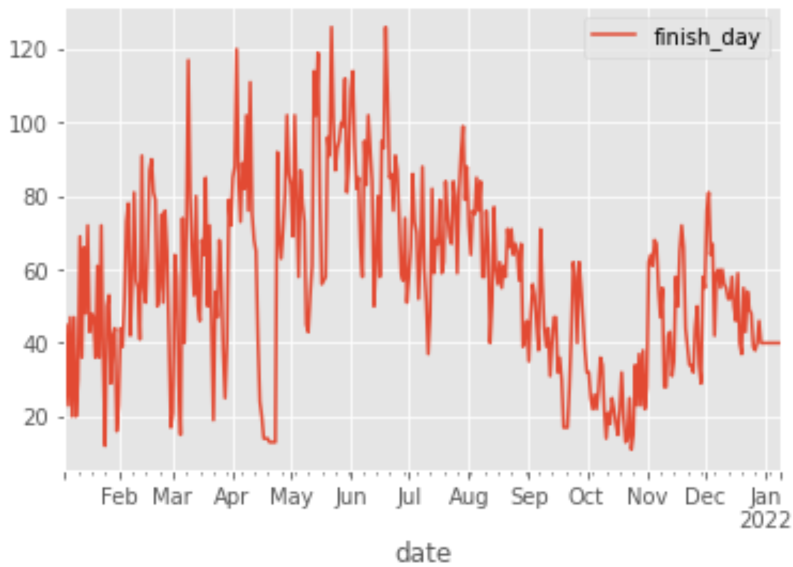
Можно предположить, что снижение количества продаж в апреле было связано с проблемами с поставками на склады.

In [72]:

```
sales_q.plot();
```



In [73]:
```
stocks_on_days_q.plot();
```



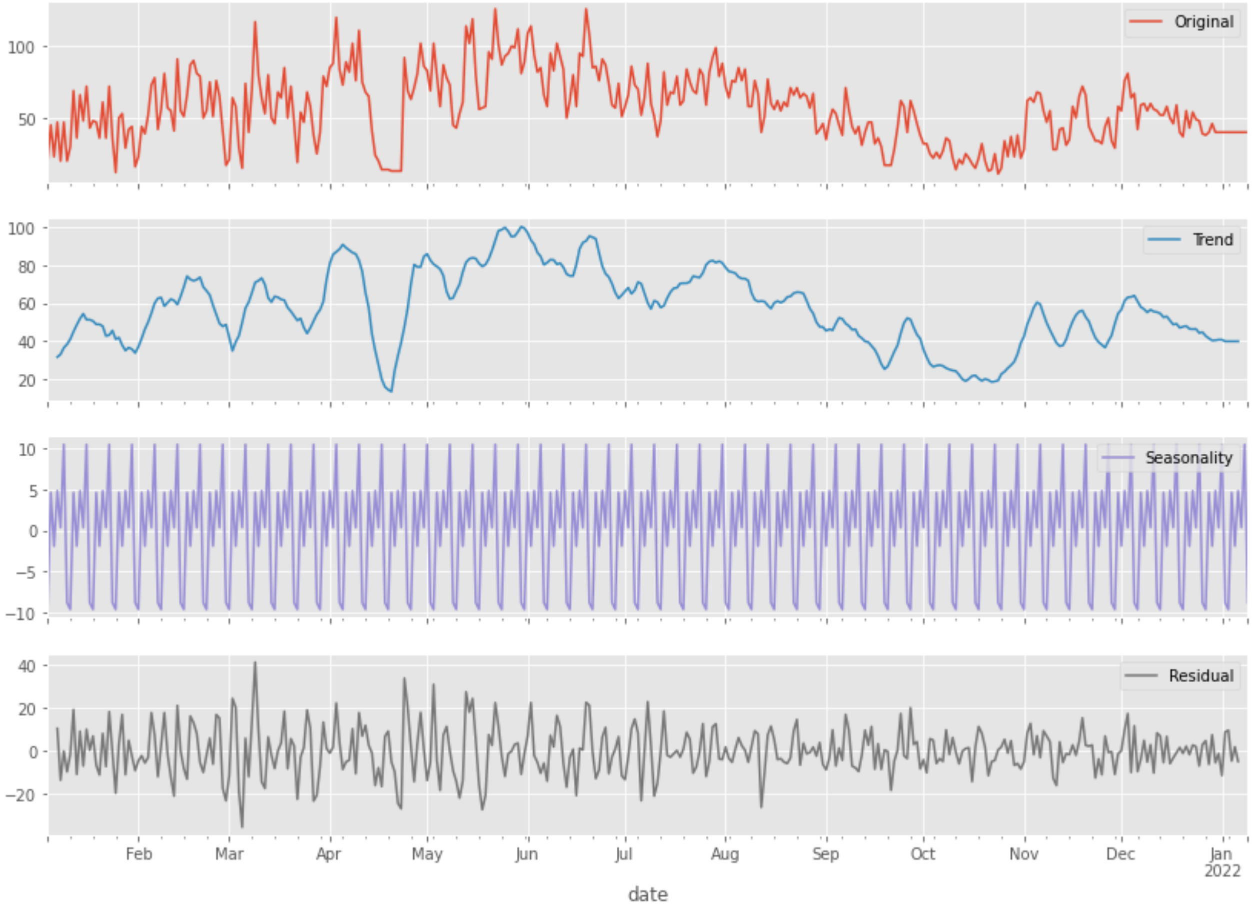
Итак, у нас есть два временных ряда, но если попытаться разложить один из них (`sales_q`) на аддитивные компоненты, то возникает ошибка: ValueError: You must specify a period or x must be a pandas object with a DatetimeIndex with a freq not set to None.

Эту ошибку можно легко устранить, вручную задав частоту сезонной составляющей. Логично предположить, что когда работаешь с датасетом продаж, обычно должна присутствовать недельная сезонность. Попробуем сначала разложить на аддитивные компоненты временной ряд `stocks_on_days_q` .

In [74]:
```
stocks_on_days_q = stocks_on_days_q.squeeze().dropna()
```

In [75]:
```
components_sod = tsa.seasonal_decompose(stocks_on_days_q, model='additive'
```

In [76]:
```
stocks_on_days_ts = (stocks_on_days_q.to_frame('Original')
       .assign(Trend=components_sod.trend)
       .assign(Seasonality=components_sod.seasonal)
       .assign(Residual=components_sod.resid))
stocks_on_days_ts.plot(subplots=True, figsize=(14, 10));
```



Код выполнился без ошибок и задания периода вручную. Посмотрим на первые несколько значений сезонной составляющей, чтобы оценить период.

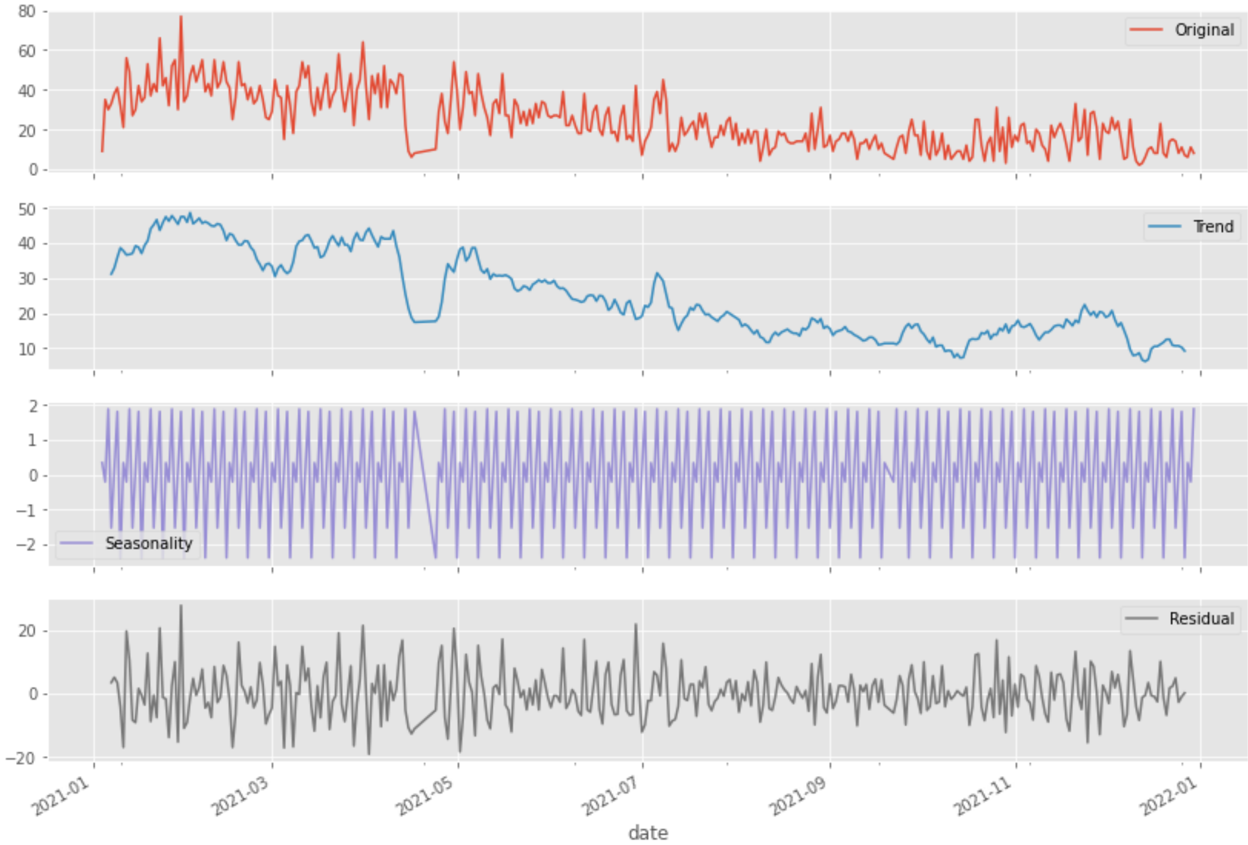
In [77]:
```
components_sod.seasonal.head(22)
```

Out[77]:
```
date
2021-01-04    -9.618561
2021-01-05     4.634186
2021-01-06    -1.904276
2021-01-07     4.837742
2021-01-08     0.356713
2021-01-09    10.485834
2021-01-10    -8.791638
2021-01-11    -9.618561
2021-01-12     4.634186
2021-01-13    -1.904276
2021-01-14     4.837742
2021-01-15     0.356713
2021-01-16    10.485834
2021-01-17    -8.791638
2021-01-18    -9.618561
2021-01-19     4.634186
2021-01-20    -1.904276
2021-01-21     4.837742
2021-01-22     0.356713
2021-01-23    10.485834
2021-01-24    -8.791638
2021-01-25    -9.618561
Name: seasonal, dtype: float64
```

Очевидно, период равен 7. Теперь вручную зададим период для временного ряда количества продаж.

In [78]:
```
sales_q = sales_q.squeeze().dropna()
```

In [79]:
```
components_s = tsa.seasonal_decompose(sales_q, model='additive', period = 
sales_ts = (sales_q.to_frame('Original')
       .assign(Trend=components_s.trend)
       .assign(Seasonality=components_s.seasonal)
       .assign(Residual=components_s.resid))
sales_ts.plot(subplots=True, figsize=(14, 10));
```



Понятно, что эти ряды не стационарны, т.к. присутствуют и тренд, и сезонность. Убедимся в этом, проведя тест Дикки-Фуллера.

In [80]:
```
def DF_test(series):
    """
    Расширенный тест Дикки-Фуллера (augmented Dickey-Fuller), ADF
    H0 - образец временного ряда имеет единичный корень
    H1 - образец временного ряда не имеет единичных корней, ряд стационаре
    """
    X = series.values
    result = adfuller(X)
    print('ADF Statistic: %f' % result[0])
    print('p-value: %f' % result[1])
    print('Critical Values:')
    for key, value in result[4].items():
        print('\t%s: %.3f' % (key, value))
    if result[0]> result[4]['5%']:
        print('есть единичные корни, ряд не стационарен')
    else:
        print('единичных корней нет, ряд стационарен')
```

In [81]:
```
DF_test(stocks_on_days_q)
```

```
ADF Statistic: -2.187185
p-value: 0.210929
Critical Values:
	1%: -3.449
	5%: -2.870
	10%: -2.571
есть единичные корни, ряд не стационарен
```

In [82]:
```
DF_test(sales_q)
```

```
ADF Statistic: -1.586683
p-value: 0.490280
Critical Values:
	1%: -3.450
	5%: -2.870
	10%: -2.571
есть единичные корни, ряд не стационарен
```

Для того, чтобы построить прогноз, нам нужно удовлетворить допущение о стационарности линейных моделей временных рядов. Воспользуемся общепринятыми преобразованиями.

Сначала применим логарифм (натуральный) к временным рядам для конвертирования регулярности экспоненциального роста в линейный тренд и стабилизации дисперсии.

In [83]:
```
# проверка на нулевые значения
(sales_q == 0).any(), (stocks_on_days_q == 0).any()
```

Out[83]:
```
(False, False)
```

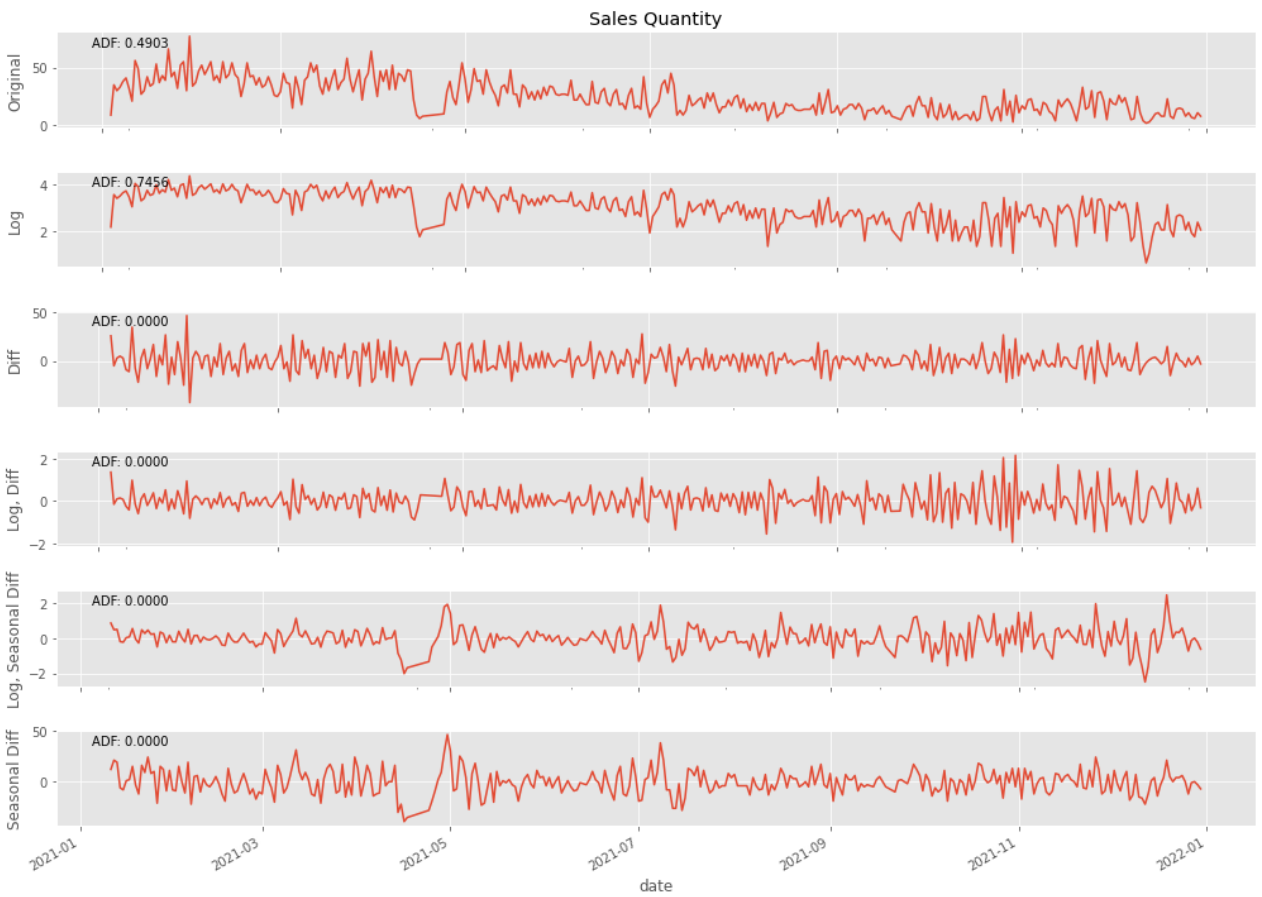
In [84]:
```
sales_log = np.log(sales_q)
stocks_on_days_log = np.log(stocks_on_days_q)
```

Во многих случаях для того, чтобы сделать ряд стационарным, детрендирования не достаточно. Вместо этого нам нужно преобразовать исходные данные во временной ряд попериодных и/или посезонных разниц. Другими словами, мы используем результат вычитания соседних точек данных или значений в сезонных сдвигах друг из друга.

In [85]:
```
sales_diff = sales_q.diff().dropna() # первые разности
sales_log_diff = sales_log.diff().dropna() # первые разности из логарифма
sales_log_diff_s = sales_log.diff(7).dropna() # сезонные разности из логари
sales_diff_s = sales_q.diff(7).dropna() # сезонные разности

stocks_on_days_diff = stocks_on_days_q.diff().dropna() # первые разности
stocks_on_days_log_diff = stocks_on_days_log.diff().dropna() # первые разно
stocks_on_days_log_diff_s = stocks_on_days_log.diff(7).dropna() # сезонные
```

Изобразим на графике сразу несколько вариантов преобразований.

In [86]:
```
fig, axes = plt.subplots(nrows=6, ncols=1, figsize=(14,10))

sales_q.plot(ax=axes[0], title='Sales Quantity')
axes[0].text(x=.03, y=.85, s=f'ADF: {tsa.adfuller(sales_q.dropna())[1]:.4f]
axes[0].set_ylabel('Original')

sales_log.plot(ax=axes[1], sharex=axes[0])
axes[1].text(x=.03, y=.85, s=f'ADF: {tsa.adfuller(sales_log.dropna())[1]:.4
axes[1].set_ylabel('Log')

sales_diff.plot(ax=axes[2], sharex=axes[0])
axes[2].text(x=.03, y=.85, s=f'ADF: {tsa.adfuller(sales_diff.dropna())[1]:
axes[2].set_ylabel('Diff')

sales_log_diff.plot(ax=axes[3], sharex=axes[0])
axes[3].text(x=.03, y=.85, s=f'ADF: {tsa.adfuller(sales_log_diff.dropna())
axes[3].set_ylabel('Log, Diff')

sales_log_diff_s.plot(ax=axes[4], sharex=axes[0])
axes[4].text(x=.03, y=.85, s=f'ADF: {tsa.adfuller(sales_log_diff_s.dropna(
axes[4].set_ylabel('Log, Seasonal Diff')

sales_diff_s.plot(ax=axes[5], sharex=axes[0])
axes[5].text(x=.03, y=.85, s=f'ADF: {tsa.adfuller(sales_diff_s.dropna())[1
axes[5].set_ylabel('Seasonal Diff')

#stocks_on_days_q.plot(ax=axes[0][1], title='Stocks on Days Quantity')
#axes[0][1].text(x=.03, y=.85, s=f'ADF: {tsa.adfuller(stocks_on_days_q)[1]
#axes[0][1].set_ylabel('Original')
#
#stocks_on_days_log.plot(ax=axes[1][1], sharex=axes[0][1])
#axes[1][1].text(x=.03, y=.85, s=f'ADF: {tsa.adfuller(stocks_on_days_log.d
#axes[1][1].set_ylabel('Log')
#
#stocks_on_days_diff.plot(ax=axes[2][1], sharex=axes[0][1])
#axes[2][1].text(x=.83, y=.85, s=f'ADF: {tsa.adfuller(stocks_on_days_diff.
#axes[2][1].set_ylabel('Diff')
#
#stocks_on_days_log_diff.plot(ax=axes[3][1], sharex=axes[0][1])
#axes[3][1].text(x=.03, y=.85, s=f'ADF: {tsa.adfuller(sales_log_diff.dropna
#axes[3][1].set_ylabel('Log, Diff')
#
#stocks_on_days_log_diff_s.plot(ax=axes[4][1], sharex=axes[0][1])
#axes[4][1].text(x=.03, y=.85, s=f'ADF: {tsa.adfuller(stocks_on_days_log_d
#axes[4][1].set_ylabel('Log, Seasonal Diff')

fig.tight_layout()
fig.align_ylabels(axes);
```



Остановимся на варианте "Diff". Ещё раз проведём тест Дикки-Фуллера.

In [87]:
```
DF_test(sales_diff)
```

```
ADF Statistic: -10.756183
p-value: 0.000000
Critical Values:
	1%: -3.450
	5%: -2.870
	10%: -2.571
единичных корней нет, ряд стационарен
```

Мы убедились, что наш ряд стационарен. Построим графики Q-Q и коррелограммы.

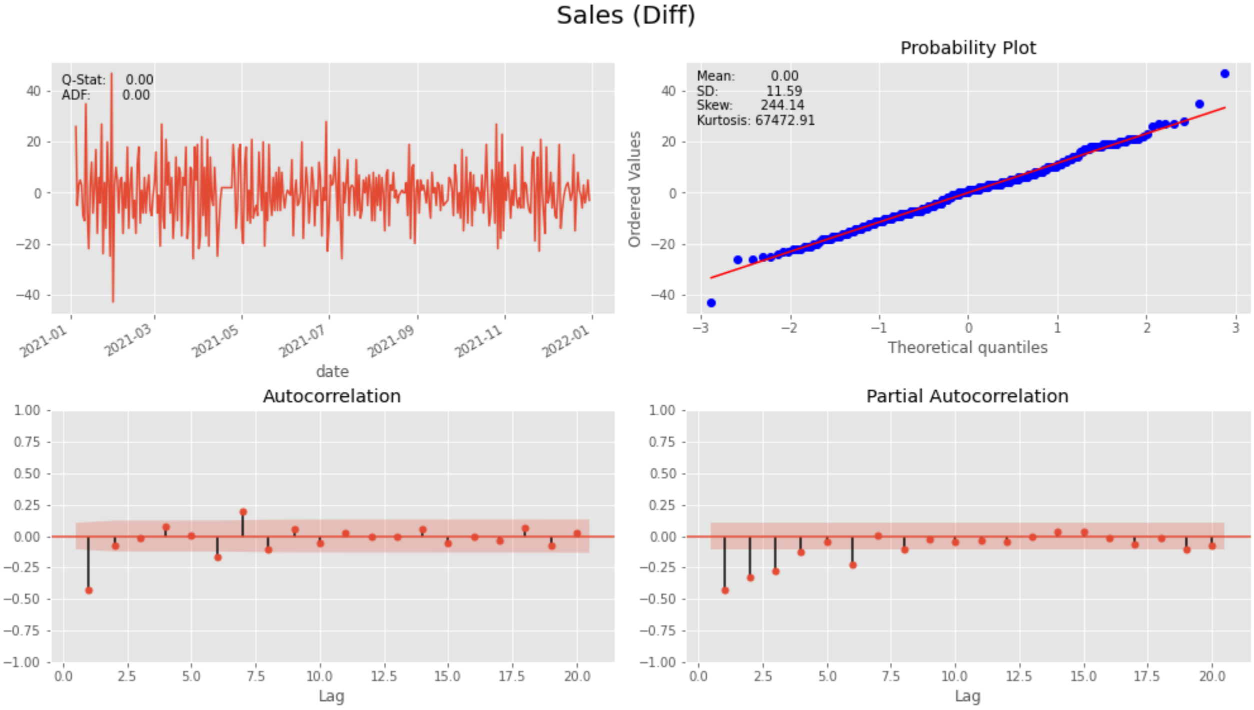
In [88]:

```
def plot_correlogram(x, lags=None, title=None):
    """
    Строит Q-Q plot (от нормального распределения) и коррелограммы.
    Выводит некоторые статистики:
    Q-Stat: статистический показатель Льюнга-Бокса
    ADF: p-value расширенной проверки Дикки-Фуллера
    Mean: среднее
    SD: стандартное отклонение
    Skew: коэффициент асимметрии
    Kurtosis: эксцесс
    """
    lags = min(10, int(len(x)/5)) if lags is None else lags
    fig, axes = plt.subplots(nrows=2, ncols=2, figsize=(14, 8))
    x.plot(ax=axes[0][0])
    q_p = np.max(q_stat(acf(x, nlags=lags), len(x))[1])
    stats = f'Q-Stat: {np.max(q_p):>8.2f}\nADF: {adfuller(x)[1]:>11.2f}'
    axes[0][0].text(x=.02, y=.85, s=stats, transform=axes[0][0].transAxes)
    probplot(x, dist='norm', plot=axes[0][1])
    """
    Skew - https://ru.wikipedia.org/wiki/Коэффициент_асимметрии
    Kurtosis - https://ru.wikipedia.org/wiki/Коэффициент_эксцесса
    """
    mean, var, skew, kurtosis = moment(x, moment=[1, 2, 3, 4])
    s = f'Mean: {mean:>12.2f}\nSD: {np.sqrt(var):>16.2f}\nSkew: {skew:12.2
    axes[0][1].text(x=.02, y=.75, s=s, transform=axes[0][1].transAxes)
    plot_acf(x=x, lags=lags, zero=False, ax=axes[1][0])
    plot_pacf(x, lags=lags, zero=False, ax=axes[1][1])
    axes[1][0].set_xlabel('Lag')
    axes[1][1].set_xlabel('Lag')
    fig.suptitle(title, fontsize=20)
    fig.tight_layout()
    fig.subplots_adjust(top=.9)
```

In [89]:

```
plot_correlogram(sales_diff, lags=20, title='Sales (Diff)')
```

```
/usr/local/lib/python3.7/dist-packages/statsmodels/graphics/tsaplots.py:353
: FutureWarning: The default method 'yw' can produce PACF values outside of
the [-1,1] interval. After 0.13, the default will change tounadjusted Yule-
Walker ('ywm'). You can use this method now by setting method='ywm'.
  FutureWarning,
```



Мы видим, что точки на графике Q-Q Plot стелятся вдоль прямой, соответствующей нормальному распределению. То есть можем сделать вывод о том, что наши данные неплохо соответствуют теоретическим квантилям, отложенным по горизонтальной оси. Хвосты нашего распределения уходят в разные стороны от прямой на графике Q-Q, что говорит о более толстых хвостах нашего распределения по сравнению с нормальным.

Так как перед нами стоит задача прогнозирования продаж на неделю (или 7 дней) вперёд без каких-либо ещё вводных данных (например, известного количества товара, предполагаемого к поставке на определённый день), нам нужно строить модель, для которой на первый день из прогнозируемой недели будут все данные, необходимые для пргноза. Поэтому мы будем строить одномерную модель, то есть модель, целиком зависящую от значений продаж в прошлом.

Модель SARIMAX

Воспользуемся моделью SARIMA, построенной для ряда первых разностей. SARIMA(p,d,q)(P,D,Q,s) - Seasonal Autoregression Moving Average model. Итак, чтобы построить модель нам нужно определить следующие параметры:

1. Порядок (order)
   - p — порядок авторегрессии тренда
   - d — порядок разности тренда
   - q — порядок скользящей средней тренда
2. Сезонный порядок(seasonal_order)
   - P — порядок авторегрессии для сезонного компонента
   - D — порядок разности ряда для сезонного компонента
   - Q — порядок скользящей средней для сезонного компонента
   - s — количество временных шагов за один сезонный период

Есть различные способы определения коэффициентов. Можно пользоваться правилами подбора коэффициентов в зависимости от значимых лагов, а можно сделать подобие своего собственного Grid Search для подбора гиперпараметров.

Разработка Grid Search для модели SARIMAX

Для моделирования будем использовать модель SARIMA из библиотеки statsmodels

Эта модель имеет следующие гиперпараметры:

1. order: кортеж p, d и q для моделирования тренда.
2. sesonal_order: кортеж параметров P, D, Q и m для моделирования сезонности
3. trend: параметр для управления моделью, принимающий одно из следующих значений:
   - 'n' - no trend,
   - 'c - constant,
   - 't' - linear trend,
   - 'ct' - constant with linear trend

Начнём с того, что определим функцию, которая будет принимать на вход конфигурацию модели и делать прогноз на один шаг вперёд.

In [245…

```
# SARIMA-прогноз на шаг вперёд
def sarima_forecast(history, config, plot_diagnostics=False):
    # определяем конфигурацию модели: [(p, d, q), (P, D, Q, s), 'n']
    order, sorder, trend = config
    # определяем модель
    model = tsa.statespace.SARIMAX(history,
                    order=order,
                    seasonal_order=sorder,
                    trend=trend,
                    enforce_stationarity=False,
                    enforce_invertibility=False)
    # обучаем модель
    model_fit = model.fit(disp=False)
    # делаем прогноз на шаг вперед
    prediction = model_fit.predict(len(history), # номер с которого начина
                                   len(history) # до какого номера предска
                                  )
    if plot_diagnostics:
        model_fit.plot_diagnostics(figsize=(15, 12)) # диагностика остатко
    else:
        return prediction[0]
```

Теперь напишем функции для реализации walk-forward валидации.

Сначала напишем свою функцию разбиения `series_train_test_split()` . В качестве параметров будем использовать список или массив данных временного ряда, а в качестве метки разбиения будем указывать количество шагов с конца временного ряда, которое отведём под тестовый набор.

In [246…

```
# разбиваем датасет на train и test наборы
def series_train_test_split(data, n_test):
    """
    Функция разделяет список или массив на тренировочный и тестовый наборы
    n_test - количество временных шагов с конца, используемых в тестовом (
    """
    return data[:-n_test], data[-n_test:]
```

In [247…

```
# проверка
series_train_test_split(sales_diff.head(8), 3)
```

Out[247…

```
(date
 2021-01-05    26.0
 2021-01-06    -5.0
 2021-01-07     3.0
 2021-01-08     5.0
 2021-01-09     3.0
 Name: quantity, dtype: float64, date
 2021-01-10    -9.0
 2021-01-11   -11.0
 2021-01-12    35.0
 Name: quantity, dtype: float64)
```

Будем использовать RMSE как метрику качества.

In [248…

```
def rmse(y_true,y_pred):
    rmse = mean_squared_error(y_true, y_pred)**(0.5)
    return rmse
```

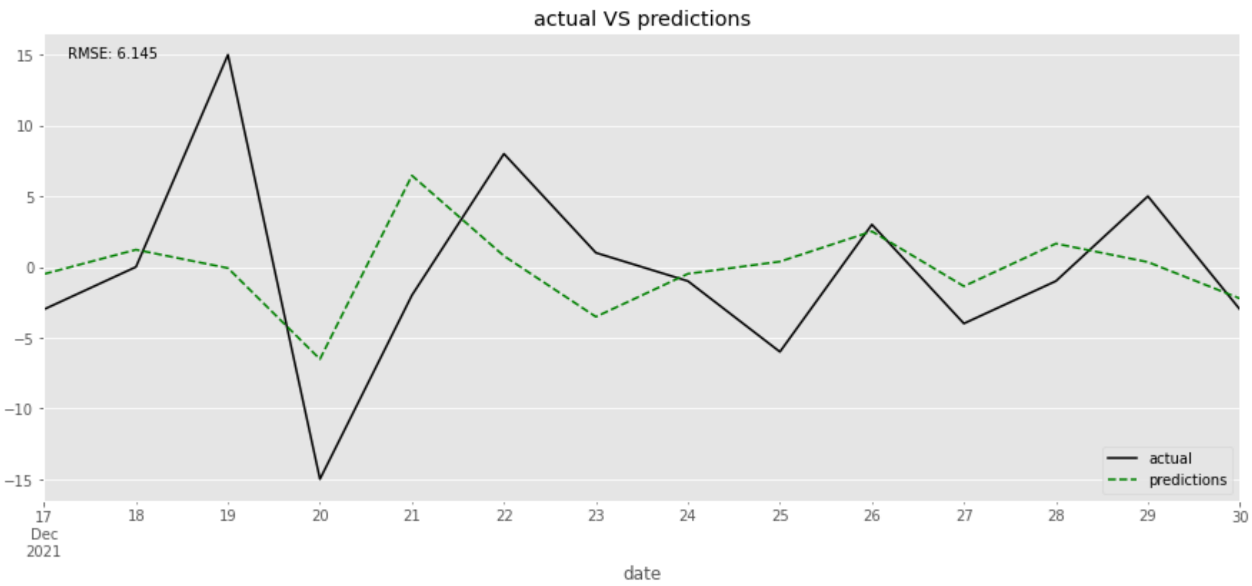
Теперь реализуем walk-forward валидацию.

In [249…

```
# walk-forward validation
def walk_forward_validation(data, # наш временной ряд
                            n_test, # количество шагов с конца data, с кото
                            model_forecast, # имя функции прогноза
                            config, # конфигурация модели SARIMA
                            plot=False, # можем построить график сравнения
                            plot_resid=False # графики остатков
                           ):
    predictions = list()
    # разделяем датасет
    train, test = series_train_test_split(data, n_test)
    # помещаем train в список исторических данных history
    history = [x for x in train]
    # проходимся по каждому из значений в тестовом наборе
    for i in range(len(test)):
        # обучаем модель на исторических данных и делаем прогноз на шаг вп
        #prediction = sarima_forecast(history, config)
        prediction = model_forecast(history, config)
        # сохраняем предсказание в список предсказаний
        predictions.append(prediction)
        # действительное значение помещаем в историю для следующего цикла
        history.append(test[i])
    # вычисляем ошибку предсказания сравнивая все одношаговые предсказания
    error = rmse(test, predictions)
    #print(len(predictions))
    #print(len(test))
    #print(len(train))
    #print(len(history))
    if plot:
        # график для визуального сравнения предсказанных значений с действ
        # (по умолчанию не строим)
        plot_result(n_test, error, test, predictions)
    if plot_resid:
        # график остатков
        model_forecast(test.asfreq('D'), config, True)
    else:
        # по умолчанию возвращаем интересующую метрику качества
        return error
```

In [95]:
```
# график для визуальной оценки
def plot_result(n_test, error, test, predictions):
    """
    Строит график сравнения предсказанных на каждом шаге
    значений с действительными значениями
    """
    test = pd.DataFrame(test.values, index=sales_diff.tail(n_test).index, c
    predictions = pd.DataFrame(predictions, index=sales_diff.tail(n_test).i
    ax = test.plot(figsize=(15,6), color='black', title='actual VS predicti
    metric = f'RMSE: {error:>.3f}'
    ax.text(x=.02, y=.95, s=metric, transform=ax.transAxes)
    predictions.plot(ax=ax, style='--', color='green')
    ax.legend(loc='lower right')
    plt.show();
```

In [250…
```
# проверка работы функции
walk_forward_validation(sales_diff, 14, sarima_forecast, [(1, 1, 1), (0, 0
```



Out[250…
```
6.145343339369119
```

Мы можем неоднократно вызывать `walk_forward_validation()` с различными списками конфигураций моделей.

Одна из возможных проблем заключается в том, что некоторые комбинации конфигураций модели могут не вызываться для модели и выдавать исключение, например, указывая некоторые, но не все аспекты сезонной структуры в данных.

Мы можем ловить исключения и игнорировать предупреждения во время поиска в сетке, обернув все вызовы walk_forward_validation() try-except блоком для игнорирования предупреждений. Мы также можем добавить поддержку отладки, чтобы отключить эти средства защиты в случае, если мы хотим увидеть, что на самом деле происходит. Наконец, если ошибка все же возникает, мы можем вернуть результат None, в противном случае мы сможем напечатать некоторую информацию о каждой оцениваемой модели. Это полезно при оценке большого количества моделей.

Функция score_model() ниже реализует это и возвращает кортеж (ключ и результат), где ключ является строковой версией протестированной конфигурации модели.

In [251…

```
# оцениваем модель возвращаем None при возникновении ошибки
def score_model(data, n_test, config, debug=False):
    result = None
    # конвертируем конфигурацию в строковый ключ
    key = str(config)
    # показываем все предупреждения, если debug=True
    if debug:
        result = walk_forward_validation(data, n_test, sarima_forecast, co
    else:
        # сбой во время проверки модели предполагает нестабильную конфигур
        try:
            # во время поиска по сетке не показываем предупреждения
            with catch_warnings():
                filterwarnings("ignore")
                result = walk_forward_validation(data, n_test, sarima_fore
        except:
            error = None
    # проверяем на наличие интересующего результата
    if result is not None:
        print(' > Model[%s] %.3f' % (key, result))
    return (key, result)
```

In [252…

```
# проверка
score_model(sales_diff, 8, [(4, 1, 1), (0, 0, 0, 0), 'n'], debug=False)[1]
```

```
 > Model[[(4, 1, 1), (0, 0, 0, 0), 'n']] 3.004
```

Out[252…

```
3.0040426776882403
```

Далее нам нужен цикл для тестирования списка различных конфигураций моделей.

Это основная функция, которая управляет процессом поиска по сетке и вызывает функцию `score_model()` для каждой конфигурации модели.

Мы можем значительно ускорить процесс поиска по сетке, параллельно оценивая конфигурации моделей. Один из способов сделать это - использовать библиотеку Joblib.

Мы можем определить параллельный объект с количеством используемых ядер и установить его на количество ядер, обнаруженных в оборудовании.

In [99]:
```
from multiprocessing import cpu_count
from joblib import Parallel
from joblib import delayed
from warnings import catch_warnings
from warnings import filterwarnings
```

In [253…
```
def grid_search(data,
                config_list, # список всех конфигураций
                n_test,
                parallel=False):
    scores = None
    if parallel:
        # определяем количество используемых ядер
        executor = Parallel(n_jobs=cpu_count(), backend='multiprocessing')
        print(executor)
        # создаём список задач для параллельного выполнения
        tasks = (delayed(score_model)(data, n_test, config) for config in c
        print(tasks)
        # передаём задачи в executor
        scores = executor(tasks)
    else:
        scores = [score_model(data, n_test, config) for config in config_l
    # удаляем пустые результаты
    scores = [r for r in scores if r[1] != None]
    # сортируем кортежи в списке по баллу в порядке возрастания (сначала л
    scores.sort(key=lambda tup: tup[1])
    return scores
```

In [101…
```
# проверка
grid_search(sales_diff, [[(1, 0, 0), (0, 0, 0, 0), 'n'], [(1, 0, 0), (0, 5
```

```
> Model[[(1, 0, 0), (0, 0, 0, 0), 'n']] 3.342
```

Out[101…
```
[("[(1, 0, 0), (0, 0, 0, 0), 'n']", 3.342422124758878)]
```

Осталось только определить список конфигураций модели, которые можно попробовать для набора данных. Мы можем определить его в общем виде. Единственный параметр, который мы, возможно, захотим указать, это периодичность сезонного компонента в серии, если таковой существует. По умолчанию мы не будем считать сезонных компонентов.

Функция `sarima_configs()` ниже создаст список конфигураций моделей для оценки.

Конфигурации предполагают, что каждый из компонентов AR, MA и I для тренда и сезонности имеет низкий порядок, например, выключен (0) или в [1,2].

Теоретически, существует 2880 возможных конфигураций модели для оценки, но на практике многие из них не будут действительными и приведут к ошибке, которую мы поймаем и проигнорируем.

In [242…

```
# задаем конфигурации sarima
def sarima_configs(seasonal=[0]):
    models = list()
    # определяем параметры
    p_params = [1, 2, 3, 4]
    d_params = [0, 1]
    q_params = [0, 1, 2]
    t_params = ['n','c','t','ct']
    P__params = [0, 1, 2, 3, 4]
    D__params = [0, 1]
    Q__params = [0, 1, 2]
    s_params = seasonal
    # сохраняем в список
    for p in p_params:
        for d in d_params:
            for q in q_params:
                for t in t_params:
                    for P_ in P__params:
                        for D_ in D__params:
                            for Q_ in Q__params:
                                for s in s_params:
                                    config = [(p,d,q), (P_,D_,Q_,s), t]
                                    models.append(config)
    return models
```

In [243…

```
len(sarima_configs())
```

Out[243… 2880

Выбор лучшей конфигурации для модели SARIMAX

Теперь у нас есть структура для поиска гиперпараметров модели SARIMA.

Он является универсальным и будет работать для любых одномерных временных рядов, предоставленных в виде списка или массива NumPy.

In [254…

```
%%time
if __name__ == '__main__':
    # загружаем датасет
    print('Всего объектов в ряде:', sales_diff.shape[0])
    # размер выборки для walk-forward валидации
    n_test = round(len(sales_diff)*0.2)
    print('Объектов в тестовой выборке:', n_test)
    # конфигурация модели
    config_list = sarima_configs()
    # grid search
    scores = grid_search(sales_diff, config_list, n_test)
    print('Лучшие модели:')
    # топ-3 конфигурации
    for config, error in scores[:3]:
        print(config, error)
```

```
Всего объектов в ряде: 352
Объектов в тестовой выборке: 70
 > Model[[(1, 0, 0), (0, 0, 0, 0), 'n']] 9.134
 > Model[[(1, 0, 0), (0, 0, 0, 0), 'c']] 9.148
 > Model[[(1, 0, 0), (0, 0, 0, 0), 't']] 9.177
 > Model[[(1, 0, 0), (0, 0, 0, 0), 'ct']] 9.192
 > Model[[(1, 0, 1), (0, 0, 0, 0), 'n']] 7.828
 > Model[[(1, 0, 1), (0, 0, 0, 0), 'c']] 8.311
 > Model[[(1, 0, 1), (0, 0, 0, 0), 't']] 8.055
 > Model[[(1, 0, 1), (0, 0, 0, 0), 'ct']] 8.412
 > Model[[(1, 0, 2), (0, 0, 0, 0), 'n']] 8.243
 > Model[[(1, 0, 2), (0, 0, 0, 0), 'c']] 8.478
 > Model[[(1, 0, 2), (0, 0, 0, 0), 't']] 8.369
 > Model[[(1, 0, 2), (0, 0, 0, 0), 'ct']] 8.527
 > Model[[(1, 1, 0), (0, 0, 0, 0), 'n']] 13.599
 > Model[[(1, 1, 0), (0, 0, 0, 0), 'c']] 13.622
 > Model[[(1, 1, 0), (0, 0, 0, 0), 't']] 13.666
 > Model[[(1, 1, 0), (0, 0, 0, 0), 'ct']] 13.687
 > Model[[(1, 1, 1), (0, 0, 0, 0), 'n']] 9.146
 > Model[[(1, 1, 1), (0, 0, 0, 0), 'c']] 9.190
 > Model[[(1, 1, 1), (0, 0, 0, 0), 't']] 9.441
 > Model[[(1, 1, 1), (0, 0, 0, 0), 'ct']] 9.431
 > Model[[(1, 1, 2), (0, 0, 0, 0), 'n']] 8.263
 > Model[[(1, 1, 2), (0, 0, 0, 0), 'c']] 8.172
 > Model[[(1, 1, 2), (0, 0, 0, 0), 't']] 9.201
 > Model[[(1, 1, 2), (0, 0, 0, 0), 'ct']] 9.431
 > Model[[(2, 0, 0), (0, 0, 0, 0), 'n']] 8.749
 > Model[[(2, 0, 0), (0, 0, 0, 0), 'c']] 8.761
 > Model[[(2, 0, 0), (0, 0, 0, 0), 't']] 8.787
 > Model[[(2, 0, 0), (0, 0, 0, 0), 'ct']] 8.802
 > Model[[(2, 0, 1), (0, 0, 0, 0), 'n']] 7.837
 > Model[[(2, 0, 1), (0, 0, 0, 0), 'c']] 8.372
 > Model[[(2, 0, 1), (0, 0, 0, 0), 't']] 8.144
 > Model[[(2, 0, 1), (0, 0, 0, 0), 'ct']] 8.373
 > Model[[(2, 0, 2), (0, 0, 0, 0), 'n']] 8.281
 > Model[[(2, 0, 2), (0, 0, 0, 0), 'c']] 8.736
```

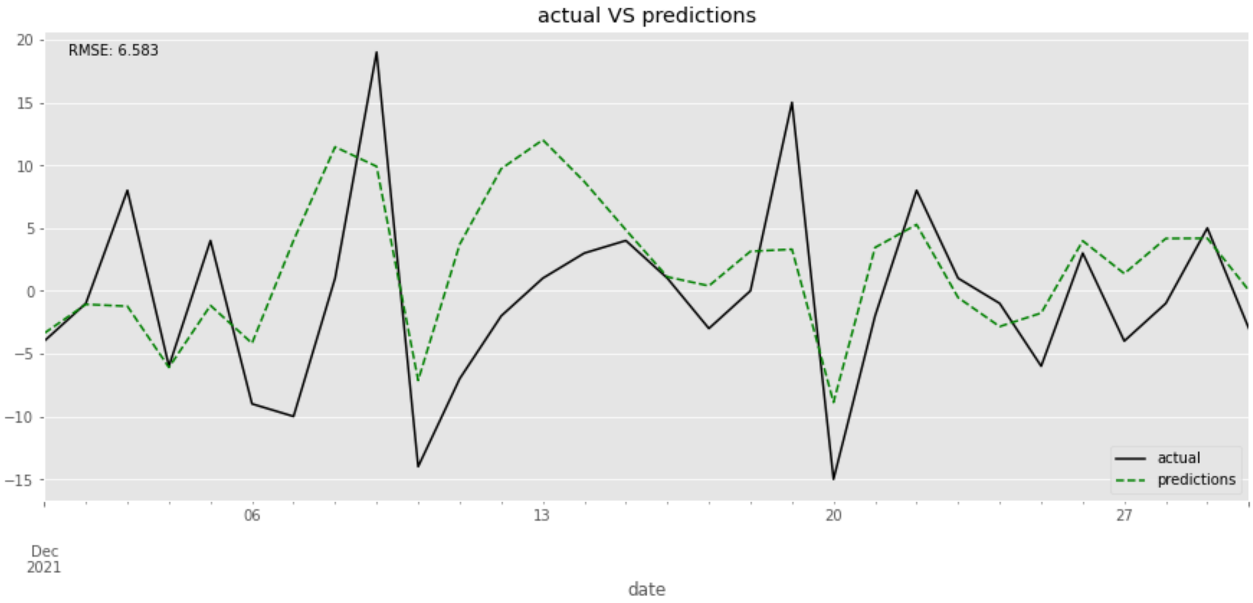
```
> Model[[(2, 0, 2), (0, 0, 0, 0), 't']] 8.556
> Model[[(2, 0, 2), (0, 0, 0, 0), 'ct']] 8.740
> Model[[(2, 1, 0), (0, 0, 0, 0), 'n']] 12.333
> Model[[(2, 1, 0), (0, 0, 0, 0), 'c']] 12.354
> Model[[(2, 1, 0), (0, 0, 0, 0), 't']] 12.394
> Model[[(2, 1, 0), (0, 0, 0, 0), 'ct']] 12.414
> Model[[(2, 1, 1), (0, 0, 0, 0), 'n']] 8.761
> Model[[(2, 1, 1), (0, 0, 0, 0), 'c']] 8.802
> Model[[(2, 1, 1), (0, 0, 0, 0), 't']] 9.228
> Model[[(2, 1, 1), (0, 0, 0, 0), 'ct']] 9.225
> Model[[(2, 1, 2), (0, 0, 0, 0), 'n']] 8.153
> Model[[(2, 1, 2), (0, 0, 0, 0), 'c']] 8.180
> Model[[(2, 1, 2), (0, 0, 0, 0), 't']] 9.326
> Model[[(2, 1, 2), (0, 0, 0, 0), 'ct']] 9.485
> Model[[(3, 0, 0), (0, 0, 0, 0), 'n']] 8.155
> Model[[(3, 0, 0), (0, 0, 0, 0), 'c']] 8.164
> Model[[(3, 0, 0), (0, 0, 0, 0), 't']] 8.187
> Model[[(3, 0, 0), (0, 0, 0, 0), 'ct']] 8.200
> Model[[(3, 0, 1), (0, 0, 0, 0), 'n']] 7.878
> Model[[(3, 0, 1), (0, 0, 0, 0), 'c']] 8.499
> Model[[(3, 0, 1), (0, 0, 0, 0), 't']] 8.162
> Model[[(3, 0, 1), (0, 0, 0, 0), 'ct']] 8.425
> Model[[(3, 0, 2), (0, 0, 0, 0), 'n']] 8.298
> Model[[(3, 0, 2), (0, 0, 0, 0), 'c']] 8.823
> Model[[(3, 0, 2), (0, 0, 0, 0), 't']] 8.676
> Model[[(3, 0, 2), (0, 0, 0, 0), 'ct']] 8.812
> Model[[(3, 1, 0), (0, 0, 0, 0), 'n']] 10.770
> Model[[(3, 1, 0), (0, 0, 0, 0), 'c']] 10.787
> Model[[(3, 1, 0), (0, 0, 0, 0), 't']] 10.822
> Model[[(3, 1, 0), (0, 0, 0, 0), 'ct']] 10.841
> Model[[(3, 1, 1), (0, 0, 0, 0), 'n']] 8.164
> Model[[(3, 1, 1), (0, 0, 0, 0), 'c']] 8.200
> Model[[(3, 1, 1), (0, 0, 0, 0), 't']] 8.418
> Model[[(3, 1, 1), (0, 0, 0, 0), 'ct']] 8.325
> Model[[(3, 1, 2), (0, 0, 0, 0), 'n']] 8.192
> Model[[(3, 1, 2), (0, 0, 0, 0), 'c']] 8.166
> Model[[(3, 1, 2), (0, 0, 0, 0), 't']] 8.778
> Model[[(3, 1, 2), (0, 0, 0, 0), 'ct']] 8.753
> Model[[(4, 0, 0), (0, 0, 0, 0), 'n']] 8.062
> Model[[(4, 0, 0), (0, 0, 0, 0), 'c']] 8.069
> Model[[(4, 0, 0), (0, 0, 0, 0), 't']] 8.093
> Model[[(4, 0, 0), (0, 0, 0, 0), 'ct']] 8.106
> Model[[(4, 0, 1), (0, 0, 0, 0), 'n']] 7.805
> Model[[(4, 0, 1), (0, 0, 0, 0), 'c']] 8.403
> Model[[(4, 0, 1), (0, 0, 0, 0), 't']] 8.111
> Model[[(4, 0, 1), (0, 0, 0, 0), 'ct']] 8.377
> Model[[(4, 0, 2), (0, 0, 0, 0), 'n']] 8.278
> Model[[(4, 0, 2), (0, 0, 0, 0), 'c']] 8.907
> Model[[(4, 0, 2), (0, 0, 0, 0), 't']] 8.301
> Model[[(4, 0, 2), (0, 0, 0, 0), 'ct']] 8.352
> Model[[(4, 1, 0), (0, 0, 0, 0), 'n']] 10.382
> Model[[(4, 1, 0), (0, 0, 0, 0), 'c']] 10.399
> Model[[(4, 1, 0), (0, 0, 0, 0), 't']] 10.433
> Model[[(4, 1, 0), (0, 0, 0, 0), 'ct']] 10.453
> Model[[(4, 1, 1), (0, 0, 0, 0), 'n']] 8.069
> Model[[(4, 1, 1), (0, 0, 0, 0), 'c']] 8.107
> Model[[(4, 1, 1), (0, 0, 0, 0), 't']] 8.595
> Model[[(4, 1, 1), (0, 0, 0, 0), 'ct']] 8.380
> Model[[(4, 1, 2), (0, 0, 0, 0), 'n']] 8.322
> Model[[(4, 1, 2), (0, 0, 0, 0), 'c']] 8.356
> Model[[(4, 1, 2), (0, 0, 0, 0), 't']] 8.543
```

```
 > Model[[(4, 1, 2), (0, 0, 0, 0), 'ct']] 8.643
Лучшие модели:
[(4, 0, 1), (0, 0, 0, 0), 'n'] 7.804742258221239
[(1, 0, 1), (0, 0, 0, 0), 'n'] 7.827625401830191
[(2, 0, 1), (0, 0, 0, 0), 'n'] 7.837023777784183
CPU times: user 26min 18s, sys: 19.5 s, total: 26min 37s
Wall time: 26min 22s
```

Итак, лучшая модель SARIMA имеет параметры [(4, 0, 1), (0, 0, 0, 0), 'n']. Оценим остатки модели. Для этого возьмём хотя бы 30 точек.

In [105…

```
walk_forward_validation(sales_diff, 30, sarima_forecast, [(4, 0, 1), (0, 0
```



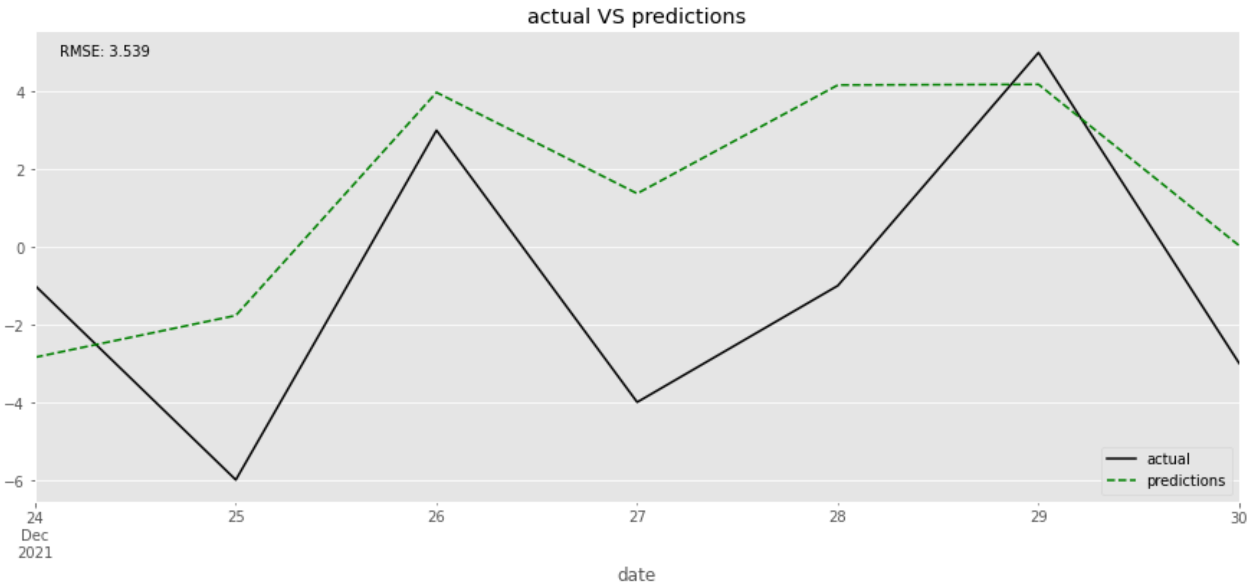
Out[105… 6.583204858236249

Судя по построенным графикам распределение остатков приближено к нормальному.

Так как нам в итоге нужно построить прогноз на неделю вперед, будем оценивать эту модель и сравнивать её по качеству с другими моделями метрикой RMSE за последнюю неделю.

In [106…

```
walk_forward_validation(sales_diff, 7, sarima_forecast, [(4, 0, 1), (0, 0,
```



Out[106… 3.5387752704318687

Мы построили модель SARIMA, теперь посмотрим, как распределены остатки модели. Судя по построенным графикам распределение остатков приближено к нормальному.

Градиентный бустинг CatBoost

Подготовка признаков

Мы можем реструктурировать последовательность временного ряда так, чтобы данные на входе в модель выглядели как задача обучения с учителем. Мы можем сделать это, используя предыдущие временные шаги в качестве входных переменных и используя следующий временной шаг в качестве выходной переменной. Попробуем добавить в качестве признаков также месяц, номер недели и день недели.

In [255…

```
def make_features(series, column, max_lag):
    """
    Функция создаёт признаки сдвига во времени (лаги)
    """
    data = pd.DataFrame(series, index=series.index)
    #data['year'] = data.index.year
    data['month'] = data.index.month
    data['day'] = data.index.day
    data['dayofweek'] = data.index.dayofweek
    #data['hour'] = data.index.hour

    for lag in range(1, max_lag + 1):
        data[column+'_lag_{}'.format(lag)] = data[column].shift(lag)
    #data['rolling_mean'] = data[column].shift().rolling(rolling_mean_size
    return data
```

In [256…

```
data = make_features(sales_diff, 'quantity', 7)
data
```

Out[256…

date	quantity	month	day	dayofweek	quantity_lag_1	quantity_lag_2	quantity_lag_3	q
2021-01-05	26.0	1	5	1	NaN	NaN	NaN	
2021-01-06	-5.0	1	6	2	26.0	NaN	NaN	
2021-01-07	3.0	1	7	3	-5.0	26.0	NaN	
2021-01-08	5.0	1	8	4	3.0	-5.0	26.0	
2021-01-09	3.0	1	9	5	5.0	3.0	-5.0	
...	...	...	...	...	...	...	...	
2021-12-26	3.0	12	26	6	-6.0	-1.0	1.0	
2021-12-27	-4.0	12	27	0	3.0	-6.0	-1.0	
2021-12-28	-1.0	12	28	1	-4.0	3.0	-6.0	
2021-12-29	5.0	12	29	2	-1.0	-4.0	3.0	
2021-12-30	-3.0	12	30	3	5.0	-1.0	-4.0	

352 rows × 11 columns

Подготовка функций

Проверим написанную нами функцию разбиения на тренировочную и тестовую выборки применительно к новым данным.

In [257…

```
# проверка
train, test = series_train_test_split(data, 70)
print(train.shape)
print(test.shape)
```

```
(282, 11)
(70, 11)
```

Изменим функцию walk-forward валидации с учётом формата входных данных.

In [258…

```
# walk-forward validation for CatBoost
def walk_forward_validation(data, n_test, target, config, plot=False):
    predictions = list()
    # разбиваем на train и test
    train, test = series_train_test_split(data, n_test)
    # помещаем train в историю
    history = train
    # проходимся по каждому из значений в тестовом наборе
    for i in range(len(test)):
        # выделяем признаки и целевой признак
        features_test, target_test = test.drop(columns=[target]).iloc[i], t
        # обучаем модель на истории и делаем предсказание на шаг вперёд
        prediction = catboost_forecast(history, features_test, target, con
        # сохраняем предсказание в список
        predictions.append(prediction)
        # добавляем действительное значение в историю
        history.append(test.iloc[i])
        # отслеживаем прогресс
        print('>expected=%.1f, predicted=%.1f' % (target_test, prediction)
    # вычисляем ошибку
    error = rmse(test[target], predictions)
    #return error, test[target], predictions
    if plot:
        # график для визуального сравнения предсказанных значений с действ
        # (по умолчанию не строим)
        plot_result(n_test, error, test[target], predictions)
        # график остатков
        #model_forecast(test.asfreq('D'), config, True)
    else:
        # по умолчанию возвращаем интересующую метрику качества
        return error
```

Напишем функцию прогноза на один шаг вперед, который будет делать лучшая выбранная по сетке параметров модель градиентного бустинга из библиотеки CatBoost.

In [259…

```
# CatBoost-прогноз на шаг вперёд
def catboost_forecast(train, features_test, target, config):
    # определяем конфигурацию
    learning_rate, depth, l2_leaf_reg, iterations, task_type, verbose, rand
    # выделяем целевой признак из train
    features_train, target_train = train.drop(columns=[target]), train[targ
    # определяем модель
    model_CBR = CatBoostRegressor(learning_rate=learning_rate,
                                  depth=depth,
                                  l2_leaf_reg=l2_leaf_reg,
                                  iterations=iterations,
                                  task_type=task_type,
                                  verbose=verbose,
                                  random_seed=random_seed,
                                  loss_function='RMSE')
    # осуществляем grid search, на выходе получаем лучшую обученную модель
    model_CBR.fit(features_train, target_train)
    # делаем прогноз на шаг вперед
    prediction = model_CBR.predict(features_test)
    return prediction
```

In [112…

```
# проверка
#catboost_forecast(train, features_test.iloc[1], 'quantity', (0.01, 2, 1, 
```

In [260…

```
# оцениваем модель и возвращаем None при возникновении ошибки
def score_model(data, n_test, target, config, debug=False):
    result = None
    # конвертируем конфигурацию в строковый ключ
    key = str(config)
    # показываем все предупреждения, если debug=True
    if debug:
        result = walk_forward_validation(data, n_test, target, config)
    else:
        # сбой во время проверки модели предполагает нестабильную конфигур
        try:
            # во время поиска по сетке не показываем предупреждения
            with catch_warnings():
                filterwarnings("ignore")
                result = walk_forward_validation(data, n_test, target, con
        except:
            error = None
    # проверяем на наличие интересующего результата
    if result is not None:
        print(' > Model[%s] %.3f' % (key, result))
    return (key, result)
```

In [261…

```
# проверка
score_model(data, 2, 'quantity', (0.01, 2, 1, 1000, 'CPU', 0, 12345), debug
```

```
>expected=5.0, predicted=3.6
>expected=-3.0, predicted=3.3
 > Model[(0.01, 2, 1, 1000, 'CPU', 0, 12345)] 4.557
```

Out[261…

```
("(0.01, 2, 1, 1000, 'CPU', 0, 12345)", 4.556707122275873)
```

В библиотеке CatBoost есть штатная функция `grid_search()` , которая красиво визуализирует поиск по сетке, однако мы сделаем свою, чтобы затем можно было сравнить полученные результаты из разных типов моделей.

In [262…

```
def grid_search(data,
                n_test,
                target,
                config_list, # список всех конфигураций
                parallel=False):
    scores = None
    if parallel:
        # определяем количество используемых ядер
        #executor = Parallel(n_jobs=cpu_count()-1, backend='multiprocessin
        scores = Parallel(n_jobs=-1, backend='multiprocessing', verbose=1)
        #print(executor)
        # создаём список задач для параллельного выполнения
        #tasks = (delayed(score_model)(data, n_test, target, config) for c
        #print(tasks)
        # передаём задачи в executor
        #scores = executor(tasks)
    else:
        scores = [score_model(data, n_test, target, config) for config in c
    # удаляем пустые результаты
    scores = [r for r in scores if r[1] != None]
    # сортируем кортежи в списке по баллу в порядке возрастания (сначала л
    scores.sort(key=lambda tup: tup[1])
    return scores
```

Создадим список всех конфигураций гиперпараметров.

In [263…

```
# создаем набор конфигураций гиперпараметров
def catboost_configs():
    models = list()
    # определяем гиперпараметры
    learning_rate = [0.01, 0.03, 0.1, 0.2, 0.3]
    depth = [2, 4, 6, 8, 10]
    l2_leaf_reg = [1, 3, 5, 7, 9]
    iterations = [1000]
    task_type = ['CPU']
    verbose = [0]
    random_seed = [12345]
    # заполняем список конфигураций
    for lr in learning_rate:
        for d in depth:
            for leaf in l2_leaf_reg:
                for i in iterations:
                    for t in task_type:
                        for v in verbose:
                            for r in random_seed:
                                config = lr,d,leaf,i,t,v,r
                                models.append(config)
    return models
```

In [117…

```
# проверка
catboost_configs()[1]
```

Out[117…

```
(0.01, 2, 3, 1000, 'CPU', 0, 12345)
```

Выбор лучшей конфигурации гиперпараметров для модели CatBoost

In [264…

```
if __name__ == '__main__':
    n_test = 7
    target = 'quantity'
    config_list = catboost_configs()
    scores = grid_search(data, n_test, target, config_list, parallel=False
    print('Лучшие модели:')
    # топ-3 конфигурации
    for config, error in scores[:3]:
        print(config, error)
```

```
>expected=-1.0, predicted=-2.2
>expected=-6.0, predicted=0.3
>expected=3.0, predicted=6.2
>expected=-4.0, predicted=1.3
>expected=-1.0, predicted=3.0
>expected=5.0, predicted=3.7
>expected=-3.0, predicted=3.1
 > Model[(0.01, 2, 1, 1000, 'CPU', 0, 12345)] 4.392
>expected=-1.0, predicted=-2.1
>expected=-6.0, predicted=0.4
>expected=3.0, predicted=6.0
```

```
>expected=-4.0, predicted=1.3
>expected=-1.0, predicted=2.8
>expected=5.0, predicted=3.3
>expected=-3.0, predicted=2.6
 > Model[(0.01, 2, 3, 1000, 'CPU', 0, 12345)] 4.272
>expected=-1.0, predicted=-1.8
>expected=-6.0, predicted=0.3
>expected=3.0, predicted=5.3
>expected=-4.0, predicted=1.1
>expected=-1.0, predicted=2.7
>expected=5.0, predicted=2.8
>expected=-3.0, predicted=1.6
 > Model[(0.01, 2, 5, 1000, 'CPU', 0, 12345)] 4.007
>expected=-1.0, predicted=-2.0
>expected=-6.0, predicted=0.1
>expected=3.0, predicted=5.2
>expected=-4.0, predicted=0.7
>expected=-1.0, predicted=2.3
>expected=5.0, predicted=2.4
>expected=-3.0, predicted=1.3
 > Model[(0.01, 2, 7, 1000, 'CPU', 0, 12345)] 3.803
>expected=-1.0, predicted=-1.8
>expected=-6.0, predicted=0.1
>expected=3.0, predicted=5.1
>expected=-4.0, predicted=0.8
>expected=-1.0, predicted=2.2
>expected=5.0, predicted=2.3
>expected=-3.0, predicted=1.0
 > Model[(0.01, 2, 9, 1000, 'CPU', 0, 12345)] 3.760
>expected=-1.0, predicted=-3.1
>expected=-6.0, predicted=1.5
>expected=3.0, predicted=6.1
>expected=-4.0, predicted=1.0
>expected=-1.0, predicted=3.5
>expected=5.0, predicted=5.1
>expected=-3.0, predicted=4.3
 > Model[(0.01, 4, 1, 1000, 'CPU', 0, 12345)] 4.888
>expected=-1.0, predicted=-3.0
>expected=-6.0, predicted=1.3
>expected=3.0, predicted=7.3
>expected=-4.0, predicted=0.5
>expected=-1.0, predicted=2.9
>expected=5.0, predicted=5.1
>expected=-3.0, predicted=4.6
 > Model[(0.01, 4, 3, 1000, 'CPU', 0, 12345)] 4.913
>expected=-1.0, predicted=-3.5
>expected=-6.0, predicted=1.3
>expected=3.0, predicted=6.8
>expected=-4.0, predicted=0.7
>expected=-1.0, predicted=2.9
>expected=5.0, predicted=4.2
>expected=-3.0, predicted=3.5
 > Model[(0.01, 4, 5, 1000, 'CPU', 0, 12345)] 4.699
>expected=-1.0, predicted=-2.8
>expected=-6.0, predicted=1.0
>expected=3.0, predicted=6.5
>expected=-4.0, predicted=0.4
>expected=-1.0, predicted=2.6
>expected=5.0, predicted=4.3
>expected=-3.0, predicted=3.0
 > Model[(0.01, 4, 7, 1000, 'CPU', 0, 12345)] 4.364
```

```
>expected=-1.0, predicted=-2.7
>expected=-6.0, predicted=1.0
>expected=3.0, predicted=6.5
>expected=-4.0, predicted=0.3
>expected=-1.0, predicted=2.5
>expected=5.0, predicted=3.8
>expected=-3.0, predicted=2.4
 > Model[(0.01, 4, 9, 1000, 'CPU', 0, 12345)] 4.243
>expected=-1.0, predicted=-5.2
>expected=-6.0, predicted=2.2
>expected=3.0, predicted=6.6
>expected=-4.0, predicted=0.9
>expected=-1.0, predicted=2.8
>expected=5.0, predicted=6.4
>expected=-3.0, predicted=3.3
 > Model[(0.01, 6, 1, 1000, 'CPU', 0, 12345)] 5.032
>expected=-1.0, predicted=-3.8
>expected=-6.0, predicted=2.6
>expected=3.0, predicted=7.0
>expected=-4.0, predicted=1.1
>expected=-1.0, predicted=3.5
>expected=5.0, predicted=5.4
>expected=-3.0, predicted=2.6
 > Model[(0.01, 6, 3, 1000, 'CPU', 0, 12345)] 5.017
>expected=-1.0, predicted=-3.8
>expected=-6.0, predicted=2.0
>expected=3.0, predicted=6.5
>expected=-4.0, predicted=1.4
>expected=-1.0, predicted=2.9
>expected=5.0, predicted=4.6
>expected=-3.0, predicted=3.2
 > Model[(0.01, 6, 5, 1000, 'CPU', 0, 12345)] 4.886
>expected=-1.0, predicted=-3.3
>expected=-6.0, predicted=2.2
>expected=3.0, predicted=6.7
>expected=-4.0, predicted=0.6
>expected=-1.0, predicted=3.0
>expected=5.0, predicted=4.7
>expected=-3.0, predicted=2.6
 > Model[(0.01, 6, 7, 1000, 'CPU', 0, 12345)] 4.709
>expected=-1.0, predicted=-3.1
>expected=-6.0, predicted=2.0
>expected=3.0, predicted=6.5
>expected=-4.0, predicted=0.5
>expected=-1.0, predicted=3.4
>expected=5.0, predicted=3.6
>expected=-3.0, predicted=1.8
 > Model[(0.01, 6, 9, 1000, 'CPU', 0, 12345)] 4.567
>expected=-1.0, predicted=-5.7
>expected=-6.0, predicted=1.6
>expected=3.0, predicted=6.6
>expected=-4.0, predicted=0.9
>expected=-1.0, predicted=4.1
>expected=5.0, predicted=5.9
>expected=-3.0, predicted=3.0
 > Model[(0.01, 8, 1, 1000, 'CPU', 0, 12345)] 5.074
>expected=-1.0, predicted=-4.8
>expected=-6.0, predicted=1.6
>expected=3.0, predicted=6.4
>expected=-4.0, predicted=0.8
>expected=-1.0, predicted=2.7
```

```
>expected=5.0, predicted=5.7
>expected=-3.0, predicted=2.5
 > Model[(0.01, 8, 3, 1000, 'CPU', 0, 12345)] 4.648
>expected=-1.0, predicted=-3.8
>expected=-6.0, predicted=1.6
>expected=3.0, predicted=6.3
>expected=-4.0, predicted=0.6
>expected=-1.0, predicted=2.5
>expected=5.0, predicted=4.7
>expected=-3.0, predicted=1.8
 > Model[(0.01, 8, 5, 1000, 'CPU', 0, 12345)] 4.359
>expected=-1.0, predicted=-4.2
>expected=-6.0, predicted=2.2
>expected=3.0, predicted=6.1
>expected=-4.0, predicted=0.5
>expected=-1.0, predicted=2.9
>expected=5.0, predicted=4.5
>expected=-3.0, predicted=1.7
 > Model[(0.01, 8, 7, 1000, 'CPU', 0, 12345)] 4.564
>expected=-1.0, predicted=-3.2
>expected=-6.0, predicted=2.1
>expected=3.0, predicted=5.9
>expected=-4.0, predicted=0.3
>expected=-1.0, predicted=3.1
>expected=5.0, predicted=4.2
>expected=-3.0, predicted=1.5
 > Model[(0.01, 8, 9, 1000, 'CPU', 0, 12345)] 4.389
>expected=-1.0, predicted=-4.8
>expected=-6.0, predicted=1.4
>expected=3.0, predicted=6.1
>expected=-4.0, predicted=1.5
>expected=-1.0, predicted=2.7
>expected=5.0, predicted=5.6
>expected=-3.0, predicted=1.5
 > Model[(0.01, 10, 1, 1000, 'CPU', 0, 12345)] 4.532
>expected=-1.0, predicted=-4.3
>expected=-6.0, predicted=1.0
>expected=3.0, predicted=5.5
>expected=-4.0, predicted=1.4
>expected=-1.0, predicted=2.7
>expected=5.0, predicted=5.6
>expected=-3.0, predicted=1.4
 > Model[(0.01, 10, 3, 1000, 'CPU', 0, 12345)] 4.279
>expected=-1.0, predicted=-3.8
>expected=-6.0, predicted=1.3
>expected=3.0, predicted=5.8
>expected=-4.0, predicted=0.8
>expected=-1.0, predicted=3.0
>expected=5.0, predicted=4.1
>expected=-3.0, predicted=0.9
 > Model[(0.01, 10, 5, 1000, 'CPU', 0, 12345)] 4.217
>expected=-1.0, predicted=-3.4
>expected=-6.0, predicted=1.1
>expected=3.0, predicted=5.4
>expected=-4.0, predicted=0.7
>expected=-1.0, predicted=2.5
>expected=5.0, predicted=3.9
>expected=-3.0, predicted=0.9
 > Model[(0.01, 10, 7, 1000, 'CPU', 0, 12345)] 4.017
>expected=-1.0, predicted=-2.9
>expected=-6.0, predicted=1.3
```

```
>expected=3.0, predicted=4.8
>expected=-4.0, predicted=0.2
>expected=-1.0, predicted=2.5
>expected=5.0, predicted=3.9
>expected=-3.0, predicted=0.7
 > Model[(0.01, 10, 9, 1000, 'CPU', 0, 12345)] 3.871
>expected=-1.0, predicted=-3.7
>expected=-6.0, predicted=0.4
>expected=3.0, predicted=8.2
>expected=-4.0, predicted=3.3
>expected=-1.0, predicted=3.5
>expected=5.0, predicted=5.3
>expected=-3.0, predicted=4.9
 > Model[(0.03, 2, 1, 1000, 'CPU', 0, 12345)] 5.495
>expected=-1.0, predicted=-3.2
>expected=-6.0, predicted=0.1
>expected=3.0, predicted=8.8
>expected=-4.0, predicted=3.5
>expected=-1.0, predicted=3.7
>expected=5.0, predicted=4.4
>expected=-3.0, predicted=5.1
 > Model[(0.03, 2, 3, 1000, 'CPU', 0, 12345)] 5.611
>expected=-1.0, predicted=-3.2
>expected=-6.0, predicted=-0.1
>expected=3.0, predicted=8.4
>expected=-4.0, predicted=3.1
>expected=-1.0, predicted=3.5
>expected=5.0, predicted=4.2
>expected=-3.0, predicted=4.8
 > Model[(0.03, 2, 5, 1000, 'CPU', 0, 12345)] 5.357
>expected=-1.0, predicted=-3.3
>expected=-6.0, predicted=0.0
>expected=3.0, predicted=8.7
>expected=-4.0, predicted=2.9
>expected=-1.0, predicted=3.4
>expected=5.0, predicted=3.9
>expected=-3.0, predicted=5.0
 > Model[(0.03, 2, 7, 1000, 'CPU', 0, 12345)] 5.423
>expected=-1.0, predicted=-3.1
>expected=-6.0, predicted=0.1
>expected=3.0, predicted=7.9
>expected=-4.0, predicted=2.9
>expected=-1.0, predicted=3.2
>expected=5.0, predicted=3.9
>expected=-3.0, predicted=4.7
 > Model[(0.03, 2, 9, 1000, 'CPU', 0, 12345)] 5.225
>expected=-1.0, predicted=-7.1
>expected=-6.0, predicted=4.1
>expected=3.0, predicted=6.7
>expected=-4.0, predicted=2.2
>expected=-1.0, predicted=4.5
>expected=5.0, predicted=6.8
>expected=-3.0, predicted=6.2
 > Model[(0.03, 4, 1, 1000, 'CPU', 0, 12345)] 6.650
>expected=-1.0, predicted=-6.1
>expected=-6.0, predicted=4.5
>expected=3.0, predicted=7.9
>expected=-4.0, predicted=2.5
>expected=-1.0, predicted=4.7
>expected=5.0, predicted=8.3
>expected=-3.0, predicted=6.7
```

```
 > Model[(0.03, 4, 3, 1000, 'CPU', 0, 12345)] 6.959
>expected=-1.0, predicted=-6.3
>expected=-6.0, predicted=1.9
>expected=3.0, predicted=8.4
>expected=-4.0, predicted=2.0
>expected=-1.0, predicted=3.4
>expected=5.0, predicted=8.9
>expected=-3.0, predicted=8.0
 > Model[(0.03, 4, 5, 1000, 'CPU', 0, 12345)] 6.647
>expected=-1.0, predicted=-6.2
>expected=-6.0, predicted=2.8
>expected=3.0, predicted=8.3
>expected=-4.0, predicted=2.6
>expected=-1.0, predicted=5.2
>expected=5.0, predicted=8.5
>expected=-3.0, predicted=7.2
 > Model[(0.03, 4, 7, 1000, 'CPU', 0, 12345)] 6.884
>expected=-1.0, predicted=-6.4
>expected=-6.0, predicted=2.2
>expected=3.0, predicted=8.0
>expected=-4.0, predicted=2.0
>expected=-1.0, predicted=4.0
>expected=5.0, predicted=7.8
>expected=-3.0, predicted=5.9
 > Model[(0.03, 4, 9, 1000, 'CPU', 0, 12345)] 6.208
>expected=-1.0, predicted=-7.0
>expected=-6.0, predicted=2.2
>expected=3.0, predicted=5.1
>expected=-4.0, predicted=1.1
>expected=-1.0, predicted=3.5
>expected=5.0, predicted=7.7
>expected=-3.0, predicted=5.3
 > Model[(0.03, 6, 1, 1000, 'CPU', 0, 12345)] 5.737
>expected=-1.0, predicted=-7.3
>expected=-6.0, predicted=1.6
>expected=3.0, predicted=7.5
>expected=-4.0, predicted=2.2
>expected=-1.0, predicted=4.3
>expected=5.0, predicted=7.9
>expected=-3.0, predicted=5.8
 > Model[(0.03, 6, 3, 1000, 'CPU', 0, 12345)] 6.200
>expected=-1.0, predicted=-7.7
>expected=-6.0, predicted=3.1
>expected=3.0, predicted=7.8
>expected=-4.0, predicted=3.5
>expected=-1.0, predicted=3.7
>expected=5.0, predicted=7.8
>expected=-3.0, predicted=6.4
 > Model[(0.03, 6, 5, 1000, 'CPU', 0, 12345)] 6.820
>expected=-1.0, predicted=-5.6
>expected=-6.0, predicted=2.9
>expected=3.0, predicted=6.5
>expected=-4.0, predicted=2.4
>expected=-1.0, predicted=2.4
>expected=5.0, predicted=6.6
>expected=-3.0, predicted=5.0
 > Model[(0.03, 6, 7, 1000, 'CPU', 0, 12345)] 5.730
>expected=-1.0, predicted=-6.1
>expected=-6.0, predicted=3.4
>expected=3.0, predicted=8.9
>expected=-4.0, predicted=3.0
```

```
>expected=-1.0, predicted=2.8
>expected=5.0, predicted=7.2
>expected=-3.0, predicted=4.3
 > Model[(0.03, 6, 9, 1000, 'CPU', 0, 12345)] 6.235
>expected=-1.0, predicted=-5.3
>expected=-6.0, predicted=1.4
>expected=3.0, predicted=5.9
>expected=-4.0, predicted=1.8
>expected=-1.0, predicted=4.9
>expected=5.0, predicted=5.4
>expected=-3.0, predicted=2.5
 > Model[(0.03, 8, 1, 1000, 'CPU', 0, 12345)] 5.073
>expected=-1.0, predicted=-5.4
>expected=-6.0, predicted=2.1
>expected=3.0, predicted=7.0
>expected=-4.0, predicted=2.0
>expected=-1.0, predicted=2.6
>expected=5.0, predicted=7.2
>expected=-3.0, predicted=4.0
 > Model[(0.03, 8, 3, 1000, 'CPU', 0, 12345)] 5.395
>expected=-1.0, predicted=-5.1
>expected=-6.0, predicted=1.3
>expected=3.0, predicted=8.1
>expected=-4.0, predicted=1.1
>expected=-1.0, predicted=3.2
>expected=5.0, predicted=7.4
>expected=-3.0, predicted=3.1
 > Model[(0.03, 8, 5, 1000, 'CPU', 0, 12345)] 5.133
>expected=-1.0, predicted=-4.7
>expected=-6.0, predicted=2.8
>expected=3.0, predicted=6.5
>expected=-4.0, predicted=0.7
>expected=-1.0, predicted=4.5
>expected=5.0, predicted=8.5
>expected=-3.0, predicted=3.9
 > Model[(0.03, 8, 7, 1000, 'CPU', 0, 12345)] 5.559
>expected=-1.0, predicted=-5.7
>expected=-6.0, predicted=2.7
>expected=3.0, predicted=8.2
>expected=-4.0, predicted=1.1
>expected=-1.0, predicted=4.0
>expected=5.0, predicted=7.9
>expected=-3.0, predicted=4.4
 > Model[(0.03, 8, 9, 1000, 'CPU', 0, 12345)] 5.828
>expected=-1.0, predicted=-3.4
>expected=-6.0, predicted=0.2
>expected=3.0, predicted=5.2
>expected=-4.0, predicted=2.8
>expected=-1.0, predicted=3.8
>expected=5.0, predicted=5.7
>expected=-3.0, predicted=2.5
 > Model[(0.03, 10, 1, 1000, 'CPU', 0, 12345)] 4.614
>expected=-1.0, predicted=-5.6
>expected=-6.0, predicted=1.1
>expected=3.0, predicted=5.3
>expected=-4.0, predicted=0.9
>expected=-1.0, predicted=3.1
>expected=5.0, predicted=8.7
>expected=-3.0, predicted=3.3
 > Model[(0.03, 10, 3, 1000, 'CPU', 0, 12345)] 4.937
>expected=-1.0, predicted=-3.9
```

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>expected=-6.0, predicted=1.4
>expected=3.0, predicted=5.6
>expected=-4.0, predicted=2.1
>expected=-1.0, predicted=2.6
>expected=5.0, predicted=5.9
>expected=-3.0, predicted=4.5
 > Model[(0.03, 10, 5, 1000, 'CPU', 0, 12345)] 5.040
>expected=-1.0, predicted=-4.4
>expected=-6.0, predicted=2.4
>expected=3.0, predicted=7.5
>expected=-4.0, predicted=1.4
>expected=-1.0, predicted=2.2
>expected=5.0, predicted=5.7
>expected=-3.0, predicted=2.7
 > Model[(0.03, 10, 7, 1000, 'CPU', 0, 12345)] 4.994
>expected=-1.0, predicted=-5.0
>expected=-6.0, predicted=1.8
>expected=3.0, predicted=6.3
>expected=-4.0, predicted=2.1
>expected=-1.0, predicted=3.5
>expected=5.0, predicted=6.0
>expected=-3.0, predicted=2.5
 > Model[(0.03, 10, 9, 1000, 'CPU', 0, 12345)] 5.024
>expected=-1.0, predicted=-7.5
>expected=-6.0, predicted=1.5
>expected=3.0, predicted=8.4
>expected=-4.0, predicted=5.9
>expected=-1.0, predicted=1.7
>expected=5.0, predicted=7.9
>expected=-3.0, predicted=8.4
 > Model[(0.1, 2, 1, 1000, 'CPU', 0, 12345)] 7.282
>expected=-1.0, predicted=-7.5
>expected=-6.0, predicted=0.1
>expected=3.0, predicted=9.0
>expected=-4.0, predicted=5.1
>expected=-1.0, predicted=1.9
>expected=5.0, predicted=7.5
>expected=-3.0, predicted=9.7
 > Model[(0.1, 2, 3, 1000, 'CPU', 0, 12345)] 7.289
>expected=-1.0, predicted=-8.0
>expected=-6.0, predicted=0.3
>expected=3.0, predicted=9.4
>expected=-4.0, predicted=4.5
>expected=-1.0, predicted=3.3
>expected=5.0, predicted=5.9
>expected=-3.0, predicted=8.6
 > Model[(0.1, 2, 5, 1000, 'CPU', 0, 12345)] 7.128
>expected=-1.0, predicted=-9.0
>expected=-6.0, predicted=2.1
>expected=3.0, predicted=9.3
>expected=-4.0, predicted=5.0
>expected=-1.0, predicted=3.2
>expected=5.0, predicted=5.7
>expected=-3.0, predicted=9.3
 > Model[(0.1, 2, 7, 1000, 'CPU', 0, 12345)] 7.739
>expected=-1.0, predicted=-7.9
>expected=-6.0, predicted=0.8
>expected=3.0, predicted=10.4
>expected=-4.0, predicted=5.0
>expected=-1.0, predicted=2.5
>expected=5.0, predicted=5.3
```

```
>expected=-3.0, predicted=9.4
 > Model[(0.1, 2, 9, 1000, 'CPU', 0, 12345)] 7.520
>expected=-1.0, predicted=-7.4
>expected=-6.0, predicted=4.0
>expected=3.0, predicted=10.1
>expected=-4.0, predicted=4.6
>expected=-1.0, predicted=6.9
>expected=5.0, predicted=5.1
>expected=-3.0, predicted=7.6
 > Model[(0.1, 4, 1, 1000, 'CPU', 0, 12345)] 7.932
>expected=-1.0, predicted=-8.3
>expected=-6.0, predicted=0.6
>expected=3.0, predicted=7.9
>expected=-4.0, predicted=1.8
>expected=-1.0, predicted=5.3
>expected=5.0, predicted=7.7
>expected=-3.0, predicted=8.1
 > Model[(0.1, 4, 3, 1000, 'CPU', 0, 12345)] 6.812
>expected=-1.0, predicted=-8.2
>expected=-6.0, predicted=2.7
>expected=3.0, predicted=6.2
>expected=-4.0, predicted=3.5
>expected=-1.0, predicted=5.5
>expected=5.0, predicted=8.4
>expected=-3.0, predicted=6.8
 > Model[(0.1, 4, 5, 1000, 'CPU', 0, 12345)] 7.043
>expected=-1.0, predicted=-9.4
>expected=-6.0, predicted=2.6
>expected=3.0, predicted=10.4
>expected=-4.0, predicted=3.5
>expected=-1.0, predicted=4.8
>expected=5.0, predicted=7.9
>expected=-3.0, predicted=7.7
 > Model[(0.1, 4, 7, 1000, 'CPU', 0, 12345)] 7.679
>expected=-1.0, predicted=-9.9
>expected=-6.0, predicted=3.6
>expected=3.0, predicted=9.7
>expected=-4.0, predicted=1.5
>expected=-1.0, predicted=4.4
>expected=5.0, predicted=8.1
>expected=-3.0, predicted=8.7
 > Model[(0.1, 4, 9, 1000, 'CPU', 0, 12345)] 7.783
>expected=-1.0, predicted=-7.3
>expected=-6.0, predicted=2.2
>expected=3.0, predicted=4.7
>expected=-4.0, predicted=1.9
>expected=-1.0, predicted=0.4
>expected=5.0, predicted=4.4
>expected=-3.0, predicted=4.2
 > Model[(0.1, 6, 1, 1000, 'CPU', 0, 12345)] 5.328
>expected=-1.0, predicted=-8.6
>expected=-6.0, predicted=5.9
>expected=3.0, predicted=8.4
>expected=-4.0, predicted=-0.4
>expected=-1.0, predicted=2.6
>expected=5.0, predicted=7.9
>expected=-3.0, predicted=6.2
 > Model[(0.1, 6, 3, 1000, 'CPU', 0, 12345)] 7.023
>expected=-1.0, predicted=-7.7
>expected=-6.0, predicted=3.1
>expected=3.0, predicted=9.3
```

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>expected=-4.0, predicted=0.8
>expected=-1.0, predicted=2.6
>expected=5.0, predicted=6.8
>expected=-3.0, predicted=5.6
 > Model[(0.1, 6, 5, 1000, 'CPU', 0, 12345)] 6.333
>expected=-1.0, predicted=-8.0
>expected=-6.0, predicted=3.9
>expected=3.0, predicted=7.6
>expected=-4.0, predicted=1.6
>expected=-1.0, predicted=5.0
>expected=5.0, predicted=9.8
>expected=-3.0, predicted=5.5
 > Model[(0.1, 6, 7, 1000, 'CPU', 0, 12345)] 6.880
>expected=-1.0, predicted=-5.9
>expected=-6.0, predicted=3.6
>expected=3.0, predicted=8.5
>expected=-4.0, predicted=1.3
>expected=-1.0, predicted=6.0
>expected=5.0, predicted=5.8
>expected=-3.0, predicted=6.3
 > Model[(0.1, 6, 9, 1000, 'CPU', 0, 12345)] 6.668
>expected=-1.0, predicted=-6.5
>expected=-6.0, predicted=-0.1
>expected=3.0, predicted=6.4
>expected=-4.0, predicted=3.4
>expected=-1.0, predicted=1.3
>expected=5.0, predicted=8.0
>expected=-3.0, predicted=3.8
 > Model[(0.1, 8, 1, 1000, 'CPU', 0, 12345)] 5.236
>expected=-1.0, predicted=-6.8
>expected=-6.0, predicted=2.1
>expected=3.0, predicted=7.4
>expected=-4.0, predicted=1.7
>expected=-1.0, predicted=2.5
>expected=5.0, predicted=5.5
>expected=-3.0, predicted=4.0
 > Model[(0.1, 8, 3, 1000, 'CPU', 0, 12345)] 5.525
>expected=-1.0, predicted=-6.3
>expected=-6.0, predicted=0.7
>expected=3.0, predicted=7.5
>expected=-4.0, predicted=3.0
>expected=-1.0, predicted=4.1
>expected=5.0, predicted=7.0
>expected=-3.0, predicted=1.6
 > Model[(0.1, 8, 5, 1000, 'CPU', 0, 12345)] 5.262
>expected=-1.0, predicted=-7.0
>expected=-6.0, predicted=4.0
>expected=3.0, predicted=7.3
>expected=-4.0, predicted=0.9
>expected=-1.0, predicted=5.2
>expected=5.0, predicted=7.2
>expected=-3.0, predicted=3.5
 > Model[(0.1, 8, 7, 1000, 'CPU', 0, 12345)] 6.143
>expected=-1.0, predicted=-7.3
>expected=-6.0, predicted=2.1
>expected=3.0, predicted=7.0
>expected=-4.0, predicted=0.5
>expected=-1.0, predicted=6.0
>expected=5.0, predicted=9.0
>expected=-3.0, predicted=7.2
 > Model[(0.1, 8, 9, 1000, 'CPU', 0, 12345)] 6.667
```

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>expected=-1.0, predicted=-2.6
>expected=-6.0, predicted=2.2
>expected=3.0, predicted=8.0
>expected=-4.0, predicted=3.9
>expected=-1.0, predicted=4.4
>expected=5.0, predicted=6.5
>expected=-3.0, predicted=4.1
 > Model[(0.1, 10, 1, 1000, 'CPU', 0, 12345)] 5.845
>expected=-1.0, predicted=-4.8
>expected=-6.0, predicted=1.6
>expected=3.0, predicted=6.2
>expected=-4.0, predicted=0.6
>expected=-1.0, predicted=3.3
>expected=5.0, predicted=6.8
>expected=-3.0, predicted=0.9
 > Model[(0.1, 10, 3, 1000, 'CPU', 0, 12345)] 4.488
>expected=-1.0, predicted=-5.2
>expected=-6.0, predicted=1.0
>expected=3.0, predicted=4.7
>expected=-4.0, predicted=0.3
>expected=-1.0, predicted=4.0
>expected=5.0, predicted=5.1
>expected=-3.0, predicted=2.8
 > Model[(0.1, 10, 5, 1000, 'CPU', 0, 12345)] 4.582
>expected=-1.0, predicted=-4.5
>expected=-6.0, predicted=2.2
>expected=3.0, predicted=4.7
>expected=-4.0, predicted=0.8
>expected=-1.0, predicted=4.8
>expected=5.0, predicted=5.7
>expected=-3.0, predicted=-0.1
 > Model[(0.1, 10, 7, 1000, 'CPU', 0, 12345)] 4.597
>expected=-1.0, predicted=-3.1
>expected=-6.0, predicted=2.0
>expected=3.0, predicted=5.8
>expected=-4.0, predicted=1.4
>expected=-1.0, predicted=3.2
>expected=5.0, predicted=7.1
>expected=-3.0, predicted=3.7
 > Model[(0.1, 10, 9, 1000, 'CPU', 0, 12345)] 4.953
>expected=-1.0, predicted=-8.9
>expected=-6.0, predicted=3.0
>expected=3.0, predicted=8.7
>expected=-4.0, predicted=6.2
>expected=-1.0, predicted=2.9
>expected=5.0, predicted=5.2
>expected=-3.0, predicted=9.9
 > Model[(0.2, 2, 1, 1000, 'CPU', 0, 12345)] 8.127
>expected=-1.0, predicted=-12.2
>expected=-6.0, predicted=4.1
>expected=3.0, predicted=10.5
>expected=-4.0, predicted=5.0
>expected=-1.0, predicted=4.0
>expected=5.0, predicted=6.9
>expected=-3.0, predicted=12.5
 > Model[(0.2, 2, 3, 1000, 'CPU', 0, 12345)] 9.519
>expected=-1.0, predicted=-9.4
>expected=-6.0, predicted=2.3
>expected=3.0, predicted=9.1
>expected=-4.0, predicted=3.6
>expected=-1.0, predicted=3.8
```

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>expected=5.0, predicted=7.6
>expected=-3.0, predicted=11.4
 > Model[(0.2, 2, 5, 1000, 'CPU', 0, 12345)] 8.199
>expected=-1.0, predicted=-11.9
>expected=-6.0, predicted=4.3
>expected=3.0, predicted=10.8
>expected=-4.0, predicted=4.9
>expected=-1.0, predicted=5.2
>expected=5.0, predicted=7.7
>expected=-3.0, predicted=10.7
 > Model[(0.2, 2, 7, 1000, 'CPU', 0, 12345)] 9.244
>expected=-1.0, predicted=-11.1
>expected=-6.0, predicted=1.9
>expected=3.0, predicted=8.9
>expected=-4.0, predicted=3.4
>expected=-1.0, predicted=6.7
>expected=5.0, predicted=5.8
>expected=-3.0, predicted=8.7
 > Model[(0.2, 2, 9, 1000, 'CPU', 0, 12345)] 8.010
>expected=-1.0, predicted=-5.1
>expected=-6.0, predicted=3.2
>expected=3.0, predicted=8.0
>expected=-4.0, predicted=2.5
>expected=-1.0, predicted=4.8
>expected=5.0, predicted=10.5
>expected=-3.0, predicted=7.2
 > Model[(0.2, 4, 1, 1000, 'CPU', 0, 12345)] 6.926
>expected=-1.0, predicted=-8.2
>expected=-6.0, predicted=1.7
>expected=3.0, predicted=8.4
>expected=-4.0, predicted=4.3
>expected=-1.0, predicted=4.8
>expected=5.0, predicted=7.2
>expected=-3.0, predicted=6.3
 > Model[(0.2, 4, 3, 1000, 'CPU', 0, 12345)] 6.910
>expected=-1.0, predicted=-9.8
>expected=-6.0, predicted=1.2
>expected=3.0, predicted=8.0
>expected=-4.0, predicted=4.9
>expected=-1.0, predicted=0.9
>expected=5.0, predicted=8.5
>expected=-3.0, predicted=8.5
 > Model[(0.2, 4, 5, 1000, 'CPU', 0, 12345)] 7.385
>expected=-1.0, predicted=-11.1
>expected=-6.0, predicted=4.8
>expected=3.0, predicted=7.9
>expected=-4.0, predicted=3.4
>expected=-1.0, predicted=6.8
>expected=5.0, predicted=7.9
>expected=-3.0, predicted=7.9
 > Model[(0.2, 4, 7, 1000, 'CPU', 0, 12345)] 8.333
>expected=-1.0, predicted=-12.8
>expected=-6.0, predicted=4.9
>expected=3.0, predicted=9.6
>expected=-4.0, predicted=4.6
>expected=-1.0, predicted=6.4
>expected=5.0, predicted=10.1
>expected=-3.0, predicted=8.7
 > Model[(0.2, 4, 9, 1000, 'CPU', 0, 12345)] 9.192
>expected=-1.0, predicted=-8.4
>expected=-6.0, predicted=2.4
```

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>expected=3.0, predicted=6.2
>expected=-4.0, predicted=4.5
>expected=-1.0, predicted=1.2
>expected=5.0, predicted=5.1
>expected=-3.0, predicted=3.5
 > Model[(0.2, 6, 1, 1000, 'CPU', 0, 12345)] 6.031
>expected=-1.0, predicted=-9.2
>expected=-6.0, predicted=1.2
>expected=3.0, predicted=8.8
>expected=-4.0, predicted=4.7
>expected=-1.0, predicted=8.2
>expected=5.0, predicted=8.9
>expected=-3.0, predicted=4.5
 > Model[(0.2, 6, 3, 1000, 'CPU', 0, 12345)] 7.410
>expected=-1.0, predicted=-5.4
>expected=-6.0, predicted=1.8
>expected=3.0, predicted=6.1
>expected=-4.0, predicted=4.3
>expected=-1.0, predicted=5.6
>expected=5.0, predicted=9.5
>expected=-3.0, predicted=5.1
 > Model[(0.2, 6, 5, 1000, 'CPU', 0, 12345)] 6.411
>expected=-1.0, predicted=-3.3
>expected=-6.0, predicted=3.7
>expected=3.0, predicted=8.3
>expected=-4.0, predicted=3.5
>expected=-1.0, predicted=4.7
>expected=5.0, predicted=8.0
>expected=-3.0, predicted=6.8
 > Model[(0.2, 6, 7, 1000, 'CPU', 0, 12345)] 6.787
>expected=-1.0, predicted=-8.1
>expected=-6.0, predicted=1.9
>expected=3.0, predicted=10.5
>expected=-4.0, predicted=0.3
>expected=-1.0, predicted=3.3
>expected=5.0, predicted=6.6
>expected=-3.0, predicted=6.2
 > Model[(0.2, 6, 9, 1000, 'CPU', 0, 12345)] 6.465
>expected=-1.0, predicted=-8.6
>expected=-6.0, predicted=-1.8
>expected=3.0, predicted=5.0
>expected=-4.0, predicted=6.3
>expected=-1.0, predicted=1.9
>expected=5.0, predicted=5.6
>expected=-3.0, predicted=0.9
 > Model[(0.2, 8, 1, 1000, 'CPU', 0, 12345)] 5.497
>expected=-1.0, predicted=-6.5
>expected=-6.0, predicted=-0.3
>expected=3.0, predicted=5.8
>expected=-4.0, predicted=1.1
>expected=-1.0, predicted=3.2
>expected=5.0, predicted=6.4
>expected=-3.0, predicted=2.7
 > Model[(0.2, 8, 3, 1000, 'CPU', 0, 12345)] 4.608
>expected=-1.0, predicted=-4.9
>expected=-6.0, predicted=2.5
>expected=3.0, predicted=5.6
>expected=-4.0, predicted=0.8
>expected=-1.0, predicted=5.1
>expected=5.0, predicted=8.2
>expected=-3.0, predicted=5.3
```

```
 > Model[(0.2, 8, 5, 1000, 'CPU', 0, 12345)] 5.776
>expected=-1.0, predicted=-3.3
>expected=-6.0, predicted=-0.5
>expected=3.0, predicted=5.8
>expected=-4.0, predicted=2.2
>expected=-1.0, predicted=2.5
>expected=5.0, predicted=5.3
>expected=-3.0, predicted=3.0
 > Model[(0.2, 8, 7, 1000, 'CPU', 0, 12345)] 4.336
>expected=-1.0, predicted=-6.4
>expected=-6.0, predicted=4.2
>expected=3.0, predicted=8.1
>expected=-4.0, predicted=-0.1
>expected=-1.0, predicted=4.4
>expected=5.0, predicted=10.8
>expected=-3.0, predicted=4.6
 > Model[(0.2, 8, 9, 1000, 'CPU', 0, 12345)] 6.499
>expected=-1.0, predicted=2.2
>expected=-6.0, predicted=3.6
>expected=3.0, predicted=4.1
>expected=-4.0, predicted=2.3
>expected=-1.0, predicted=-0.4
>expected=5.0, predicted=5.6
>expected=-3.0, predicted=1.0
 > Model[(0.2, 10, 1, 1000, 'CPU', 0, 12345)] 4.784
>expected=-1.0, predicted=-2.9
>expected=-6.0, predicted=1.0
>expected=3.0, predicted=7.3
>expected=-4.0, predicted=4.3
>expected=-1.0, predicted=3.8
>expected=5.0, predicted=6.9
>expected=-3.0, predicted=0.5
 > Model[(0.2, 10, 3, 1000, 'CPU', 0, 12345)] 5.062
>expected=-1.0, predicted=-5.5
>expected=-6.0, predicted=2.5
>expected=3.0, predicted=5.3
>expected=-4.0, predicted=0.8
>expected=-1.0, predicted=4.4
>expected=5.0, predicted=6.6
>expected=-3.0, predicted=1.9
 > Model[(0.2, 10, 5, 1000, 'CPU', 0, 12345)] 5.039
>expected=-1.0, predicted=-3.4
>expected=-6.0, predicted=1.3
>expected=3.0, predicted=8.6
>expected=-4.0, predicted=2.4
>expected=-1.0, predicted=4.3
>expected=5.0, predicted=6.7
>expected=-3.0, predicted=5.3
 > Model[(0.2, 10, 7, 1000, 'CPU', 0, 12345)] 5.749
>expected=-1.0, predicted=-1.1
>expected=-6.0, predicted=1.1
>expected=3.0, predicted=5.1
>expected=-4.0, predicted=1.6
>expected=-1.0, predicted=4.7
>expected=5.0, predicted=6.1
>expected=-3.0, predicted=0.7
 > Model[(0.2, 10, 9, 1000, 'CPU', 0, 12345)] 4.373
>expected=-1.0, predicted=-10.1
>expected=-6.0, predicted=4.5
>expected=3.0, predicted=10.9
>expected=-4.0, predicted=6.6
```

```
>expected=-1.0, predicted=6.1
>expected=5.0, predicted=10.4
>expected=-3.0, predicted=10.4
 > Model[(0.3, 2, 1, 1000, 'CPU', 0, 12345)] 9.458
>expected=-1.0, predicted=-11.4
>expected=-6.0, predicted=1.0
>expected=3.0, predicted=9.3
>expected=-4.0, predicted=5.5
>expected=-1.0, predicted=3.5
>expected=5.0, predicted=11.0
>expected=-3.0, predicted=11.3
 > Model[(0.3, 2, 3, 1000, 'CPU', 0, 12345)] 8.836
>expected=-1.0, predicted=-10.8
>expected=-6.0, predicted=2.6
>expected=3.0, predicted=10.5
>expected=-4.0, predicted=2.7
>expected=-1.0, predicted=4.2
>expected=5.0, predicted=6.4
>expected=-3.0, predicted=9.6
 > Model[(0.3, 2, 5, 1000, 'CPU', 0, 12345)] 8.096
>expected=-1.0, predicted=-9.2
>expected=-6.0, predicted=1.2
>expected=3.0, predicted=10.3
>expected=-4.0, predicted=7.1
>expected=-1.0, predicted=1.5
>expected=5.0, predicted=4.7
>expected=-3.0, predicted=11.1
 > Model[(0.3, 2, 7, 1000, 'CPU', 0, 12345)] 8.476
>expected=-1.0, predicted=-9.6
>expected=-6.0, predicted=2.5
>expected=3.0, predicted=10.9
>expected=-4.0, predicted=4.8
>expected=-1.0, predicted=4.8
>expected=5.0, predicted=7.3
>expected=-3.0, predicted=10.2
 > Model[(0.3, 2, 9, 1000, 'CPU', 0, 12345)] 8.427
>expected=-1.0, predicted=-2.5
>expected=-6.0, predicted=3.0
>expected=3.0, predicted=13.2
>expected=-4.0, predicted=2.7
>expected=-1.0, predicted=13.8
>expected=5.0, predicted=7.2
>expected=-3.0, predicted=10.0
 > Model[(0.3, 4, 1, 1000, 'CPU', 0, 12345)] 9.465
>expected=-1.0, predicted=-5.9
>expected=-6.0, predicted=1.5
>expected=3.0, predicted=5.0
>expected=-4.0, predicted=2.1
>expected=-1.0, predicted=4.7
>expected=5.0, predicted=8.0
>expected=-3.0, predicted=4.8
 > Model[(0.3, 4, 3, 1000, 'CPU', 0, 12345)] 5.649
>expected=-1.0, predicted=-10.0
>expected=-6.0, predicted=0.4
>expected=3.0, predicted=7.6
>expected=-4.0, predicted=-0.0
>expected=-1.0, predicted=3.4
>expected=5.0, predicted=7.0
>expected=-3.0, predicted=5.3
 > Model[(0.3, 4, 5, 1000, 'CPU', 0, 12345)] 6.004
>expected=-1.0, predicted=-9.8
```

```
>expected=-6.0, predicted=2.7
>expected=3.0, predicted=13.9
>expected=-4.0, predicted=1.3
>expected=-1.0, predicted=3.9
>expected=5.0, predicted=9.5
>expected=-3.0, predicted=6.4
 > Model[(0.3, 4, 7, 1000, 'CPU', 0, 12345)] 7.847
>expected=-1.0, predicted=-9.7
>expected=-6.0, predicted=4.1
>expected=3.0, predicted=11.0
>expected=-4.0, predicted=1.8
>expected=-1.0, predicted=3.7
>expected=5.0, predicted=6.9
>expected=-3.0, predicted=7.2
 > Model[(0.3, 4, 9, 1000, 'CPU', 0, 12345)] 7.601
>expected=-1.0, predicted=-4.8
>expected=-6.0, predicted=-3.1
>expected=3.0, predicted=9.3
>expected=-4.0, predicted=1.5
>expected=-1.0, predicted=0.8
>expected=5.0, predicted=6.2
>expected=-3.0, predicted=4.5
 > Model[(0.3, 6, 1, 1000, 'CPU', 0, 12345)] 4.660
>expected=-1.0, predicted=-10.7
>expected=-6.0, predicted=1.5
>expected=3.0, predicted=6.9
>expected=-4.0, predicted=1.5
>expected=-1.0, predicted=0.5
>expected=5.0, predicted=6.6
>expected=-3.0, predicted=4.9
 > Model[(0.3, 6, 3, 1000, 'CPU', 0, 12345)] 6.134
>expected=-1.0, predicted=-7.6
>expected=-6.0, predicted=2.0
>expected=3.0, predicted=6.6
>expected=-4.0, predicted=4.3
>expected=-1.0, predicted=2.9
>expected=5.0, predicted=7.2
>expected=-3.0, predicted=2.7
 > Model[(0.3, 6, 5, 1000, 'CPU', 0, 12345)] 5.870
>expected=-1.0, predicted=-8.3
>expected=-6.0, predicted=2.8
>expected=3.0, predicted=8.9
>expected=-4.0, predicted=2.5
>expected=-1.0, predicted=6.1
>expected=5.0, predicted=7.0
>expected=-3.0, predicted=5.1
 > Model[(0.3, 6, 7, 1000, 'CPU', 0, 12345)] 6.847
>expected=-1.0, predicted=-7.0
>expected=-6.0, predicted=3.3
>expected=3.0, predicted=7.6
>expected=-4.0, predicted=2.6
>expected=-1.0, predicted=2.6
>expected=5.0, predicted=6.7
>expected=-3.0, predicted=4.1
 > Model[(0.3, 6, 9, 1000, 'CPU', 0, 12345)] 6.025
>expected=-1.0, predicted=-6.8
>expected=-6.0, predicted=-1.4
>expected=3.0, predicted=4.9
>expected=-4.0, predicted=4.8
>expected=-1.0, predicted=1.5
>expected=5.0, predicted=9.7
```

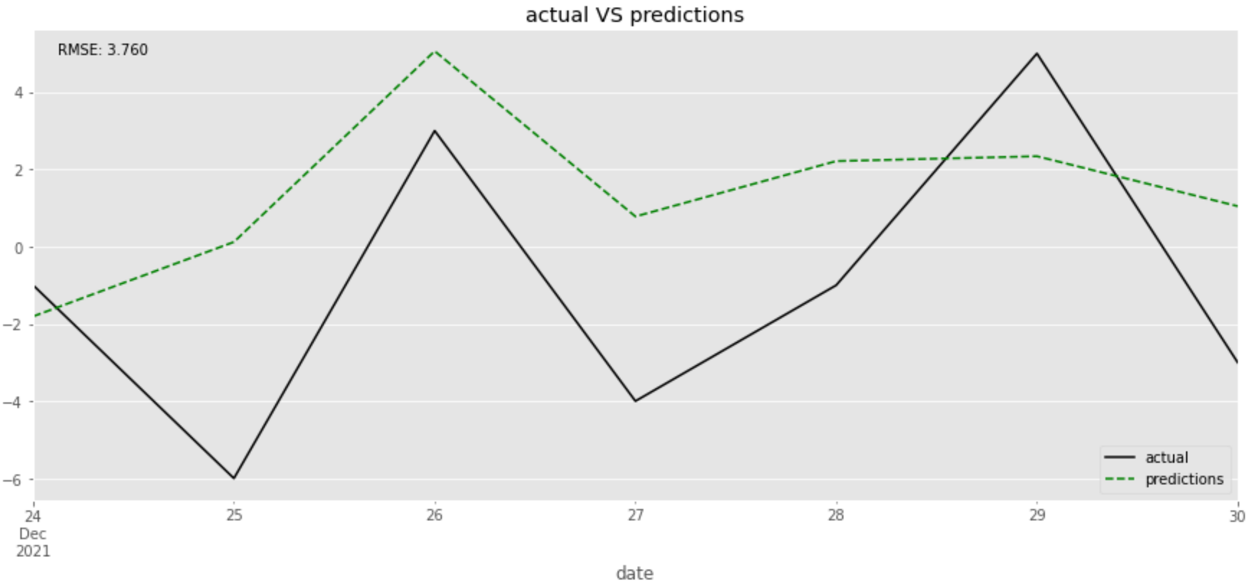
```
>expected=-3.0, predicted=0.3
 > Model[(0.3, 8, 1, 1000, 'CPU', 0, 12345)] 4.999
>expected=-1.0, predicted=-7.8
>expected=-6.0, predicted=-0.8
>expected=3.0, predicted=8.3
>expected=-4.0, predicted=1.4
>expected=-1.0, predicted=0.1
>expected=5.0, predicted=7.6
>expected=-3.0, predicted=0.1
 > Model[(0.3, 8, 3, 1000, 'CPU', 0, 12345)] 4.613
>expected=-1.0, predicted=-3.3
>expected=-6.0, predicted=2.6
>expected=3.0, predicted=4.4
>expected=-4.0, predicted=-1.8
>expected=-1.0, predicted=8.6
>expected=5.0, predicted=3.9
>expected=-3.0, predicted=2.6
 > Model[(0.3, 8, 5, 1000, 'CPU', 0, 12345)] 5.496
>expected=-1.0, predicted=-5.8
>expected=-6.0, predicted=5.3
>expected=3.0, predicted=7.0
>expected=-4.0, predicted=1.7
>expected=-1.0, predicted=3.4
>expected=5.0, predicted=4.6
>expected=-3.0, predicted=2.3
 > Model[(0.3, 8, 7, 1000, 'CPU', 0, 12345)] 5.919
>expected=-1.0, predicted=-2.9
>expected=-6.0, predicted=2.3
>expected=3.0, predicted=8.4
>expected=-4.0, predicted=2.3
>expected=-1.0, predicted=2.0
>expected=5.0, predicted=11.2
>expected=-3.0, predicted=5.0
 > Model[(0.3, 8, 9, 1000, 'CPU', 0, 12345)] 5.993
>expected=-1.0, predicted=-4.8
>expected=-6.0, predicted=0.9
>expected=3.0, predicted=4.6
>expected=-4.0, predicted=1.8
>expected=-1.0, predicted=4.6
>expected=5.0, predicted=10.1
>expected=-3.0, predicted=0.9
 > Model[(0.3, 10, 1, 1000, 'CPU', 0, 12345)] 4.940
>expected=-1.0, predicted=-4.0
>expected=-6.0, predicted=0.1
>expected=3.0, predicted=1.1
>expected=-4.0, predicted=-0.5
>expected=-1.0, predicted=1.9
>expected=5.0, predicted=6.5
>expected=-3.0, predicted=3.2
 > Model[(0.3, 10, 3, 1000, 'CPU', 0, 12345)] 3.985
>expected=-1.0, predicted=-6.9
>expected=-6.0, predicted=1.3
>expected=3.0, predicted=5.4
>expected=-4.0, predicted=0.2
>expected=-1.0, predicted=-3.1
>expected=5.0, predicted=8.6
>expected=-3.0, predicted=3.2
 > Model[(0.3, 10, 5, 1000, 'CPU', 0, 12345)] 4.884
>expected=-1.0, predicted=-2.5
>expected=-6.0, predicted=3.5
>expected=3.0, predicted=1.4
```

```
>expected=-4.0, predicted=2.1
>expected=-1.0, predicted=1.6
>expected=5.0, predicted=6.1
>expected=-3.0, predicted=3.7
 > Model[(0.3, 10, 7, 1000, 'CPU', 0, 12345)] 5.131
>expected=-1.0, predicted=-3.4
>expected=-6.0, predicted=3.6
>expected=3.0, predicted=3.9
>expected=-4.0, predicted=2.5
>expected=-1.0, predicted=4.4
>expected=5.0, predicted=5.3
>expected=-3.0, predicted=2.7
 > Model[(0.3, 10, 9, 1000, 'CPU', 0, 12345)] 5.383
Лучшие модели:
(0.01, 2, 9, 1000, 'CPU', 0, 12345) 3.760407747333892
(0.01, 2, 7, 1000, 'CPU', 0, 12345) 3.8028673083024542
(0.01, 10, 9, 1000, 'CPU', 0, 12345) 3.8710005116083273
```

In [266…

```
n_test = 7
target = 'quantity'
config = (0.01, 2, 9, 1000, 'CPU', 0, 12345)
walk_forward_validation(data, n_test, target, config, plot=True)
```

```
>expected=-1.0, predicted=-1.8
>expected=-6.0, predicted=0.1
>expected=3.0, predicted=5.1
>expected=-4.0, predicted=0.8
>expected=-1.0, predicted=2.2
>expected=5.0, predicted=2.3
>expected=-3.0, predicted=1.0
```



Мы построили модель CatBoost, однако в нашем случае она уступает модели SARIMA.

Нейронная сеть для временного ряда

Такие нейронные сети обладают рядом особенностей:

- Устойчивость к шуму. Нейронные сети устойчивы к шуму во входных данных и могут поддерживать обучение и прогнозирование при наличии отсутствующих значений.
- Нелинейность. Нейронные сети способны аппроксимировать произвольные нелинейные функции и учитывать линейные и нелинейные отношения.
- Многомерные входы. Можно указать произвольное количество входных функций.
- Многоэтапные прогнозы. Можно указать произвольное количество выходных значений, обеспечивающее поддержку многоступенчатого и даже многомерного прогнозирования.
- Фиксированные входы. Количество входных переменных с задержкой фиксировано так же, как и традиционные методы прогнозирования временных рядов.
- Выходные данные. Количество выходных переменных также фиксировано.

Рекуррентные нейронные сети, такие как сеть Long Short-Term Memory, добавляют явную обработку порядка между наблюдениями при изучении функции отображения от входов к выходам.

Добавление последовательности является новым измерением к аппроксимируемой функции. Вместо того, чтобы сопоставлять входы только с выходами, сеть способна со временем изучать функцию сопоставления входов с выходом.

В простейшем случае сеть показывает по одному наблюдению за раз из последовательности и может узнать, какие наблюдения она видела ранее, актуальны лм они, и насколько они актуальны для прогнозирования.

Если для традиционных методов прогнозирования временных рядов обязательно наличие стационарности ряда, то для нейронных сетей стационарность может не быть обязательным требованием для построения хорошей модели.

Vanilla LSTM

In [120…

```
from keras.models import Sequential
from keras.layers import LSTM
from keras.layers import Dense
```

На вход модель LSTM принимает последовательность прошлых наблюдений. Преобразуем датасет соответствующим образом.

Оставим в качестве признаков только лаги.

In [121…

```
data = data.drop(columns=['month', 'day', 'dayofweek'])
data
```

Out[121…

	quantity	quantity_lag_1	quantity_lag_2	quantity_lag_3	quantity_lag_4	quantity_la
date						
2021-01-05	26.0	NaN	NaN	NaN	NaN	I
2021-01-06	-5.0	26.0	NaN	NaN	NaN	I
2021-01-07	3.0	-5.0	26.0	NaN	NaN	I
2021-01-08	5.0	3.0	-5.0	26.0	NaN	I
2021-01-09	3.0	5.0	3.0	-5.0	26.0	I
...	...	...	...	...	...	
2021-12-26	3.0	-6.0	-1.0	1.0	8.0	
2021-12-27	-4.0	3.0	-6.0	-1.0	1.0	
2021-12-28	-1.0	-4.0	3.0	-6.0	-1.0	
2021-12-29	5.0	-1.0	-4.0	3.0	-6.0	
2021-12-30	-3.0	5.0	-1.0	-4.0	3.0	

352 rows × 8 columns

В отличие от моделей из библиотеки CatBoost, которые по умолчанию удаляют NaN значения, на вход в LSTM нам нужно подать уже очищенные значения.

In [122…

```
data = data.dropna()
```

Изменим функцию `walk_forward_validation()` применительно к модели LSTM.

In [123…

```
# walk-forward validation for LSTM
def walk_forward_validation(data, n_test, target, config, plot=False):
    predictions = list()
    # разбиваем последовательность
    train, test = series_train_test_split(data, n_test)
    # сохраняем обучающую выборку в истории
    history = train
    # проходимся по каждому из значений в тестовой последовательности
    for i in range(len(test)):
        # выделяем признаки и целевой признак в тесте
        features_test, target_test = test.drop(columns=[target]).iloc[i], t
        # обучаемся на истории и делаем предсказание на шаг вперёд
        prediction = lstm_forecast(history, features_test, target, config)
        # сохраняем предсказание в список
        predictions.append(prediction)
        # сохраняем действительное значение в историю
        history.append(test.iloc[i])
        # для отслеживания процесса на каждом шаге:
        print('>expected=%.1f, predicted=%.1f' % (target_test, prediction)
    # вычисляем ошибку предсказаний
    error = rmse(test[target], predictions)
    #return error, test[target], predictions
    if plot:
        # график для визуального сравнения предсказанных значений с действ
        # (по умолчанию не строим)
        plot_result(n_test, error, test[target], predictions)
        return error, test[target], predictions
    else:
        # по умолчанию возвращаем интересующую метрику качества
        return error
```

Напишем функцию для одношагового прогноза при помощи LSTM.

In [124…

```
config = (70, 'relu', 'adam', 'mse', 1, 270, 1)
# lstm-прогноз на шаг вперёд
def lstm_forecast(train,
                  features_test, # строка признаков для валидаии
                  target, # имя колонки датафрейма целевого признака
                  config):
    # определяем конфигурацию
    units, activation, optimizer, loss, n_features, epochs, verbose = conf
    # выделяем целевой признак из train
    features_train, target_train = train.drop(columns=[target]), train[targ
    # преобразуем датафреймы в объекты numpy (нам нужен определённый форма
    features_train_arr = features_train.to_numpy()
    features_test_arr = features_test.to_numpy()
    target_train_arr = target_train.to_numpy()
    # Модель принимает тренировочные данные в таком формате: (samples, tim
    # Изменим форму входных данных.
    n_steps = features_train_arr.shape[1]
    features_train_arr = features_train_arr.reshape((features_train.shape[
    features_test_arr = features_test_arr.reshape((1, n_steps, n_features)
    # определяем модель
    model_vanilla_LSTM = Sequential()
    model_vanilla_LSTM.add(LSTM(units=units, activation=activation, input_
    model_vanilla_LSTM.add(Dense(1))
    model_vanilla_LSTM.compile(optimizer='adam', loss='mse')
    # обучаем модель, на выходе получаем обученную модель с минимальной MS
    model_vanilla_LSTM.fit(features_train_arr, target_train_arr, epochs=epo
    # делаем прогноз на шаг вперед
    prediction = model_vanilla_LSTM.predict(features_test_arr)
    #prediction = pd.DataFrame(prediction[0], columns=['prediction'], inde
    #prediction = prediction.reshape((features_train.shape[0], n_steps))
    return prediction[0]
```

Так как обучение нейросети займёт значительное время, а из гиперпараметров мы будем менять разве что количество нейронов в скрытом слое и количество эпох, то функцию `grid_search()` специально писать не будем.

In [125…

```
error_stckd, val, pred_stckd = walk_forward_validation(data, 7, 'quantity'
```

```
Epoch 1/270
11/11 [==============================] - 2s 5ms/step - loss: 136.0064
Epoch 2/270
11/11 [==============================] - 0s 5ms/step - loss: 133.3614
Epoch 3/270
11/11 [==============================] - 0s 5ms/step - loss: 130.2023
Epoch 4/270
11/11 [==============================] - 0s 6ms/step - loss: 121.9947
Epoch 5/270
11/11 [==============================] - 0s 5ms/step - loss: 102.7057
Epoch 6/270
11/11 [==============================] - 0s 5ms/step - loss: 91.6894
Epoch 7/270
11/11 [==============================] - 0s 5ms/step - loss: 99.5159
Epoch 8/270
11/11 [==============================] - 0s 5ms/step - loss: 96.3748
Epoch 9/270
```

```
11/11 [==============================] - 0s 5ms/step - loss: 85.4527
Epoch 10/270
11/11 [==============================] - 0s 7ms/step - loss: 88.9953
Epoch 11/270
11/11 [==============================] - 0s 5ms/step - loss: 86.2955
Epoch 12/270
11/11 [==============================] - 0s 5ms/step - loss: 81.7419
Epoch 13/270
11/11 [==============================] - 0s 5ms/step - loss: 81.2393
Epoch 14/270
11/11 [==============================] - 0s 5ms/step - loss: 79.2705
Epoch 15/270
11/11 [==============================] - 0s 5ms/step - loss: 81.1145
Epoch 16/270
11/11 [==============================] - 0s 5ms/step - loss: 77.2212
Epoch 17/270
11/11 [==============================] - 0s 6ms/step - loss: 77.7946
Epoch 18/270
11/11 [==============================] - 0s 5ms/step - loss: 73.9082
Epoch 19/270
11/11 [==============================] - 0s 5ms/step - loss: 72.9242
Epoch 20/270
11/11 [==============================] - 0s 5ms/step - loss: 72.4808
Epoch 21/270
11/11 [==============================] - 0s 7ms/step - loss: 70.0792
Epoch 22/270
11/11 [==============================] - 0s 5ms/step - loss: 69.5165
Epoch 23/270
11/11 [==============================] - 0s 5ms/step - loss: 72.4822
Epoch 24/270
11/11 [==============================] - 0s 5ms/step - loss: 70.3398
Epoch 25/270
11/11 [==============================] - 0s 5ms/step - loss: 68.8997
Epoch 26/270
11/11 [==============================] - 0s 6ms/step - loss: 66.2689
Epoch 27/270
11/11 [==============================] - 0s 5ms/step - loss: 65.1430
Epoch 28/270
11/11 [==============================] - 0s 5ms/step - loss: 66.0814
Epoch 29/270
11/11 [==============================] - 0s 5ms/step - loss: 63.6436
Epoch 30/270
11/11 [==============================] - 0s 5ms/step - loss: 61.4414
Epoch 31/270
11/11 [==============================] - 0s 5ms/step - loss: 61.3532
Epoch 32/270
11/11 [==============================] - 0s 5ms/step - loss: 60.5484
Epoch 33/270
11/11 [==============================] - 0s 5ms/step - loss: 65.0378
Epoch 34/270
11/11 [==============================] - 0s 5ms/step - loss: 58.8126
Epoch 35/270
11/11 [==============================] - 0s 5ms/step - loss: 57.7011
Epoch 36/270
11/11 [==============================] - 0s 5ms/step - loss: 55.6348
Epoch 37/270
11/11 [==============================] - 0s 5ms/step - loss: 55.4409
Epoch 38/270
11/11 [==============================] - 0s 5ms/step - loss: 57.3608
Epoch 39/270
11/11 [==============================] - 0s 5ms/step - loss: 53.1639
```

```
Epoch 40/270
11/11 [==============================] - 0s 5ms/step - loss: 52.0997
Epoch 41/270
11/11 [==============================] - 0s 6ms/step - loss: 50.6574
Epoch 42/270
11/11 [==============================] - 0s 5ms/step - loss: 49.3999
Epoch 43/270
11/11 [==============================] - 0s 5ms/step - loss: 47.8435
Epoch 44/270
11/11 [==============================] - 0s 6ms/step - loss: 46.3023
Epoch 45/270
11/11 [==============================] - 0s 5ms/step - loss: 45.5367
Epoch 46/270
11/11 [==============================] - 0s 5ms/step - loss: 45.0832
Epoch 47/270
11/11 [==============================] - 0s 5ms/step - loss: 47.9775
Epoch 48/270
11/11 [==============================] - 0s 5ms/step - loss: 47.6078
Epoch 49/270
11/11 [==============================] - 0s 5ms/step - loss: 44.4522
Epoch 50/270
11/11 [==============================] - 0s 6ms/step - loss: 44.6239
Epoch 51/270
11/11 [==============================] - 0s 5ms/step - loss: 41.5763
Epoch 52/270
11/11 [==============================] - 0s 5ms/step - loss: 42.2254
Epoch 53/270
11/11 [==============================] - 0s 5ms/step - loss: 40.3928
Epoch 54/270
11/11 [==============================] - 0s 5ms/step - loss: 43.5378
Epoch 55/270
11/11 [==============================] - 0s 5ms/step - loss: 42.1760
Epoch 56/270
11/11 [==============================] - 0s 5ms/step - loss: 41.2004
Epoch 57/270
11/11 [==============================] - 0s 5ms/step - loss: 39.5830
Epoch 58/270
11/11 [==============================] - 0s 5ms/step - loss: 39.2810
Epoch 59/270
11/11 [==============================] - 0s 5ms/step - loss: 36.7705
Epoch 60/270
11/11 [==============================] - 0s 7ms/step - loss: 36.1900
Epoch 61/270
11/11 [==============================] - 0s 5ms/step - loss: 35.8416
Epoch 62/270
11/11 [==============================] - 0s 5ms/step - loss: 33.4045
Epoch 63/270
11/11 [==============================] - 0s 5ms/step - loss: 31.2724
Epoch 64/270
11/11 [==============================] - 0s 5ms/step - loss: 31.0519
Epoch 65/270
11/11 [==============================] - 0s 5ms/step - loss: 30.3543
Epoch 66/270
11/11 [==============================] - 0s 5ms/step - loss: 28.7178
Epoch 67/270
11/11 [==============================] - 0s 6ms/step - loss: 27.8154
Epoch 68/270
11/11 [==============================] - 0s 5ms/step - loss: 26.2412
Epoch 69/270
11/11 [==============================] - 0s 4ms/step - loss: 27.5788
Epoch 70/270
```

```
11/11 [==============================] - 0s 5ms/step - loss: 25.7057
Epoch 71/270
11/11 [==============================] - 0s 5ms/step - loss: 23.6658
Epoch 72/270
11/11 [==============================] - 0s 5ms/step - loss: 25.4389
Epoch 73/270
11/11 [==============================] - 0s 5ms/step - loss: 24.2433
Epoch 74/270
11/11 [==============================] - 0s 5ms/step - loss: 20.6596
Epoch 75/270
11/11 [==============================] - 0s 5ms/step - loss: 22.7752
Epoch 76/270
11/11 [==============================] - 0s 5ms/step - loss: 22.2327
Epoch 77/270
11/11 [==============================] - 0s 5ms/step - loss: 26.0234
Epoch 78/270
11/11 [==============================] - 0s 6ms/step - loss: 22.4330
Epoch 79/270
11/11 [==============================] - 0s 5ms/step - loss: 20.3691
Epoch 80/270
11/11 [==============================] - 0s 5ms/step - loss: 18.3374
Epoch 81/270
11/11 [==============================] - 0s 5ms/step - loss: 17.8379
Epoch 82/270
11/11 [==============================] - 0s 5ms/step - loss: 18.6308
Epoch 83/270
11/11 [==============================] - 0s 5ms/step - loss: 17.6024
Epoch 84/270
11/11 [==============================] - 0s 5ms/step - loss: 16.2183
Epoch 85/270
11/11 [==============================] - 0s 6ms/step - loss: 15.6017
Epoch 86/270
11/11 [==============================] - 0s 7ms/step - loss: 16.6638
Epoch 87/270
11/11 [==============================] - 0s 6ms/step - loss: 17.0051
Epoch 88/270
11/11 [==============================] - 0s 5ms/step - loss: 15.9893
Epoch 89/270
11/11 [==============================] - 0s 6ms/step - loss: 16.4547
Epoch 90/270
11/11 [==============================] - 0s 5ms/step - loss: 15.2576
Epoch 91/270
11/11 [==============================] - 0s 5ms/step - loss: 14.2930
Epoch 92/270
11/11 [==============================] - 0s 5ms/step - loss: 12.3325
Epoch 93/270
11/11 [==============================] - 0s 7ms/step - loss: 11.6485
Epoch 94/270
11/11 [==============================] - 0s 6ms/step - loss: 10.8579
Epoch 95/270
11/11 [==============================] - 0s 5ms/step - loss: 10.6674
Epoch 96/270
11/11 [==============================] - 0s 5ms/step - loss: 10.5811
Epoch 97/270
11/11 [==============================] - 0s 5ms/step - loss: 10.1109
Epoch 98/270
11/11 [==============================] - 0s 5ms/step - loss: 10.5528
Epoch 99/270
11/11 [==============================] - 0s 6ms/step - loss: 10.4360
Epoch 100/270
11/11 [==============================] - 0s 4ms/step - loss: 10.3579
```

```
Epoch 101/270
11/11 [==============================] - 0s 5ms/step - loss: 9.6695
Epoch 102/270
11/11 [==============================] - 0s 5ms/step - loss: 8.8435
Epoch 103/270
11/11 [==============================] - 0s 5ms/step - loss: 9.2732
Epoch 104/270
11/11 [==============================] - 0s 5ms/step - loss: 8.0153
Epoch 105/270
11/11 [==============================] - 0s 5ms/step - loss: 7.8105
Epoch 106/270
11/11 [==============================] - 0s 5ms/step - loss: 7.7025
Epoch 107/270
11/11 [==============================] - 0s 5ms/step - loss: 7.6829
Epoch 108/270
11/11 [==============================] - 0s 6ms/step - loss: 7.9947
Epoch 109/270
11/11 [==============================] - 0s 5ms/step - loss: 7.5304
Epoch 110/270
11/11 [==============================] - 0s 6ms/step - loss: 7.5021
Epoch 111/270
11/11 [==============================] - 0s 5ms/step - loss: 6.4878
Epoch 112/270
11/11 [==============================] - 0s 6ms/step - loss: 7.6778
Epoch 113/270
11/11 [==============================] - 0s 5ms/step - loss: 7.6174
Epoch 114/270
11/11 [==============================] - 0s 5ms/step - loss: 7.8407
Epoch 115/270
11/11 [==============================] - 0s 4ms/step - loss: 6.7818
Epoch 116/270
11/11 [==============================] - 0s 4ms/step - loss: 7.5380
Epoch 117/270
11/11 [==============================] - 0s 5ms/step - loss: 7.4684
Epoch 118/270
11/11 [==============================] - 0s 6ms/step - loss: 6.2520
Epoch 119/270
11/11 [==============================] - 0s 5ms/step - loss: 5.6679
Epoch 120/270
11/11 [==============================] - 0s 5ms/step - loss: 5.4801
Epoch 121/270
11/11 [==============================] - 0s 5ms/step - loss: 5.2674
Epoch 122/270
11/11 [==============================] - 0s 5ms/step - loss: 4.6586
Epoch 123/270
11/11 [==============================] - 0s 5ms/step - loss: 3.6173
Epoch 124/270
11/11 [==============================] - 0s 5ms/step - loss: 3.5054
Epoch 125/270
11/11 [==============================] - 0s 5ms/step - loss: 3.3579
Epoch 126/270
11/11 [==============================] - 0s 5ms/step - loss: 3.6484
Epoch 127/270
11/11 [==============================] - 0s 5ms/step - loss: 3.6577
Epoch 128/270
11/11 [==============================] - 0s 5ms/step - loss: 3.5619
Epoch 129/270
11/11 [==============================] - 0s 5ms/step - loss: 3.8791
Epoch 130/270
11/11 [==============================] - 0s 4ms/step - loss: 4.2394
Epoch 131/270
```

```
11/11 [==============================] - 0s 5ms/step - loss: 4.6450
Epoch 132/270
11/11 [==============================] - 0s 5ms/step - loss: 4.4595
Epoch 133/270
11/11 [==============================] - 0s 5ms/step - loss: 4.6814
Epoch 134/270
11/11 [==============================] - 0s 5ms/step - loss: 4.5676
Epoch 135/270
11/11 [==============================] - 0s 5ms/step - loss: 4.6892
Epoch 136/270
11/11 [==============================] - 0s 5ms/step - loss: 3.4730
Epoch 137/270
11/11 [==============================] - 0s 5ms/step - loss: 3.6413
Epoch 138/270
11/11 [==============================] - 0s 5ms/step - loss: 3.1299
Epoch 139/270
11/11 [==============================] - 0s 5ms/step - loss: 2.9435
Epoch 140/270
11/11 [==============================] - 0s 5ms/step - loss: 2.8038
Epoch 141/270
11/11 [==============================] - 0s 5ms/step - loss: 2.5247
Epoch 142/270
11/11 [==============================] - 0s 5ms/step - loss: 2.2854
Epoch 143/270
11/11 [==============================] - 0s 5ms/step - loss: 2.1797
Epoch 144/270
11/11 [==============================] - 0s 7ms/step - loss: 1.9440
Epoch 145/270
11/11 [==============================] - 0s 5ms/step - loss: 2.1910
Epoch 146/270
11/11 [==============================] - 0s 5ms/step - loss: 1.8288
Epoch 147/270
11/11 [==============================] - 0s 5ms/step - loss: 1.5870
Epoch 148/270
11/11 [==============================] - 0s 6ms/step - loss: 1.5475
Epoch 149/270
11/11 [==============================] - 0s 5ms/step - loss: 1.5985
Epoch 150/270
11/11 [==============================] - 0s 5ms/step - loss: 1.6574
Epoch 151/270
11/11 [==============================] - 0s 5ms/step - loss: 1.5012
Epoch 152/270
11/11 [==============================] - 0s 6ms/step - loss: 1.3977
Epoch 153/270
11/11 [==============================] - 0s 5ms/step - loss: 1.3041
Epoch 154/270
11/11 [==============================] - 0s 5ms/step - loss: 1.3725
Epoch 155/270
11/11 [==============================] - 0s 5ms/step - loss: 1.4081
Epoch 156/270
11/11 [==============================] - 0s 6ms/step - loss: 1.3457
Epoch 157/270
11/11 [==============================] - 0s 5ms/step - loss: 1.4045
Epoch 158/270
11/11 [==============================] - 0s 5ms/step - loss: 1.4028
Epoch 159/270
11/11 [==============================] - 0s 4ms/step - loss: 1.7084
Epoch 160/270
11/11 [==============================] - 0s 6ms/step - loss: 1.6628
Epoch 161/270
11/11 [==============================] - 0s 5ms/step - loss: 1.5731
```

```
Epoch 162/270
11/11 [==============================] - 0s 5ms/step - loss: 2.2015
Epoch 163/270
11/11 [==============================] - 0s 5ms/step - loss: 2.1334
Epoch 164/270
11/11 [==============================] - 0s 5ms/step - loss: 1.8343
Epoch 165/270
11/11 [==============================] - 0s 5ms/step - loss: 1.6710
Epoch 166/270
11/11 [==============================] - 0s 6ms/step - loss: 1.5175
Epoch 167/270
11/11 [==============================] - 0s 5ms/step - loss: 1.4987
Epoch 168/270
11/11 [==============================] - 0s 5ms/step - loss: 1.6539
Epoch 169/270
11/11 [==============================] - 0s 5ms/step - loss: 1.7545
Epoch 170/270
11/11 [==============================] - 0s 5ms/step - loss: 1.7778
Epoch 171/270
11/11 [==============================] - 0s 5ms/step - loss: 1.4865
Epoch 172/270
11/11 [==============================] - 0s 5ms/step - loss: 1.3338
Epoch 173/270
11/11 [==============================] - 0s 5ms/step - loss: 1.2012
Epoch 174/270
11/11 [==============================] - 0s 5ms/step - loss: 1.2679
Epoch 175/270
11/11 [==============================] - 0s 5ms/step - loss: 1.0546
Epoch 176/270
11/11 [==============================] - 0s 6ms/step - loss: 0.9938
Epoch 177/270
11/11 [==============================] - 0s 5ms/step - loss: 1.2345
Epoch 178/270
11/11 [==============================] - 0s 5ms/step - loss: 1.2018
Epoch 179/270
11/11 [==============================] - 0s 6ms/step - loss: 1.0084
Epoch 180/270
11/11 [==============================] - 0s 5ms/step - loss: 0.9694
Epoch 181/270
11/11 [==============================] - 0s 5ms/step - loss: 1.2091
Epoch 182/270
11/11 [==============================] - 0s 4ms/step - loss: 1.1321
Epoch 183/270
11/11 [==============================] - 0s 5ms/step - loss: 0.9446
Epoch 184/270
11/11 [==============================] - 0s 5ms/step - loss: 0.8419
Epoch 185/270
11/11 [==============================] - 0s 5ms/step - loss: 0.7889
Epoch 186/270
11/11 [==============================] - 0s 5ms/step - loss: 0.8105
Epoch 187/270
11/11 [==============================] - 0s 6ms/step - loss: 0.6798
Epoch 188/270
11/11 [==============================] - 0s 5ms/step - loss: 0.6877
Epoch 189/270
11/11 [==============================] - 0s 6ms/step - loss: 0.6955
Epoch 190/270
11/11 [==============================] - 0s 5ms/step - loss: 0.6616
Epoch 191/270
11/11 [==============================] - 0s 5ms/step - loss: 0.7610
Epoch 192/270
```

```
11/11 [==============================] - 0s 6ms/step - loss: 0.8370
Epoch 193/270
11/11 [==============================] - 0s 5ms/step - loss: 0.8976
Epoch 194/270
11/11 [==============================] - 0s 5ms/step - loss: 0.6733
Epoch 195/270
11/11 [==============================] - 0s 5ms/step - loss: 0.8665
Epoch 196/270
11/11 [==============================] - 0s 5ms/step - loss: 1.0790
Epoch 197/270
11/11 [==============================] - 0s 5ms/step - loss: 1.2089
Epoch 198/270
11/11 [==============================] - 0s 5ms/step - loss: 0.8968
Epoch 199/270
11/11 [==============================] - 0s 5ms/step - loss: 0.9496
Epoch 200/270
11/11 [==============================] - 0s 5ms/step - loss: 1.0090
Epoch 201/270
11/11 [==============================] - 0s 5ms/step - loss: 0.7978
Epoch 202/270
11/11 [==============================] - 0s 5ms/step - loss: 0.9945
Epoch 203/270
11/11 [==============================] - 0s 5ms/step - loss: 1.0368
Epoch 204/270
11/11 [==============================] - 0s 5ms/step - loss: 0.9424
Epoch 205/270
11/11 [==============================] - 0s 5ms/step - loss: 0.9150
Epoch 206/270
11/11 [==============================] - 0s 6ms/step - loss: 0.8312
Epoch 207/270
11/11 [==============================] - 0s 5ms/step - loss: 0.5806
Epoch 208/270
11/11 [==============================] - 0s 5ms/step - loss: 0.5558
Epoch 209/270
11/11 [==============================] - 0s 7ms/step - loss: 0.5760
Epoch 210/270
11/11 [==============================] - 0s 5ms/step - loss: 0.5206
Epoch 211/270
11/11 [==============================] - 0s 5ms/step - loss: 0.5644
Epoch 212/270
11/11 [==============================] - 0s 5ms/step - loss: 0.5542
Epoch 213/270
11/11 [==============================] - 0s 5ms/step - loss: 0.7049
Epoch 214/270
11/11 [==============================] - 0s 5ms/step - loss: 0.8205
Epoch 215/270
11/11 [==============================] - 0s 5ms/step - loss: 0.9832
Epoch 216/270
11/11 [==============================] - 0s 5ms/step - loss: 1.1749
Epoch 217/270
11/11 [==============================] - 0s 5ms/step - loss: 1.1863
Epoch 218/270
11/11 [==============================] - 0s 5ms/step - loss: 1.1175
Epoch 219/270
11/11 [==============================] - 0s 5ms/step - loss: 1.1278
Epoch 220/270
11/11 [==============================] - 0s 5ms/step - loss: 1.1059
Epoch 221/270
11/11 [==============================] - 0s 6ms/step - loss: 1.2726
Epoch 222/270
11/11 [==============================] - 0s 5ms/step - loss: 1.0427
```

```
Epoch 223/270
11/11 [==============================] - 0s 5ms/step - loss: 1.0038
Epoch 224/270
11/11 [==============================] - 0s 5ms/step - loss: 0.9994
Epoch 225/270
11/11 [==============================] - 0s 5ms/step - loss: 0.8949
Epoch 226/270
11/11 [==============================] - 0s 6ms/step - loss: 0.9438
Epoch 227/270
11/11 [==============================] - 0s 5ms/step - loss: 1.0505
Epoch 228/270
11/11 [==============================] - 0s 5ms/step - loss: 1.0195
Epoch 229/270
11/11 [==============================] - 0s 5ms/step - loss: 0.7463
Epoch 230/270
11/11 [==============================] - 0s 5ms/step - loss: 0.7391
Epoch 231/270
11/11 [==============================] - 0s 5ms/step - loss: 0.9165
Epoch 232/270
11/11 [==============================] - 0s 5ms/step - loss: 0.8214
Epoch 233/270
11/11 [==============================] - 0s 5ms/step - loss: 0.8938
Epoch 234/270
11/11 [==============================] - 0s 5ms/step - loss: 0.7705
Epoch 235/270
11/11 [==============================] - 0s 5ms/step - loss: 0.6267
Epoch 236/270
11/11 [==============================] - 0s 6ms/step - loss: 0.5736
Epoch 237/270
11/11 [==============================] - 0s 5ms/step - loss: 0.5107
Epoch 238/270
11/11 [==============================] - 0s 5ms/step - loss: 0.6215
Epoch 239/270
11/11 [==============================] - 0s 5ms/step - loss: 0.7153
Epoch 240/270
11/11 [==============================] - 0s 6ms/step - loss: 0.4711
Epoch 241/270
11/11 [==============================] - 0s 5ms/step - loss: 0.3687
Epoch 242/270
11/11 [==============================] - 0s 6ms/step - loss: 0.3411
Epoch 243/270
11/11 [==============================] - 0s 5ms/step - loss: 0.3129
Epoch 244/270
11/11 [==============================] - 0s 6ms/step - loss: 0.3211
Epoch 245/270
11/11 [==============================] - 0s 5ms/step - loss: 0.2898
Epoch 246/270
11/11 [==============================] - 0s 5ms/step - loss: 0.2786
Epoch 247/270
11/11 [==============================] - 0s 5ms/step - loss: 0.2671
Epoch 248/270
11/11 [==============================] - 0s 6ms/step - loss: 0.2686
Epoch 249/270
11/11 [==============================] - 0s 5ms/step - loss: 0.2643
Epoch 250/270
11/11 [==============================] - 0s 4ms/step - loss: 0.3071
Epoch 251/270
11/11 [==============================] - 0s 7ms/step - loss: 0.3821
Epoch 252/270
11/11 [==============================] - 0s 5ms/step - loss: 0.3802
Epoch 253/270
```

```
11/11 [==============================] - 0s 5ms/step - loss: 0.5122
Epoch 254/270
11/11 [==============================] - 0s 5ms/step - loss: 0.5004
Epoch 255/270
11/11 [==============================] - 0s 5ms/step - loss: 0.4004
Epoch 256/270
11/11 [==============================] - 0s 5ms/step - loss: 0.3433
Epoch 257/270
11/11 [==============================] - 0s 5ms/step - loss: 0.3925
Epoch 258/270
11/11 [==============================] - 0s 6ms/step - loss: 0.4253
Epoch 259/270
11/11 [==============================] - 0s 5ms/step - loss: 0.4617
Epoch 260/270
11/11 [==============================] - 0s 5ms/step - loss: 0.5125
Epoch 261/270
11/11 [==============================] - 0s 5ms/step - loss: 0.6241
Epoch 262/270
11/11 [==============================] - 0s 5ms/step - loss: 0.8746
Epoch 263/270
11/11 [==============================] - 0s 5ms/step - loss: 0.9808
Epoch 264/270
11/11 [==============================] - 0s 5ms/step - loss: 1.1933
Epoch 265/270
11/11 [==============================] - 0s 5ms/step - loss: 1.0103
Epoch 266/270
11/11 [==============================] - 0s 5ms/step - loss: 1.3161
Epoch 267/270
11/11 [==============================] - 0s 5ms/step - loss: 1.0988
Epoch 268/270
11/11 [==============================] - 0s 5ms/step - loss: 0.9758
Epoch 269/270
11/11 [==============================] - 0s 5ms/step - loss: 0.9317
Epoch 270/270
11/11 [==============================] - 0s 5ms/step - loss: 0.7580
>expected=-1.0, predicted=-11.4
Epoch 1/270
11/11 [==============================] - 1s 5ms/step - loss: 136.0085
Epoch 2/270
11/11 [==============================] - 0s 5ms/step - loss: 133.4925
Epoch 3/270
11/11 [==============================] - 0s 6ms/step - loss: 131.0149
Epoch 4/270
11/11 [==============================] - 0s 5ms/step - loss: 121.9745
Epoch 5/270
11/11 [==============================] - 0s 6ms/step - loss: 114.2433
Epoch 6/270
11/11 [==============================] - 0s 5ms/step - loss: 96.1086
Epoch 7/270
11/11 [==============================] - 0s 5ms/step - loss: 96.2667
Epoch 8/270
11/11 [==============================] - 0s 6ms/step - loss: 91.1821
Epoch 9/270
11/11 [==============================] - 0s 6ms/step - loss: 88.6810
Epoch 10/270
11/11 [==============================] - 0s 6ms/step - loss: 88.4614
Epoch 11/270
11/11 [==============================] - 0s 7ms/step - loss: 88.6491
Epoch 12/270
11/11 [==============================] - 0s 7ms/step - loss: 84.9040
Epoch 13/270
```

```
11/11 [==============================] - 0s 5ms/step - loss: 83.5089
Epoch 14/270
11/11 [==============================] - 0s 5ms/step - loss: 81.6622
Epoch 15/270
11/11 [==============================] - 0s 6ms/step - loss: 80.5490
Epoch 16/270
11/11 [==============================] - 0s 6ms/step - loss: 79.6893
Epoch 17/270
11/11 [==============================] - 0s 6ms/step - loss: 77.3109
Epoch 18/270
11/11 [==============================] - 0s 6ms/step - loss: 79.6712
Epoch 19/270
11/11 [==============================] - 0s 5ms/step - loss: 75.7919
Epoch 20/270
11/11 [==============================] - 0s 5ms/step - loss: 73.9996
Epoch 21/270
11/11 [==============================] - 0s 6ms/step - loss: 76.0469
Epoch 22/270
11/11 [==============================] - 0s 6ms/step - loss: 74.6879
Epoch 23/270
11/11 [==============================] - 0s 5ms/step - loss: 72.6800
Epoch 24/270
11/11 [==============================] - 0s 5ms/step - loss: 73.6261
Epoch 25/270
11/11 [==============================] - 0s 7ms/step - loss: 72.6516
Epoch 26/270
11/11 [==============================] - 0s 5ms/step - loss: 70.9145
Epoch 27/270
11/11 [==============================] - 0s 5ms/step - loss: 70.2978
Epoch 28/270
11/11 [==============================] - 0s 6ms/step - loss: 69.8432
Epoch 29/270
11/11 [==============================] - 0s 5ms/step - loss: 67.1840
Epoch 30/270
11/11 [==============================] - 0s 5ms/step - loss: 67.7111
Epoch 31/270
11/11 [==============================] - 0s 5ms/step - loss: 65.5261
Epoch 32/270
11/11 [==============================] - 0s 5ms/step - loss: 64.2529
Epoch 33/270
11/11 [==============================] - 0s 6ms/step - loss: 62.9275
Epoch 34/270
11/11 [==============================] - 0s 5ms/step - loss: 60.7126
Epoch 35/270
11/11 [==============================] - 0s 6ms/step - loss: 60.5406
Epoch 36/270
11/11 [==============================] - 0s 5ms/step - loss: 58.3284
Epoch 37/270
11/11 [==============================] - 0s 6ms/step - loss: 58.1271
Epoch 38/270
11/11 [==============================] - 0s 5ms/step - loss: 56.6307
Epoch 39/270
11/11 [==============================] - 0s 5ms/step - loss: 54.7203
Epoch 40/270
11/11 [==============================] - 0s 6ms/step - loss: 54.1575
Epoch 41/270
11/11 [==============================] - 0s 6ms/step - loss: 51.6227
Epoch 42/270
11/11 [==============================] - 0s 5ms/step - loss: 54.3343
Epoch 43/270
11/11 [==============================] - 0s 5ms/step - loss: 54.8767
```

```
Epoch 44/270
11/11 [==============================] - 0s 5ms/step - loss: 50.3262
Epoch 45/270
11/11 [==============================] - 0s 6ms/step - loss: 51.4243
Epoch 46/270
11/11 [==============================] - 0s 6ms/step - loss: 49.9674
Epoch 47/270
11/11 [==============================] - 0s 5ms/step - loss: 49.1019
Epoch 48/270
11/11 [==============================] - 0s 6ms/step - loss: 46.5375
Epoch 49/270
11/11 [==============================] - 0s 5ms/step - loss: 45.1186
Epoch 50/270
11/11 [==============================] - 0s 5ms/step - loss: 43.7275
Epoch 51/270
11/11 [==============================] - 0s 7ms/step - loss: 42.9951
Epoch 52/270
11/11 [==============================] - 0s 5ms/step - loss: 40.4240
Epoch 53/270
11/11 [==============================] - 0s 6ms/step - loss: 42.1486
Epoch 54/270
11/11 [==============================] - 0s 5ms/step - loss: 39.5090
Epoch 55/270
11/11 [==============================] - 0s 7ms/step - loss: 38.4719
Epoch 56/270
11/11 [==============================] - 0s 5ms/step - loss: 37.0518
Epoch 57/270
11/11 [==============================] - 0s 5ms/step - loss: 36.8590
Epoch 58/270
11/11 [==============================] - 0s 5ms/step - loss: 37.2894
Epoch 59/270
11/11 [==============================] - 0s 7ms/step - loss: 35.0885
Epoch 60/270
11/11 [==============================] - 0s 5ms/step - loss: 32.5178
Epoch 61/270
11/11 [==============================] - 0s 5ms/step - loss: 32.6889
Epoch 62/270
11/11 [==============================] - 0s 5ms/step - loss: 34.9376
Epoch 63/270
11/11 [==============================] - 0s 5ms/step - loss: 30.5366
Epoch 64/270
11/11 [==============================] - 0s 5ms/step - loss: 29.6731
Epoch 65/270
11/11 [==============================] - 0s 5ms/step - loss: 29.8740
Epoch 66/270
11/11 [==============================] - 0s 6ms/step - loss: 28.1197
Epoch 67/270
11/11 [==============================] - 0s 5ms/step - loss: 27.0966
Epoch 68/270
11/11 [==============================] - 0s 5ms/step - loss: 25.4658
Epoch 69/270
11/11 [==============================] - 0s 5ms/step - loss: 23.5462
Epoch 70/270
11/11 [==============================] - 0s 8ms/step - loss: 25.1778
Epoch 71/270
11/11 [==============================] - 0s 5ms/step - loss: 24.1197
Epoch 72/270
11/11 [==============================] - 0s 5ms/step - loss: 23.0460
Epoch 73/270
11/11 [==============================] - 0s 5ms/step - loss: 22.8094
Epoch 74/270
```

```
11/11 [==============================] - 0s 5ms/step - loss: 22.6090
Epoch 75/270
11/11 [==============================] - 0s 5ms/step - loss: 21.7424
Epoch 76/270
11/11 [==============================] - 0s 5ms/step - loss: 19.7049
Epoch 77/270
11/11 [==============================] - 0s 6ms/step - loss: 18.4042
Epoch 78/270
11/11 [==============================] - 0s 6ms/step - loss: 17.3642
Epoch 79/270
11/11 [==============================] - 0s 5ms/step - loss: 18.1883
Epoch 80/270
11/11 [==============================] - 0s 5ms/step - loss: 17.6138
Epoch 81/270
11/11 [==============================] - 0s 5ms/step - loss: 16.4476
Epoch 82/270
11/11 [==============================] - 0s 5ms/step - loss: 17.2864
Epoch 83/270
11/11 [==============================] - 0s 5ms/step - loss: 16.5075
Epoch 84/270
11/11 [==============================] - 0s 5ms/step - loss: 14.7946
Epoch 85/270
11/11 [==============================] - 0s 5ms/step - loss: 15.3275
Epoch 86/270
11/11 [==============================] - 0s 7ms/step - loss: 17.0198
Epoch 87/270
11/11 [==============================] - 0s 5ms/step - loss: 20.1820
Epoch 88/270
11/11 [==============================] - 0s 5ms/step - loss: 20.0513
Epoch 89/270
11/11 [==============================] - 0s 5ms/step - loss: 17.0289
Epoch 90/270
11/11 [==============================] - 0s 5ms/step - loss: 15.0435
Epoch 91/270
11/11 [==============================] - 0s 5ms/step - loss: 13.1403
Epoch 92/270
11/11 [==============================] - 0s 5ms/step - loss: 13.0410
Epoch 93/270
11/11 [==============================] - 0s 5ms/step - loss: 12.5719
Epoch 94/270
11/11 [==============================] - 0s 5ms/step - loss: 11.9355
Epoch 95/270
11/11 [==============================] - 0s 5ms/step - loss: 10.9587
Epoch 96/270
11/11 [==============================] - 0s 5ms/step - loss: 12.1452
Epoch 97/270
11/11 [==============================] - 0s 5ms/step - loss: 12.3184
Epoch 98/270
11/11 [==============================] - 0s 6ms/step - loss: 10.8854
Epoch 99/270
11/11 [==============================] - 0s 5ms/step - loss: 9.3490
Epoch 100/270
11/11 [==============================] - 0s 5ms/step - loss: 9.3834
Epoch 101/270
11/11 [==============================] - 0s 5ms/step - loss: 9.3006
Epoch 102/270
11/11 [==============================] - 0s 6ms/step - loss: 9.5550
Epoch 103/270
11/11 [==============================] - 0s 5ms/step - loss: 8.9935
Epoch 104/270
11/11 [==============================] - 0s 6ms/step - loss: 9.0477
```

```
Epoch 105/270
11/11 [==============================] - 0s 6ms/step - loss: 8.2399
Epoch 106/270
11/11 [==============================] - 0s 5ms/step - loss: 7.2759
Epoch 107/270
11/11 [==============================] - 0s 5ms/step - loss: 6.3083
Epoch 108/270
11/11 [==============================] - 0s 5ms/step - loss: 6.2939
Epoch 109/270
11/11 [==============================] - 0s 5ms/step - loss: 6.8045
Epoch 110/270
11/11 [==============================] - 0s 6ms/step - loss: 6.7804
Epoch 111/270
11/11 [==============================] - 0s 5ms/step - loss: 7.5911
Epoch 112/270
11/11 [==============================] - 0s 6ms/step - loss: 7.4973
Epoch 113/270
11/11 [==============================] - 0s 5ms/step - loss: 7.0897
Epoch 114/270
11/11 [==============================] - 0s 5ms/step - loss: 5.8960
Epoch 115/270
11/11 [==============================] - 0s 5ms/step - loss: 5.1404
Epoch 116/270
11/11 [==============================] - 0s 5ms/step - loss: 4.9811
Epoch 117/270
11/11 [==============================] - 0s 6ms/step - loss: 4.5730
Epoch 118/270
11/11 [==============================] - 0s 5ms/step - loss: 4.6545
Epoch 119/270
11/11 [==============================] - 0s 5ms/step - loss: 5.3582
Epoch 120/270
11/11 [==============================] - 0s 5ms/step - loss: 5.4086
Epoch 121/270
11/11 [==============================] - 0s 5ms/step - loss: 4.7685
Epoch 122/270
11/11 [==============================] - 0s 5ms/step - loss: 5.5480
Epoch 123/270
11/11 [==============================] - 0s 6ms/step - loss: 5.1087
Epoch 124/270
11/11 [==============================] - 0s 5ms/step - loss: 4.7227
Epoch 125/270
11/11 [==============================] - 0s 5ms/step - loss: 5.4220
Epoch 126/270
11/11 [==============================] - 0s 5ms/step - loss: 4.3288
Epoch 127/270
11/11 [==============================] - 0s 5ms/step - loss: 3.7733
Epoch 128/270
11/11 [==============================] - 0s 5ms/step - loss: 3.2892
Epoch 129/270
11/11 [==============================] - 0s 5ms/step - loss: 3.0319
Epoch 130/270
11/11 [==============================] - 0s 5ms/step - loss: 2.9049
Epoch 131/270
11/11 [==============================] - 0s 5ms/step - loss: 2.4921
Epoch 132/270
11/11 [==============================] - 0s 6ms/step - loss: 2.4724
Epoch 133/270
11/11 [==============================] - 0s 5ms/step - loss: 2.5362
Epoch 134/270
11/11 [==============================] - 0s 6ms/step - loss: 2.5688
Epoch 135/270
```

```
11/11 [==============================] - 0s 5ms/step - loss: 3.4103
Epoch 136/270
11/11 [==============================] - 0s 5ms/step - loss: 2.9675
Epoch 137/270
11/11 [==============================] - 0s 5ms/step - loss: 3.0429
Epoch 138/270
11/11 [==============================] - 0s 6ms/step - loss: 3.2215
Epoch 139/270
11/11 [==============================] - 0s 6ms/step - loss: 3.4856
Epoch 140/270
11/11 [==============================] - 0s 5ms/step - loss: 2.7029
Epoch 141/270
11/11 [==============================] - 0s 5ms/step - loss: 2.5676
Epoch 142/270
11/11 [==============================] - 0s 7ms/step - loss: 2.7037
Epoch 143/270
11/11 [==============================] - 0s 5ms/step - loss: 2.8584
Epoch 144/270
11/11 [==============================] - 0s 5ms/step - loss: 2.4470
Epoch 145/270
11/11 [==============================] - 0s 5ms/step - loss: 2.2492
Epoch 146/270
11/11 [==============================] - 0s 5ms/step - loss: 2.3076
Epoch 147/270
11/11 [==============================] - 0s 5ms/step - loss: 2.3989
Epoch 148/270
11/11 [==============================] - 0s 6ms/step - loss: 2.4434
Epoch 149/270
11/11 [==============================] - 0s 6ms/step - loss: 2.0733
Epoch 150/270
11/11 [==============================] - 0s 6ms/step - loss: 1.9470
Epoch 151/270
11/11 [==============================] - 0s 5ms/step - loss: 1.7213
Epoch 152/270
11/11 [==============================] - 0s 5ms/step - loss: 1.4262
Epoch 153/270
11/11 [==============================] - 0s 5ms/step - loss: 1.5234
Epoch 154/270
11/11 [==============================] - 0s 5ms/step - loss: 1.5170
Epoch 155/270
11/11 [==============================] - 0s 5ms/step - loss: 1.4672
Epoch 156/270
11/11 [==============================] - 0s 5ms/step - loss: 1.2155
Epoch 157/270
11/11 [==============================] - 0s 5ms/step - loss: 1.2871
Epoch 158/270
11/11 [==============================] - 0s 5ms/step - loss: 1.2989
Epoch 159/270
11/11 [==============================] - 0s 5ms/step - loss: 1.3064
Epoch 160/270
11/11 [==============================] - 0s 6ms/step - loss: 1.2948
Epoch 161/270
11/11 [==============================] - 0s 5ms/step - loss: 1.1378
Epoch 162/270
11/11 [==============================] - 0s 5ms/step - loss: 1.1075
Epoch 163/270
11/11 [==============================] - 0s 7ms/step - loss: 1.1605
Epoch 164/270
11/11 [==============================] - 0s 5ms/step - loss: 1.1181
Epoch 165/270
11/11 [==============================] - 0s 5ms/step - loss: 1.0169
```

```
Epoch 166/270
11/11 [==============================] - 0s 5ms/step - loss: 1.0513
Epoch 167/270
11/11 [==============================] - 0s 5ms/step - loss: 1.0656
Epoch 168/270
11/11 [==============================] - 0s 6ms/step - loss: 0.9634
Epoch 169/270
11/11 [==============================] - 0s 6ms/step - loss: 1.0667
Epoch 170/270
11/11 [==============================] - 0s 5ms/step - loss: 1.1367
Epoch 171/270
11/11 [==============================] - 0s 5ms/step - loss: 1.0414
Epoch 172/270
11/11 [==============================] - 0s 5ms/step - loss: 1.1375
Epoch 173/270
11/11 [==============================] - 0s 5ms/step - loss: 1.1384
Epoch 174/270
11/11 [==============================] - 0s 5ms/step - loss: 1.0495
Epoch 175/270
11/11 [==============================] - 0s 5ms/step - loss: 1.1817
Epoch 176/270
11/11 [==============================] - 0s 5ms/step - loss: 1.1678
Epoch 177/270
11/11 [==============================] - 0s 5ms/step - loss: 1.2634
Epoch 178/270
11/11 [==============================] - 0s 7ms/step - loss: 0.9985
Epoch 179/270
11/11 [==============================] - 0s 5ms/step - loss: 0.8312
Epoch 180/270
11/11 [==============================] - 0s 6ms/step - loss: 0.8420
Epoch 181/270
11/11 [==============================] - 0s 7ms/step - loss: 0.8948
Epoch 182/270
11/11 [==============================] - 0s 8ms/step - loss: 0.8582
Epoch 183/270
11/11 [==============================] - 0s 5ms/step - loss: 0.9309
Epoch 184/270
11/11 [==============================] - 0s 5ms/step - loss: 1.4930
Epoch 185/270
11/11 [==============================] - 0s 5ms/step - loss: 1.6203
Epoch 186/270
11/11 [==============================] - 0s 5ms/step - loss: 2.0648
Epoch 187/270
11/11 [==============================] - 0s 7ms/step - loss: 2.0803
Epoch 188/270
11/11 [==============================] - 0s 5ms/step - loss: 1.9618
Epoch 189/270
11/11 [==============================] - 0s 6ms/step - loss: 2.1851
Epoch 190/270
11/11 [==============================] - 0s 5ms/step - loss: 1.8274
Epoch 191/270
11/11 [==============================] - 0s 5ms/step - loss: 1.4955
Epoch 192/270
11/11 [==============================] - 0s 7ms/step - loss: 1.7083
Epoch 193/270
11/11 [==============================] - 0s 5ms/step - loss: 1.3971
Epoch 194/270
11/11 [==============================] - 0s 5ms/step - loss: 1.3643
Epoch 195/270
11/11 [==============================] - 0s 5ms/step - loss: 1.3532
Epoch 196/270
```

```
11/11 [==============================] - 0s 6ms/step - loss: 1.2867
Epoch 197/270
11/11 [==============================] - 0s 6ms/step - loss: 1.5673
Epoch 198/270
11/11 [==============================] - 0s 6ms/step - loss: 1.6945
Epoch 199/270
11/11 [==============================] - 0s 5ms/step - loss: 1.4630
Epoch 200/270
11/11 [==============================] - 0s 5ms/step - loss: 1.4096
Epoch 201/270
11/11 [==============================] - 0s 5ms/step - loss: 1.0198
Epoch 202/270
11/11 [==============================] - 0s 5ms/step - loss: 1.0078
Epoch 203/270
11/11 [==============================] - 0s 6ms/step - loss: 0.8692
Epoch 204/270
11/11 [==============================] - 0s 5ms/step - loss: 0.7329
Epoch 205/270
11/11 [==============================] - 0s 6ms/step - loss: 0.6954
Epoch 206/270
11/11 [==============================] - 0s 5ms/step - loss: 0.7521
Epoch 207/270
11/11 [==============================] - 0s 6ms/step - loss: 0.6125
Epoch 208/270
11/11 [==============================] - 0s 5ms/step - loss: 0.5582
Epoch 209/270
11/11 [==============================] - 0s 5ms/step - loss: 0.4176
Epoch 210/270
11/11 [==============================] - 0s 5ms/step - loss: 0.3903
Epoch 211/270
11/11 [==============================] - 0s 6ms/step - loss: 0.3655
Epoch 212/270
11/11 [==============================] - 0s 6ms/step - loss: 0.3403
Epoch 213/270
11/11 [==============================] - 0s 6ms/step - loss: 0.3071
Epoch 214/270
11/11 [==============================] - 0s 5ms/step - loss: 0.2858
Epoch 215/270
11/11 [==============================] - 0s 6ms/step - loss: 0.3006
Epoch 216/270
11/11 [==============================] - 0s 6ms/step - loss: 0.3134
Epoch 217/270
11/11 [==============================] - 0s 5ms/step - loss: 0.2993
Epoch 218/270
11/11 [==============================] - 0s 5ms/step - loss: 0.3303
Epoch 219/270
11/11 [==============================] - 0s 5ms/step - loss: 0.3162
Epoch 220/270
11/11 [==============================] - 0s 6ms/step - loss: 0.3678
Epoch 221/270
11/11 [==============================] - 0s 7ms/step - loss: 0.4099
Epoch 222/270
11/11 [==============================] - 0s 6ms/step - loss: 0.3321
Epoch 223/270
11/11 [==============================] - 0s 6ms/step - loss: 0.3616
Epoch 224/270
11/11 [==============================] - 0s 6ms/step - loss: 0.3505
Epoch 225/270
11/11 [==============================] - 0s 5ms/step - loss: 0.2821
Epoch 226/270
11/11 [==============================] - 0s 5ms/step - loss: 0.3181
```

```
Epoch 227/270
11/11 [==============================] - 0s 6ms/step - loss: 0.3164
Epoch 228/270
11/11 [==============================] - 0s 5ms/step - loss: 0.2592
Epoch 229/270
11/11 [==============================] - 0s 5ms/step - loss: 0.2333
Epoch 230/270
11/11 [==============================] - 0s 6ms/step - loss: 0.2329
Epoch 231/270
11/11 [==============================] - 0s 6ms/step - loss: 0.2120
Epoch 232/270
11/11 [==============================] - 0s 7ms/step - loss: 0.2380
Epoch 233/270
11/11 [==============================] - 0s 5ms/step - loss: 0.2198
Epoch 234/270
11/11 [==============================] - 0s 6ms/step - loss: 0.2450
Epoch 235/270
11/11 [==============================] - 0s 5ms/step - loss: 0.2504
Epoch 236/270
11/11 [==============================] - 0s 6ms/step - loss: 0.3054
Epoch 237/270
11/11 [==============================] - 0s 5ms/step - loss: 0.3279
Epoch 238/270
11/11 [==============================] - 0s 6ms/step - loss: 0.3565
Epoch 239/270
11/11 [==============================] - 0s 6ms/step - loss: 0.3910
Epoch 240/270
11/11 [==============================] - 0s 5ms/step - loss: 0.4484
Epoch 241/270
11/11 [==============================] - 0s 5ms/step - loss: 0.4795
Epoch 242/270
11/11 [==============================] - 0s 6ms/step - loss: 0.3629
Epoch 243/270
11/11 [==============================] - 0s 6ms/step - loss: 0.3284
Epoch 244/270
11/11 [==============================] - 0s 5ms/step - loss: 0.4740
Epoch 245/270
11/11 [==============================] - 0s 5ms/step - loss: 0.5970
Epoch 246/270
11/11 [==============================] - 0s 5ms/step - loss: 0.6316
Epoch 247/270
11/11 [==============================] - 0s 6ms/step - loss: 0.6433
Epoch 248/270
11/11 [==============================] - 0s 7ms/step - loss: 0.6276
Epoch 249/270
11/11 [==============================] - 0s 6ms/step - loss: 0.7133
Epoch 250/270
11/11 [==============================] - 0s 5ms/step - loss: 0.7797
Epoch 251/270
11/11 [==============================] - 0s 6ms/step - loss: 0.7026
Epoch 252/270
11/11 [==============================] - 0s 5ms/step - loss: 0.7889
Epoch 253/270
11/11 [==============================] - 0s 5ms/step - loss: 0.6596
Epoch 254/270
11/11 [==============================] - 0s 5ms/step - loss: 0.7439
Epoch 255/270
11/11 [==============================] - 0s 5ms/step - loss: 0.9389
Epoch 256/270
11/11 [==============================] - 0s 5ms/step - loss: 0.7090
Epoch 257/270
```

```
11/11 [==============================] - 0s 5ms/step - loss: 0.6814
Epoch 258/270
11/11 [==============================] - 0s 6ms/step - loss: 0.6938
Epoch 259/270
11/11 [==============================] - 0s 6ms/step - loss: 0.7171
Epoch 260/270
11/11 [==============================] - 0s 5ms/step - loss: 0.7374
Epoch 261/270
11/11 [==============================] - 0s 5ms/step - loss: 0.8289
Epoch 262/270
11/11 [==============================] - 0s 6ms/step - loss: 1.0886
Epoch 263/270
11/11 [==============================] - 0s 5ms/step - loss: 0.9518
Epoch 264/270
11/11 [==============================] - 0s 5ms/step - loss: 0.8644
Epoch 265/270
11/11 [==============================] - 0s 7ms/step - loss: 0.7051
Epoch 266/270
11/11 [==============================] - 0s 5ms/step - loss: 0.5904
Epoch 267/270
11/11 [==============================] - 0s 6ms/step - loss: 0.8817
Epoch 268/270
11/11 [==============================] - 0s 5ms/step - loss: 1.1964
Epoch 269/270
11/11 [==============================] - 0s 6ms/step - loss: 1.3157
Epoch 270/270
11/11 [==============================] - 0s 5ms/step - loss: 1.5695
>expected=-6.0, predicted=-5.0
Epoch 1/270
11/11 [==============================] - 1s 6ms/step - loss: 134.6376
Epoch 2/270
11/11 [==============================] - 0s 5ms/step - loss: 132.8432
Epoch 3/270
11/11 [==============================] - 0s 7ms/step - loss: 131.1074
Epoch 4/270
11/11 [==============================] - 0s 6ms/step - loss: 125.9388
Epoch 5/270
11/11 [==============================] - 0s 7ms/step - loss: 112.3452
Epoch 6/270
11/11 [==============================] - 0s 5ms/step - loss: 101.1358
Epoch 7/270
11/11 [==============================] - 0s 5ms/step - loss: 97.0587
Epoch 8/270
11/11 [==============================] - 0s 6ms/step - loss: 92.2394
Epoch 9/270
11/11 [==============================] - 0s 5ms/step - loss: 88.2882
Epoch 10/270
11/11 [==============================] - 0s 5ms/step - loss: 85.5348
Epoch 11/270
11/11 [==============================] - 0s 5ms/step - loss: 83.4556
Epoch 12/270
11/11 [==============================] - 0s 6ms/step - loss: 80.5405
Epoch 13/270
11/11 [==============================] - 0s 6ms/step - loss: 80.8987
Epoch 14/270
11/11 [==============================] - 0s 6ms/step - loss: 78.9444
Epoch 15/270
11/11 [==============================] - 0s 6ms/step - loss: 78.6884
Epoch 16/270
11/11 [==============================] - 0s 6ms/step - loss: 77.2268
Epoch 17/270
```

```
11/11 [==============================] - 0s 7ms/step - loss: 75.5916
Epoch 18/270
11/11 [==============================] - 0s 6ms/step - loss: 75.9908
Epoch 19/270
11/11 [==============================] - 0s 6ms/step - loss: 78.8125
Epoch 20/270
11/11 [==============================] - 0s 5ms/step - loss: 74.4955
Epoch 21/270
11/11 [==============================] - 0s 6ms/step - loss: 71.3373
Epoch 22/270
11/11 [==============================] - 0s 6ms/step - loss: 73.0757
Epoch 23/270
11/11 [==============================] - 0s 6ms/step - loss: 73.5644
Epoch 24/270
11/11 [==============================] - 0s 6ms/step - loss: 70.9130
Epoch 25/270
11/11 [==============================] - 0s 6ms/step - loss: 67.6955
Epoch 26/270
11/11 [==============================] - 0s 6ms/step - loss: 71.1298
Epoch 27/270
11/11 [==============================] - 0s 6ms/step - loss: 76.0277
Epoch 28/270
11/11 [==============================] - 0s 6ms/step - loss: 70.8591
Epoch 29/270
11/11 [==============================] - 0s 6ms/step - loss: 67.2132
Epoch 30/270
11/11 [==============================] - 0s 7ms/step - loss: 63.8540
Epoch 31/270
11/11 [==============================] - 0s 6ms/step - loss: 64.1038
Epoch 32/270
11/11 [==============================] - 0s 6ms/step - loss: 61.9417
Epoch 33/270
11/11 [==============================] - 0s 6ms/step - loss: 61.9689
Epoch 34/270
11/11 [==============================] - 0s 6ms/step - loss: 65.2747
Epoch 35/270
11/11 [==============================] - 0s 6ms/step - loss: 66.3835
Epoch 36/270
11/11 [==============================] - 0s 6ms/step - loss: 59.6937
Epoch 37/270
11/11 [==============================] - 0s 6ms/step - loss: 60.6951
Epoch 38/270
11/11 [==============================] - 0s 5ms/step - loss: 60.6726
Epoch 39/270
11/11 [==============================] - 0s 6ms/step - loss: 56.4598
Epoch 40/270
11/11 [==============================] - 0s 5ms/step - loss: 54.4508
Epoch 41/270
11/11 [==============================] - 0s 7ms/step - loss: 52.9609
Epoch 42/270
11/11 [==============================] - 0s 6ms/step - loss: 52.2941
Epoch 43/270
11/11 [==============================] - 0s 6ms/step - loss: 51.5825
Epoch 44/270
11/11 [==============================] - 0s 13ms/step - loss: 49.9284
Epoch 45/270
11/11 [==============================] - 0s 9ms/step - loss: 48.6831
Epoch 46/270
11/11 [==============================] - 0s 10ms/step - loss: 47.3849
Epoch 47/270
11/11 [==============================] - 0s 8ms/step - loss: 46.7699
```

```
Epoch 48/270
11/11 [==============================] - 0s 7ms/step - loss: 46.3651
Epoch 49/270
11/11 [==============================] - 0s 9ms/step - loss: 47.4287
Epoch 50/270
11/11 [==============================] - 0s 9ms/step - loss: 48.5843
Epoch 51/270
11/11 [==============================] - 0s 15ms/step - loss: 43.1120
Epoch 52/270
11/11 [==============================] - 0s 10ms/step - loss: 43.9766
Epoch 53/270
11/11 [==============================] - 0s 5ms/step - loss: 45.8089
Epoch 54/270
11/11 [==============================] - 0s 7ms/step - loss: 49.4248
Epoch 55/270
11/11 [==============================] - 0s 6ms/step - loss: 43.1110
Epoch 56/270
11/11 [==============================] - 0s 5ms/step - loss: 39.8451
Epoch 57/270
11/11 [==============================] - 0s 7ms/step - loss: 38.8514
Epoch 58/270
11/11 [==============================] - 0s 5ms/step - loss: 37.1648
Epoch 59/270
11/11 [==============================] - 0s 7ms/step - loss: 35.3116
Epoch 60/270
11/11 [==============================] - 0s 5ms/step - loss: 33.6486
Epoch 61/270
11/11 [==============================] - 0s 7ms/step - loss: 33.8948
Epoch 62/270
11/11 [==============================] - 0s 6ms/step - loss: 32.7664
Epoch 63/270
11/11 [==============================] - 0s 7ms/step - loss: 30.6428
Epoch 64/270
11/11 [==============================] - 0s 5ms/step - loss: 30.0490
Epoch 65/270
11/11 [==============================] - 0s 5ms/step - loss: 30.5255
Epoch 66/270
11/11 [==============================] - 0s 6ms/step - loss: 31.0160
Epoch 67/270
11/11 [==============================] - 0s 7ms/step - loss: 31.2501
Epoch 68/270
11/11 [==============================] - 0s 6ms/step - loss: 29.8394
Epoch 69/270
11/11 [==============================] - 0s 6ms/step - loss: 26.9937
Epoch 70/270
11/11 [==============================] - 0s 5ms/step - loss: 26.8711
Epoch 71/270
11/11 [==============================] - 0s 7ms/step - loss: 27.0794
Epoch 72/270
11/11 [==============================] - 0s 5ms/step - loss: 27.0212
Epoch 73/270
11/11 [==============================] - 0s 5ms/step - loss: 24.5192
Epoch 74/270
11/11 [==============================] - 0s 6ms/step - loss: 23.8864
Epoch 75/270
11/11 [==============================] - 0s 6ms/step - loss: 21.5156
Epoch 76/270
11/11 [==============================] - 0s 5ms/step - loss: 22.9817
Epoch 77/270
11/11 [==============================] - 0s 7ms/step - loss: 20.8368
Epoch 78/270
```

```
11/11 [==============================] - 0s 6ms/step - loss: 20.6553
Epoch 79/270
11/11 [==============================] - 0s 6ms/step - loss: 21.8030
Epoch 80/270
11/11 [==============================] - 0s 6ms/step - loss: 23.2560
Epoch 81/270
11/11 [==============================] - 0s 7ms/step - loss: 28.1501
Epoch 82/270
11/11 [==============================] - 0s 7ms/step - loss: 24.4680
Epoch 83/270
11/11 [==============================] - 0s 5ms/step - loss: 19.7307
Epoch 84/270
11/11 [==============================] - 0s 6ms/step - loss: 18.8903
Epoch 85/270
11/11 [==============================] - 0s 6ms/step - loss: 16.5350
Epoch 86/270
11/11 [==============================] - 0s 5ms/step - loss: 17.5082
Epoch 87/270
11/11 [==============================] - 0s 5ms/step - loss: 17.8694
Epoch 88/270
11/11 [==============================] - 0s 7ms/step - loss: 16.3133
Epoch 89/270
11/11 [==============================] - 0s 6ms/step - loss: 16.1992
Epoch 90/270
11/11 [==============================] - 0s 5ms/step - loss: 16.2224
Epoch 91/270
11/11 [==============================] - 0s 6ms/step - loss: 14.2847
Epoch 92/270
11/11 [==============================] - 0s 6ms/step - loss: 14.4439
Epoch 93/270
11/11 [==============================] - 0s 5ms/step - loss: 13.0189
Epoch 94/270
11/11 [==============================] - 0s 6ms/step - loss: 13.3327
Epoch 95/270
11/11 [==============================] - 0s 5ms/step - loss: 13.6435
Epoch 96/270
11/11 [==============================] - 0s 8ms/step - loss: 12.3186
Epoch 97/270
11/11 [==============================] - 0s 6ms/step - loss: 14.1111
Epoch 98/270
11/11 [==============================] - 0s 6ms/step - loss: 13.5357
Epoch 99/270
11/11 [==============================] - 0s 5ms/step - loss: 12.3821
Epoch 100/270
11/11 [==============================] - 0s 6ms/step - loss: 12.1124
Epoch 101/270
11/11 [==============================] - 0s 6ms/step - loss: 11.1514
Epoch 102/270
11/11 [==============================] - 0s 5ms/step - loss: 11.2024
Epoch 103/270
11/11 [==============================] - 0s 6ms/step - loss: 10.0361
Epoch 104/270
11/11 [==============================] - 0s 5ms/step - loss: 9.8116
Epoch 105/270
11/11 [==============================] - 0s 6ms/step - loss: 9.6130
Epoch 106/270
11/11 [==============================] - 0s 6ms/step - loss: 9.7536
Epoch 107/270
11/11 [==============================] - 0s 6ms/step - loss: 10.3727
Epoch 108/270
11/11 [==============================] - 0s 7ms/step - loss: 10.6597
```

```
Epoch 109/270
11/11 [==============================] - 0s 6ms/step - loss: 10.1687
Epoch 110/270
11/11 [==============================] - 0s 7ms/step - loss: 8.9415
Epoch 111/270
11/11 [==============================] - 0s 5ms/step - loss: 8.7423
Epoch 112/270
11/11 [==============================] - 0s 6ms/step - loss: 9.0722
Epoch 113/270
11/11 [==============================] - 0s 5ms/step - loss: 8.8759
Epoch 114/270
11/11 [==============================] - 0s 6ms/step - loss: 8.4429
Epoch 115/270
11/11 [==============================] - 0s 6ms/step - loss: 8.3210
Epoch 116/270
11/11 [==============================] - 0s 6ms/step - loss: 8.4219
Epoch 117/270
11/11 [==============================] - 0s 5ms/step - loss: 7.6933
Epoch 118/270
11/11 [==============================] - 0s 7ms/step - loss: 7.8149
Epoch 119/270
11/11 [==============================] - 0s 6ms/step - loss: 8.2192
Epoch 120/270
11/11 [==============================] - 0s 5ms/step - loss: 8.8777
Epoch 121/270
11/11 [==============================] - 0s 6ms/step - loss: 8.8102
Epoch 122/270
11/11 [==============================] - 0s 6ms/step - loss: 7.9282
Epoch 123/270
11/11 [==============================] - 0s 6ms/step - loss: 7.7077
Epoch 124/270
11/11 [==============================] - 0s 7ms/step - loss: 7.1157
Epoch 125/270
11/11 [==============================] - 0s 5ms/step - loss: 6.5771
Epoch 126/270
11/11 [==============================] - 0s 7ms/step - loss: 6.1060
Epoch 127/270
11/11 [==============================] - 0s 6ms/step - loss: 6.0965
Epoch 128/270
11/11 [==============================] - 0s 5ms/step - loss: 5.4416
Epoch 129/270
11/11 [==============================] - 0s 5ms/step - loss: 5.3974
Epoch 130/270
11/11 [==============================] - 0s 6ms/step - loss: 5.1793
Epoch 131/270
11/11 [==============================] - 0s 6ms/step - loss: 5.4264
Epoch 132/270
11/11 [==============================] - 0s 7ms/step - loss: 5.0102
Epoch 133/270
11/11 [==============================] - 0s 5ms/step - loss: 4.9407
Epoch 134/270
11/11 [==============================] - 0s 5ms/step - loss: 4.2138
Epoch 135/270
11/11 [==============================] - 0s 6ms/step - loss: 4.2267
Epoch 136/270
11/11 [==============================] - 0s 6ms/step - loss: 4.5640
Epoch 137/270
11/11 [==============================] - 0s 5ms/step - loss: 4.5224
Epoch 138/270
11/11 [==============================] - 0s 6ms/step - loss: 4.0871
Epoch 139/270
```

```
11/11 [==============================] - 0s 7ms/step - loss: 5.1722
Epoch 140/270
11/11 [==============================] - 0s 6ms/step - loss: 5.2771
Epoch 141/270
11/11 [==============================] - 0s 8ms/step - loss: 4.9717
Epoch 142/270
11/11 [==============================] - 0s 6ms/step - loss: 4.6599
Epoch 143/270
11/11 [==============================] - 0s 6ms/step - loss: 4.1817
Epoch 144/270
11/11 [==============================] - 0s 6ms/step - loss: 3.8035
Epoch 145/270
11/11 [==============================] - 0s 6ms/step - loss: 3.7871
Epoch 146/270
11/11 [==============================] - 0s 5ms/step - loss: 3.9984
Epoch 147/270
11/11 [==============================] - 0s 6ms/step - loss: 3.6378
Epoch 148/270
11/11 [==============================] - 0s 5ms/step - loss: 3.0458
Epoch 149/270
11/11 [==============================] - 0s 7ms/step - loss: 3.0592
Epoch 150/270
11/11 [==============================] - 0s 5ms/step - loss: 2.8878
Epoch 151/270
11/11 [==============================] - 0s 6ms/step - loss: 3.0638
Epoch 152/270
11/11 [==============================] - 0s 6ms/step - loss: 3.3905
Epoch 153/270
11/11 [==============================] - 0s 7ms/step - loss: 3.5063
Epoch 154/270
11/11 [==============================] - 0s 5ms/step - loss: 3.6921
Epoch 155/270
11/11 [==============================] - 0s 6ms/step - loss: 3.4019
Epoch 156/270
11/11 [==============================] - 0s 7ms/step - loss: 3.2626
Epoch 157/270
11/11 [==============================] - 0s 5ms/step - loss: 2.7768
Epoch 158/270
11/11 [==============================] - 0s 5ms/step - loss: 2.9257
Epoch 159/270
11/11 [==============================] - 0s 6ms/step - loss: 2.6558
Epoch 160/270
11/11 [==============================] - 0s 6ms/step - loss: 2.3810
Epoch 161/270
11/11 [==============================] - 0s 5ms/step - loss: 2.6020
Epoch 162/270
11/11 [==============================] - 0s 6ms/step - loss: 2.5495
Epoch 163/270
11/11 [==============================] - 0s 6ms/step - loss: 2.5663
Epoch 164/270
11/11 [==============================] - 0s 6ms/step - loss: 2.4223
Epoch 165/270
11/11 [==============================] - 0s 6ms/step - loss: 2.0857
Epoch 166/270
11/11 [==============================] - 0s 6ms/step - loss: 2.0678
Epoch 167/270
11/11 [==============================] - 0s 7ms/step - loss: 1.9263
Epoch 168/270
11/11 [==============================] - 0s 6ms/step - loss: 1.9268
Epoch 169/270
11/11 [==============================] - 0s 5ms/step - loss: 1.9490
```

```
Epoch 170/270
11/11 [==============================] - 0s 5ms/step - loss: 2.3901
Epoch 171/270
11/11 [==============================] - 0s 7ms/step - loss: 2.0318
Epoch 172/270
11/11 [==============================] - 0s 5ms/step - loss: 1.8370
Epoch 173/270
11/11 [==============================] - 0s 6ms/step - loss: 1.8056
Epoch 174/270
11/11 [==============================] - 0s 5ms/step - loss: 1.5779
Epoch 175/270
11/11 [==============================] - 0s 5ms/step - loss: 1.5276
Epoch 176/270
11/11 [==============================] - 0s 6ms/step - loss: 1.5577
Epoch 177/270
11/11 [==============================] - 0s 5ms/step - loss: 1.5237
Epoch 178/270
11/11 [==============================] - 0s 6ms/step - loss: 1.6268
Epoch 179/270
11/11 [==============================] - 0s 6ms/step - loss: 1.4639
Epoch 180/270
11/11 [==============================] - 0s 6ms/step - loss: 1.4292
Epoch 181/270
11/11 [==============================] - 0s 7ms/step - loss: 1.2841
Epoch 182/270
11/11 [==============================] - 0s 5ms/step - loss: 1.2485
Epoch 183/270
11/11 [==============================] - 0s 5ms/step - loss: 1.0150
Epoch 184/270
11/11 [==============================] - 0s 5ms/step - loss: 1.0439
Epoch 185/270
11/11 [==============================] - 0s 5ms/step - loss: 1.0366
Epoch 186/270
11/11 [==============================] - 0s 7ms/step - loss: 1.0670
Epoch 187/270
11/11 [==============================] - 0s 5ms/step - loss: 0.9353
Epoch 188/270
11/11 [==============================] - 0s 6ms/step - loss: 0.9436
Epoch 189/270
11/11 [==============================] - 0s 7ms/step - loss: 0.9114
Epoch 190/270
11/11 [==============================] - 0s 5ms/step - loss: 1.0419
Epoch 191/270
11/11 [==============================] - 0s 7ms/step - loss: 1.2169
Epoch 192/270
11/11 [==============================] - 0s 7ms/step - loss: 1.0372
Epoch 193/270
11/11 [==============================] - 0s 5ms/step - loss: 0.9930
Epoch 194/270
11/11 [==============================] - 0s 6ms/step - loss: 1.1307
Epoch 195/270
11/11 [==============================] - 0s 8ms/step - loss: 1.3802
Epoch 196/270
11/11 [==============================] - 0s 5ms/step - loss: 1.6412
Epoch 197/270
11/11 [==============================] - 0s 6ms/step - loss: 1.4573
Epoch 198/270
11/11 [==============================] - 0s 7ms/step - loss: 1.3228
Epoch 199/270
11/11 [==============================] - 0s 5ms/step - loss: 1.2316
Epoch 200/270
```

```
11/11 [==============================] - 0s 6ms/step - loss: 1.1846
Epoch 201/270
11/11 [==============================] - 0s 5ms/step - loss: 1.2724
Epoch 202/270
11/11 [==============================] - 0s 6ms/step - loss: 2.5099
Epoch 203/270
11/11 [==============================] - 0s 5ms/step - loss: 2.4292
Epoch 204/270
11/11 [==============================] - 0s 7ms/step - loss: 2.3007
Epoch 205/270
11/11 [==============================] - 0s 5ms/step - loss: 1.9734
Epoch 206/270
11/11 [==============================] - 0s 6ms/step - loss: 1.7425
Epoch 207/270
11/11 [==============================] - 0s 5ms/step - loss: 1.7667
Epoch 208/270
11/11 [==============================] - 0s 6ms/step - loss: 1.4615
Epoch 209/270
11/11 [==============================] - 0s 6ms/step - loss: 1.3188
Epoch 210/270
11/11 [==============================] - 0s 5ms/step - loss: 1.3827
Epoch 211/270
11/11 [==============================] - 0s 7ms/step - loss: 1.0643
Epoch 212/270
11/11 [==============================] - 0s 6ms/step - loss: 1.0469
Epoch 213/270
11/11 [==============================] - 0s 6ms/step - loss: 0.9431
Epoch 214/270
11/11 [==============================] - 0s 6ms/step - loss: 0.9998
Epoch 215/270
11/11 [==============================] - 0s 6ms/step - loss: 0.8742
Epoch 216/270
11/11 [==============================] - 0s 6ms/step - loss: 0.8336
Epoch 217/270
11/11 [==============================] - 0s 6ms/step - loss: 1.0502
Epoch 218/270
11/11 [==============================] - 0s 6ms/step - loss: 0.8637
Epoch 219/270
11/11 [==============================] - 0s 7ms/step - loss: 0.6603
Epoch 220/270
11/11 [==============================] - 0s 5ms/step - loss: 0.6914
Epoch 221/270
11/11 [==============================] - 0s 7ms/step - loss: 0.5956
Epoch 222/270
11/11 [==============================] - 0s 7ms/step - loss: 0.5070
Epoch 223/270
11/11 [==============================] - 0s 8ms/step - loss: 0.5005
Epoch 224/270
11/11 [==============================] - 0s 6ms/step - loss: 0.4419
Epoch 225/270
11/11 [==============================] - 0s 5ms/step - loss: 0.4588
Epoch 226/270
11/11 [==============================] - 0s 6ms/step - loss: 0.4637
Epoch 227/270
11/11 [==============================] - 0s 6ms/step - loss: 0.4456
Epoch 228/270
11/11 [==============================] - 0s 5ms/step - loss: 0.5261
Epoch 229/270
11/11 [==============================] - 0s 6ms/step - loss: 0.5478
Epoch 230/270
11/11 [==============================] - 0s 6ms/step - loss: 0.5369
```

```
Epoch 231/270
11/11 [==============================] - 0s 6ms/step - loss: 0.4960
Epoch 232/270
11/11 [==============================] - 0s 7ms/step - loss: 0.5790
Epoch 233/270
11/11 [==============================] - 0s 7ms/step - loss: 0.6076
Epoch 234/270
11/11 [==============================] - 0s 7ms/step - loss: 0.6382
Epoch 235/270
11/11 [==============================] - 0s 7ms/step - loss: 0.7777
Epoch 236/270
11/11 [==============================] - 0s 6ms/step - loss: 0.8155
Epoch 237/270
11/11 [==============================] - 0s 5ms/step - loss: 0.9056
Epoch 238/270
11/11 [==============================] - 0s 7ms/step - loss: 0.7155
Epoch 239/270
11/11 [==============================] - 0s 6ms/step - loss: 0.7197
Epoch 240/270
11/11 [==============================] - 0s 7ms/step - loss: 0.6337
Epoch 241/270
11/11 [==============================] - 0s 5ms/step - loss: 0.6004
Epoch 242/270
11/11 [==============================] - 0s 7ms/step - loss: 0.5069
Epoch 243/270
11/11 [==============================] - 0s 6ms/step - loss: 0.4943
Epoch 244/270
11/11 [==============================] - 0s 7ms/step - loss: 0.5376
Epoch 245/270
11/11 [==============================] - 0s 6ms/step - loss: 0.3799
Epoch 246/270
11/11 [==============================] - 0s 6ms/step - loss: 0.4199
Epoch 247/270
11/11 [==============================] - 0s 6ms/step - loss: 0.3572
Epoch 248/270
11/11 [==============================] - 0s 6ms/step - loss: 0.3217
Epoch 249/270
11/11 [==============================] - 0s 7ms/step - loss: 0.3352
Epoch 250/270
11/11 [==============================] - 0s 7ms/step - loss: 0.4776
Epoch 251/270
11/11 [==============================] - 0s 6ms/step - loss: 0.5971
Epoch 252/270
11/11 [==============================] - 0s 8ms/step - loss: 0.8953
Epoch 253/270
11/11 [==============================] - 0s 7ms/step - loss: 1.1537
Epoch 254/270
11/11 [==============================] - 0s 6ms/step - loss: 1.1357
Epoch 255/270
11/11 [==============================] - 0s 5ms/step - loss: 1.5135
Epoch 256/270
11/11 [==============================] - 0s 7ms/step - loss: 1.9035
Epoch 257/270
11/11 [==============================] - 0s 7ms/step - loss: 2.3722
Epoch 258/270
11/11 [==============================] - 0s 5ms/step - loss: 2.5171
Epoch 259/270
11/11 [==============================] - 0s 6ms/step - loss: 3.1762
Epoch 260/270
11/11 [==============================] - 0s 6ms/step - loss: 2.3677
Epoch 261/270
```

```
11/11 [==============================] - 0s 6ms/step - loss: 1.8034
Epoch 262/270
11/11 [==============================] - 0s 7ms/step - loss: 1.8006
Epoch 263/270
11/11 [==============================] - 0s 7ms/step - loss: 1.4415
Epoch 264/270
11/11 [==============================] - 0s 5ms/step - loss: 1.2316
Epoch 265/270
11/11 [==============================] - 0s 7ms/step - loss: 0.6305
Epoch 266/270
11/11 [==============================] - 0s 7ms/step - loss: 0.4907
Epoch 267/270
11/11 [==============================] - 0s 5ms/step - loss: 0.3616
Epoch 268/270
11/11 [==============================] - 0s 6ms/step - loss: 0.3503
Epoch 269/270
11/11 [==============================] - 0s 6ms/step - loss: 0.2896
Epoch 270/270
11/11 [==============================] - 0s 7ms/step - loss: 0.2280
>expected=3.0, predicted=14.4
Epoch 1/270
11/11 [==============================] - 1s 6ms/step - loss: 136.7525
Epoch 2/270
11/11 [==============================] - 0s 7ms/step - loss: 134.5323
Epoch 3/270
11/11 [==============================] - 0s 6ms/step - loss: 132.3066
Epoch 4/270
11/11 [==============================] - 0s 7ms/step - loss: 128.4761
Epoch 5/270
11/11 [==============================] - 0s 6ms/step - loss: 110.8124
Epoch 6/270
11/11 [==============================] - 0s 7ms/step - loss: 108.0234
Epoch 7/270
11/11 [==============================] - 0s 6ms/step - loss: 95.6776
Epoch 8/270
11/11 [==============================] - 0s 6ms/step - loss: 94.2772
Epoch 9/270
11/11 [==============================] - 0s 5ms/step - loss: 88.9060
Epoch 10/270
11/11 [==============================] - 0s 8ms/step - loss: 86.2684
Epoch 11/270
11/11 [==============================] - 0s 7ms/step - loss: 83.0532
Epoch 12/270
11/11 [==============================] - 0s 6ms/step - loss: 81.5846
Epoch 13/270
11/11 [==============================] - 0s 7ms/step - loss: 79.4763
Epoch 14/270
11/11 [==============================] - 0s 7ms/step - loss: 78.6301
Epoch 15/270
11/11 [==============================] - 0s 7ms/step - loss: 78.1359
Epoch 16/270
11/11 [==============================] - 0s 7ms/step - loss: 78.5795
Epoch 17/270
11/11 [==============================] - 0s 6ms/step - loss: 78.3949
Epoch 18/270
11/11 [==============================] - 0s 6ms/step - loss: 75.6918
Epoch 19/270
11/11 [==============================] - 0s 6ms/step - loss: 73.7555
Epoch 20/270
11/11 [==============================] - 0s 7ms/step - loss: 71.0557
Epoch 21/270
```

```
11/11 [==============================] - 0s 5ms/step - loss: 72.6706
Epoch 22/270
11/11 [==============================] - 0s 6ms/step - loss: 69.6174
Epoch 23/270
11/11 [==============================] - 0s 7ms/step - loss: 69.2129
Epoch 24/270
11/11 [==============================] - 0s 6ms/step - loss: 68.1400
Epoch 25/270
11/11 [==============================] - 0s 6ms/step - loss: 66.3277
Epoch 26/270
11/11 [==============================] - 0s 6ms/step - loss: 64.9600
Epoch 27/270
11/11 [==============================] - 0s 7ms/step - loss: 64.9025
Epoch 28/270
11/11 [==============================] - 0s 7ms/step - loss: 62.3742
Epoch 29/270
11/11 [==============================] - 0s 7ms/step - loss: 61.5731
Epoch 30/270
11/11 [==============================] - 0s 6ms/step - loss: 60.3144
Epoch 31/270
11/11 [==============================] - 0s 7ms/step - loss: 57.6951
Epoch 32/270
11/11 [==============================] - 0s 6ms/step - loss: 60.9784
Epoch 33/270
11/11 [==============================] - 0s 6ms/step - loss: 59.4430
Epoch 34/270
11/11 [==============================] - 0s 7ms/step - loss: 61.9742
Epoch 35/270
11/11 [==============================] - 0s 6ms/step - loss: 60.5362
Epoch 36/270
11/11 [==============================] - 0s 7ms/step - loss: 55.0664
Epoch 37/270
11/11 [==============================] - 0s 7ms/step - loss: 54.0702
Epoch 38/270
11/11 [==============================] - 0s 7ms/step - loss: 55.3221
Epoch 39/270
11/11 [==============================] - 0s 7ms/step - loss: 51.3800
Epoch 40/270
11/11 [==============================] - 0s 6ms/step - loss: 52.7030
Epoch 41/270
11/11 [==============================] - 0s 8ms/step - loss: 52.9886
Epoch 42/270
11/11 [==============================] - 0s 6ms/step - loss: 49.3920
Epoch 43/270
11/11 [==============================] - 0s 6ms/step - loss: 47.9480
Epoch 44/270
11/11 [==============================] - 0s 7ms/step - loss: 52.5288
Epoch 45/270
11/11 [==============================] - 0s 6ms/step - loss: 47.2826
Epoch 46/270
11/11 [==============================] - 0s 7ms/step - loss: 45.4175
Epoch 47/270
11/11 [==============================] - 0s 6ms/step - loss: 45.7265
Epoch 48/270
11/11 [==============================] - 0s 7ms/step - loss: 45.8840
Epoch 49/270
11/11 [==============================] - 0s 7ms/step - loss: 42.8418
Epoch 50/270
11/11 [==============================] - 0s 6ms/step - loss: 42.4343
Epoch 51/270
11/11 [==============================] - 0s 6ms/step - loss: 44.8227
```

```
Epoch 52/270
11/11 [==============================] - 0s 7ms/step - loss: 43.2017
Epoch 53/270
11/11 [==============================] - 0s 6ms/step - loss: 41.8545
Epoch 54/270
11/11 [==============================] - 0s 7ms/step - loss: 39.3965
Epoch 55/270
11/11 [==============================] - 0s 7ms/step - loss: 38.4963
Epoch 56/270
11/11 [==============================] - 0s 6ms/step - loss: 37.6146
Epoch 57/270
11/11 [==============================] - 0s 6ms/step - loss: 35.2757
Epoch 58/270
11/11 [==============================] - 0s 7ms/step - loss: 33.9639
Epoch 59/270
11/11 [==============================] - 0s 6ms/step - loss: 34.8421
Epoch 60/270
11/11 [==============================] - 0s 7ms/step - loss: 34.2459
Epoch 61/270
11/11 [==============================] - 0s 7ms/step - loss: 35.2921
Epoch 62/270
11/11 [==============================] - 0s 5ms/step - loss: 32.7659
Epoch 63/270
11/11 [==============================] - 0s 7ms/step - loss: 32.6518
Epoch 64/270
11/11 [==============================] - 0s 6ms/step - loss: 30.7302
Epoch 65/270
11/11 [==============================] - 0s 6ms/step - loss: 28.4813
Epoch 66/270
11/11 [==============================] - 0s 8ms/step - loss: 28.7736
Epoch 67/270
11/11 [==============================] - 0s 7ms/step - loss: 28.7863
Epoch 68/270
11/11 [==============================] - 0s 6ms/step - loss: 27.4966
Epoch 69/270
11/11 [==============================] - 0s 7ms/step - loss: 26.5345
Epoch 70/270
11/11 [==============================] - 0s 6ms/step - loss: 25.1163
Epoch 71/270
11/11 [==============================] - 0s 6ms/step - loss: 24.2083
Epoch 72/270
11/11 [==============================] - 0s 7ms/step - loss: 25.4346
Epoch 73/270
11/11 [==============================] - 0s 6ms/step - loss: 24.2874
Epoch 74/270
11/11 [==============================] - 0s 5ms/step - loss: 22.4931
Epoch 75/270
11/11 [==============================] - 0s 6ms/step - loss: 21.2479
Epoch 76/270
11/11 [==============================] - 0s 8ms/step - loss: 21.1543
Epoch 77/270
11/11 [==============================] - 0s 7ms/step - loss: 21.8334
Epoch 78/270
11/11 [==============================] - 0s 7ms/step - loss: 18.7833
Epoch 79/270
11/11 [==============================] - 0s 6ms/step - loss: 18.8679
Epoch 80/270
11/11 [==============================] - 0s 6ms/step - loss: 17.7401
Epoch 81/270
11/11 [==============================] - 0s 6ms/step - loss: 17.0195
Epoch 82/270
```

```
11/11 [==============================] - 0s 6ms/step - loss: 15.6838
Epoch 83/270
11/11 [==============================] - 0s 6ms/step - loss: 15.3611
Epoch 84/270
11/11 [==============================] - 0s 7ms/step - loss: 16.8025
Epoch 85/270
11/11 [==============================] - 0s 6ms/step - loss: 16.1738
Epoch 86/270
11/11 [==============================] - 0s 6ms/step - loss: 15.9106
Epoch 87/270
11/11 [==============================] - 0s 6ms/step - loss: 15.2417
Epoch 88/270
11/11 [==============================] - 0s 7ms/step - loss: 12.9303
Epoch 89/270
11/11 [==============================] - 0s 8ms/step - loss: 12.6700
Epoch 90/270
11/11 [==============================] - 0s 7ms/step - loss: 12.7132
Epoch 91/270
11/11 [==============================] - 0s 6ms/step - loss: 12.9329
Epoch 92/270
11/11 [==============================] - 0s 6ms/step - loss: 13.1194
Epoch 93/270
11/11 [==============================] - 0s 7ms/step - loss: 12.9077
Epoch 94/270
11/11 [==============================] - 0s 6ms/step - loss: 13.2534
Epoch 95/270
11/11 [==============================] - 0s 7ms/step - loss: 11.8841
Epoch 96/270
11/11 [==============================] - 0s 6ms/step - loss: 12.5960
Epoch 97/270
11/11 [==============================] - 0s 7ms/step - loss: 10.7014
Epoch 98/270
11/11 [==============================] - 0s 7ms/step - loss: 9.9295
Epoch 99/270
11/11 [==============================] - 0s 7ms/step - loss: 10.1133
Epoch 100/270
11/11 [==============================] - 0s 6ms/step - loss: 10.6340
Epoch 101/270
11/11 [==============================] - 0s 7ms/step - loss: 8.9373
Epoch 102/270
11/11 [==============================] - 0s 7ms/step - loss: 9.3755
Epoch 103/270
11/11 [==============================] - 0s 7ms/step - loss: 9.4145
Epoch 104/270
11/11 [==============================] - 0s 6ms/step - loss: 9.9771
Epoch 105/270
11/11 [==============================] - 0s 7ms/step - loss: 8.9232
Epoch 106/270
11/11 [==============================] - 0s 6ms/step - loss: 8.2789
Epoch 107/270
11/11 [==============================] - 0s 6ms/step - loss: 7.3970
Epoch 108/270
11/11 [==============================] - 0s 7ms/step - loss: 7.2655
Epoch 109/270
11/11 [==============================] - 0s 7ms/step - loss: 6.6891
Epoch 110/270
11/11 [==============================] - 0s 6ms/step - loss: 6.5947
Epoch 111/270
11/11 [==============================] - 0s 7ms/step - loss: 7.3336
Epoch 112/270
11/11 [==============================] - 0s 7ms/step - loss: 7.7409
```

```
Epoch 113/270
11/11 [==============================] - 0s 7ms/step - loss: 6.9813
Epoch 114/270
11/11 [==============================] - 0s 6ms/step - loss: 6.0286
Epoch 115/270
11/11 [==============================] - 0s 7ms/step - loss: 6.6751
Epoch 116/270
11/11 [==============================] - 0s 7ms/step - loss: 6.7093
Epoch 117/270
11/11 [==============================] - 0s 6ms/step - loss: 5.9442
Epoch 118/270
11/11 [==============================] - 0s 6ms/step - loss: 5.6094
Epoch 119/270
11/11 [==============================] - 0s 7ms/step - loss: 4.8719
Epoch 120/270
11/11 [==============================] - 0s 5ms/step - loss: 4.7556
Epoch 121/270
11/11 [==============================] - 0s 7ms/step - loss: 4.5174
Epoch 122/270
11/11 [==============================] - 0s 7ms/step - loss: 4.3491
Epoch 123/270
11/11 [==============================] - 0s 6ms/step - loss: 3.7790
Epoch 124/270
11/11 [==============================] - 0s 7ms/step - loss: 3.5076
Epoch 125/270
11/11 [==============================] - 0s 6ms/step - loss: 3.1416
Epoch 126/270
11/11 [==============================] - 0s 7ms/step - loss: 3.1394
Epoch 127/270
11/11 [==============================] - 0s 6ms/step - loss: 3.3935
Epoch 128/270
11/11 [==============================] - 0s 7ms/step - loss: 3.2145
Epoch 129/270
11/11 [==============================] - 0s 8ms/step - loss: 3.2705
Epoch 130/270
11/11 [==============================] - 0s 6ms/step - loss: 3.2060
Epoch 131/270
11/11 [==============================] - 0s 7ms/step - loss: 3.0964
Epoch 132/270
11/11 [==============================] - 0s 7ms/step - loss: 2.8011
Epoch 133/270
11/11 [==============================] - 0s 7ms/step - loss: 3.2553
Epoch 134/270
11/11 [==============================] - 0s 7ms/step - loss: 3.3024
Epoch 135/270
11/11 [==============================] - 0s 6ms/step - loss: 3.2849
Epoch 136/270
11/11 [==============================] - 0s 7ms/step - loss: 3.2377
Epoch 137/270
11/11 [==============================] - 0s 6ms/step - loss: 3.5759
Epoch 138/270
11/11 [==============================] - 0s 6ms/step - loss: 3.8501
Epoch 139/270
11/11 [==============================] - 0s 5ms/step - loss: 3.2544
Epoch 140/270
11/11 [==============================] - 0s 7ms/step - loss: 3.1187
Epoch 141/270
11/11 [==============================] - 0s 6ms/step - loss: 2.5115
Epoch 142/270
11/11 [==============================] - 0s 8ms/step - loss: 2.5000
Epoch 143/270
```

```
11/11 [==============================] - 0s 6ms/step - loss: 2.3921
Epoch 144/270
11/11 [==============================] - 0s 7ms/step - loss: 2.0117
Epoch 145/270
11/11 [==============================] - 0s 6ms/step - loss: 1.9275
Epoch 146/270
11/11 [==============================] - 0s 7ms/step - loss: 1.8125
Epoch 147/270
11/11 [==============================] - 0s 6ms/step - loss: 1.6044
Epoch 148/270
11/11 [==============================] - 0s 6ms/step - loss: 1.5574
Epoch 149/270
11/11 [==============================] - 0s 6ms/step - loss: 1.5211
Epoch 150/270
11/11 [==============================] - 0s 7ms/step - loss: 1.5025
Epoch 151/270
11/11 [==============================] - 0s 6ms/step - loss: 1.5907
Epoch 152/270
11/11 [==============================] - 0s 6ms/step - loss: 1.6477
Epoch 153/270
11/11 [==============================] - 0s 6ms/step - loss: 1.7632
Epoch 154/270
11/11 [==============================] - 0s 7ms/step - loss: 1.7657
Epoch 155/270
11/11 [==============================] - 0s 6ms/step - loss: 1.6019
Epoch 156/270
11/11 [==============================] - 0s 8ms/step - loss: 1.5898
Epoch 157/270
11/11 [==============================] - 0s 7ms/step - loss: 1.5624
Epoch 158/270
11/11 [==============================] - 0s 6ms/step - loss: 1.6334
Epoch 159/270
11/11 [==============================] - 0s 6ms/step - loss: 1.3521
Epoch 160/270
11/11 [==============================] - 0s 7ms/step - loss: 1.3693
Epoch 161/270
11/11 [==============================] - 0s 6ms/step - loss: 1.3785
Epoch 162/270
11/11 [==============================] - 0s 5ms/step - loss: 1.2969
Epoch 163/270
11/11 [==============================] - 0s 7ms/step - loss: 1.5968
Epoch 164/270
11/11 [==============================] - 0s 6ms/step - loss: 1.5694
Epoch 165/270
11/11 [==============================] - 0s 7ms/step - loss: 1.5060
Epoch 166/270
11/11 [==============================] - 0s 6ms/step - loss: 1.6062
Epoch 167/270
11/11 [==============================] - 0s 6ms/step - loss: 1.4961
Epoch 168/270
11/11 [==============================] - 0s 7ms/step - loss: 1.3257
Epoch 169/270
11/11 [==============================] - 0s 8ms/step - loss: 1.3329
Epoch 170/270
11/11 [==============================] - 0s 7ms/step - loss: 1.4157
Epoch 171/270
11/11 [==============================] - 0s 6ms/step - loss: 1.4568
Epoch 172/270
11/11 [==============================] - 0s 6ms/step - loss: 1.2610
Epoch 173/270
11/11 [==============================] - 0s 7ms/step - loss: 1.2801
```

```
Epoch 174/270
11/11 [==============================] - 0s 7ms/step - loss: 1.2528
Epoch 175/270
11/11 [==============================] - 0s 7ms/step - loss: 1.2211
Epoch 176/270
11/11 [==============================] - 0s 7ms/step - loss: 1.0617
Epoch 177/270
11/11 [==============================] - 0s 7ms/step - loss: 1.3357
Epoch 178/270
11/11 [==============================] - 0s 6ms/step - loss: 1.2634
Epoch 179/270
11/11 [==============================] - 0s 6ms/step - loss: 1.1192
Epoch 180/270
11/11 [==============================] - 0s 6ms/step - loss: 1.1131
Epoch 181/270
11/11 [==============================] - 0s 7ms/step - loss: 1.0064
Epoch 182/270
11/11 [==============================] - 0s 8ms/step - loss: 1.2104
Epoch 183/270
11/11 [==============================] - 0s 7ms/step - loss: 1.2838
Epoch 184/270
11/11 [==============================] - 0s 7ms/step - loss: 1.1845
Epoch 185/270
11/11 [==============================] - 0s 7ms/step - loss: 1.2132
Epoch 186/270
11/11 [==============================] - 0s 5ms/step - loss: 1.2785
Epoch 187/270
11/11 [==============================] - 0s 7ms/step - loss: 1.2957
Epoch 188/270
11/11 [==============================] - 0s 6ms/step - loss: 1.2889
Epoch 189/270
11/11 [==============================] - 0s 6ms/step - loss: 1.3234
Epoch 190/270
11/11 [==============================] - 0s 6ms/step - loss: 1.3770
Epoch 191/270
11/11 [==============================] - 0s 6ms/step - loss: 1.7877
Epoch 192/270
11/11 [==============================] - 0s 6ms/step - loss: 1.7471
Epoch 193/270
11/11 [==============================] - 0s 6ms/step - loss: 1.8738
Epoch 194/270
11/11 [==============================] - 0s 6ms/step - loss: 1.2358
Epoch 195/270
11/11 [==============================] - 0s 8ms/step - loss: 1.0790
Epoch 196/270
11/11 [==============================] - 0s 6ms/step - loss: 1.0921
Epoch 197/270
11/11 [==============================] - 0s 7ms/step - loss: 0.9614
Epoch 198/270
11/11 [==============================] - 0s 6ms/step - loss: 0.8419
Epoch 199/270
11/11 [==============================] - 0s 7ms/step - loss: 0.8112
Epoch 200/270
11/11 [==============================] - 0s 6ms/step - loss: 0.7216
Epoch 201/270
11/11 [==============================] - 0s 7ms/step - loss: 0.7454
Epoch 202/270
11/11 [==============================] - 0s 6ms/step - loss: 0.6661
Epoch 203/270
11/11 [==============================] - 0s 7ms/step - loss: 0.5853
Epoch 204/270
```

```
11/11 [==============================] - 0s 5ms/step - loss: 0.5910
Epoch 205/270
11/11 [==============================] - 0s 7ms/step - loss: 0.5900
Epoch 206/270
11/11 [==============================] - 0s 6ms/step - loss: 0.6024
Epoch 207/270
11/11 [==============================] - 0s 6ms/step - loss: 0.5659
Epoch 208/270
11/11 [==============================] - 0s 8ms/step - loss: 0.5401
Epoch 209/270
11/11 [==============================] - 0s 6ms/step - loss: 0.5307
Epoch 210/270
11/11 [==============================] - 0s 7ms/step - loss: 0.4926
Epoch 211/270
11/11 [==============================] - 0s 6ms/step - loss: 0.4503
Epoch 212/270
11/11 [==============================] - 0s 7ms/step - loss: 0.4551
Epoch 213/270
11/11 [==============================] - 0s 6ms/step - loss: 0.5157
Epoch 214/270
11/11 [==============================] - 0s 6ms/step - loss: 0.4932
Epoch 215/270
11/11 [==============================] - 0s 8ms/step - loss: 0.5278
Epoch 216/270
11/11 [==============================] - 0s 7ms/step - loss: 0.5189
Epoch 217/270
11/11 [==============================] - 0s 7ms/step - loss: 0.6271
Epoch 218/270
11/11 [==============================] - 0s 6ms/step - loss: 0.6737
Epoch 219/270
11/11 [==============================] - 0s 7ms/step - loss: 0.7696
Epoch 220/270
11/11 [==============================] - 0s 6ms/step - loss: 0.8303
Epoch 221/270
11/11 [==============================] - 0s 7ms/step - loss: 0.6969
Epoch 222/270
11/11 [==============================] - 0s 7ms/step - loss: 0.7209
Epoch 223/270
11/11 [==============================] - 0s 7ms/step - loss: 0.9104
Epoch 224/270
11/11 [==============================] - 0s 6ms/step - loss: 0.9753
Epoch 225/270
11/11 [==============================] - 0s 7ms/step - loss: 0.8516
Epoch 226/270
11/11 [==============================] - 0s 7ms/step - loss: 0.9892
Epoch 227/270
11/11 [==============================] - 0s 6ms/step - loss: 0.9512
Epoch 228/270
11/11 [==============================] - 0s 8ms/step - loss: 0.9440
Epoch 229/270
11/11 [==============================] - 0s 7ms/step - loss: 0.8355
Epoch 230/270
11/11 [==============================] - 0s 7ms/step - loss: 0.6098
Epoch 231/270
11/11 [==============================] - 0s 6ms/step - loss: 0.6880
Epoch 232/270
11/11 [==============================] - 0s 6ms/step - loss: 0.7744
Epoch 233/270
11/11 [==============================] - 0s 8ms/step - loss: 0.7164
Epoch 234/270
11/11 [==============================] - 0s 7ms/step - loss: 0.9572
```

```
Epoch 235/270
11/11 [==============================] - 0s 7ms/step - loss: 0.9076
Epoch 236/270
11/11 [==============================] - 0s 7ms/step - loss: 1.2895
Epoch 237/270
11/11 [==============================] - 0s 6ms/step - loss: 1.2885
Epoch 238/270
11/11 [==============================] - 0s 6ms/step - loss: 0.8199
Epoch 239/270
11/11 [==============================] - 0s 7ms/step - loss: 0.7493
Epoch 240/270
11/11 [==============================] - 0s 6ms/step - loss: 0.8500
Epoch 241/270
11/11 [==============================] - 0s 7ms/step - loss: 1.0916
Epoch 242/270
11/11 [==============================] - 0s 7ms/step - loss: 0.6854
Epoch 243/270
11/11 [==============================] - 0s 7ms/step - loss: 0.6412
Epoch 244/270
11/11 [==============================] - 0s 7ms/step - loss: 0.5032
Epoch 245/270
11/11 [==============================] - 0s 6ms/step - loss: 0.3653
Epoch 246/270
11/11 [==============================] - 0s 8ms/step - loss: 0.3905
Epoch 247/270
11/11 [==============================] - 0s 7ms/step - loss: 0.3688
Epoch 248/270
11/11 [==============================] - 0s 6ms/step - loss: 0.4368
Epoch 249/270
11/11 [==============================] - 0s 8ms/step - loss: 0.4249
Epoch 250/270
11/11 [==============================] - 0s 6ms/step - loss: 0.4297
Epoch 251/270
11/11 [==============================] - 0s 7ms/step - loss: 0.3683
Epoch 252/270
11/11 [==============================] - 0s 6ms/step - loss: 0.3481
Epoch 253/270
11/11 [==============================] - 0s 6ms/step - loss: 0.2982
Epoch 254/270
11/11 [==============================] - 0s 7ms/step - loss: 0.2832
Epoch 255/270
11/11 [==============================] - 0s 6ms/step - loss: 0.2728
Epoch 256/270
11/11 [==============================] - 0s 7ms/step - loss: 0.2718
Epoch 257/270
11/11 [==============================] - 0s 6ms/step - loss: 0.2821
Epoch 258/270
11/11 [==============================] - 0s 7ms/step - loss: 0.2988
Epoch 259/270
11/11 [==============================] - 0s 8ms/step - loss: 0.3262
Epoch 260/270
11/11 [==============================] - 0s 8ms/step - loss: 0.3523
Epoch 261/270
11/11 [==============================] - 0s 7ms/step - loss: 0.4228
Epoch 262/270
11/11 [==============================] - 0s 7ms/step - loss: 0.5093
Epoch 263/270
11/11 [==============================] - 0s 9ms/step - loss: 0.7783
Epoch 264/270
11/11 [==============================] - 0s 7ms/step - loss: 0.8116
Epoch 265/270
```

```
11/11 [==============================] - 0s 6ms/step - loss: 0.7376
Epoch 266/270
11/11 [==============================] - 0s 9ms/step - loss: 0.7841
Epoch 267/270
11/11 [==============================] - 0s 12ms/step - loss: 0.9467
Epoch 268/270
11/11 [==============================] - 0s 22ms/step - loss: 0.9124
Epoch 269/270
11/11 [==============================] - 0s 22ms/step - loss: 0.8768
Epoch 270/270
11/11 [==============================] - 0s 20ms/step - loss: 0.8635
>expected=-4.0, predicted=5.0
Epoch 1/270
11/11 [==============================] - 3s 10ms/step - loss: 137.7173
Epoch 2/270
11/11 [==============================] - 0s 11ms/step - loss: 134.7468
Epoch 3/270
11/11 [==============================] - 0s 15ms/step - loss: 131.4207
Epoch 4/270
11/11 [==============================] - 0s 9ms/step - loss: 123.1707
Epoch 5/270
11/11 [==============================] - 0s 11ms/step - loss: 106.8550
Epoch 6/270
11/11 [==============================] - 0s 12ms/step - loss: 99.2565
Epoch 7/270
11/11 [==============================] - 0s 12ms/step - loss: 94.4395
Epoch 8/270
11/11 [==============================] - 0s 12ms/step - loss: 92.0576
Epoch 9/270
11/11 [==============================] - 0s 10ms/step - loss: 88.2394
Epoch 10/270
11/11 [==============================] - 0s 7ms/step - loss: 84.8712
Epoch 11/270
11/11 [==============================] - 0s 10ms/step - loss: 83.2097
Epoch 12/270
11/11 [==============================] - 0s 13ms/step - loss: 80.8292
Epoch 13/270
11/11 [==============================] - 0s 14ms/step - loss: 79.6990
Epoch 14/270
11/11 [==============================] - 0s 9ms/step - loss: 77.4188
Epoch 15/270
11/11 [==============================] - 0s 13ms/step - loss: 77.3162
Epoch 16/270
11/11 [==============================] - 0s 15ms/step - loss: 76.4620
Epoch 17/270
11/11 [==============================] - 0s 12ms/step - loss: 75.4291
Epoch 18/270
11/11 [==============================] - 0s 14ms/step - loss: 73.3438
Epoch 19/270
11/11 [==============================] - 0s 16ms/step - loss: 73.4731
Epoch 20/270
11/11 [==============================] - 0s 12ms/step - loss: 70.6837
Epoch 21/270
11/11 [==============================] - 0s 12ms/step - loss: 68.8443
Epoch 22/270
11/11 [==============================] - 0s 11ms/step - loss: 67.6484
Epoch 23/270
11/11 [==============================] - 0s 16ms/step - loss: 66.2354
Epoch 24/270
11/11 [==============================] - 0s 15ms/step - loss: 64.7102
Epoch 25/270
```

```
11/11 [==============================] - 0s 12ms/step - loss: 64.2695
Epoch 26/270
11/11 [==============================] - 0s 13ms/step - loss: 63.6661
Epoch 27/270
11/11 [==============================] - 0s 15ms/step - loss: 62.0457
Epoch 28/270
11/11 [==============================] - 0s 12ms/step - loss: 58.6538
Epoch 29/270
11/11 [==============================] - 0s 16ms/step - loss: 57.1242
Epoch 30/270
11/11 [==============================] - 0s 22ms/step - loss: 54.7592
Epoch 31/270
11/11 [==============================] - 0s 16ms/step - loss: 54.7359
Epoch 32/270
11/11 [==============================] - 0s 9ms/step - loss: 53.7758
Epoch 33/270
11/11 [==============================] - 0s 15ms/step - loss: 54.9166
Epoch 34/270
11/11 [==============================] - 0s 15ms/step - loss: 51.7937
Epoch 35/270
11/11 [==============================] - 0s 13ms/step - loss: 49.0857
Epoch 36/270
11/11 [==============================] - 0s 13ms/step - loss: 46.7240
Epoch 37/270
11/11 [==============================] - 0s 19ms/step - loss: 48.4568
Epoch 38/270
11/11 [==============================] - 0s 15ms/step - loss: 48.1127
Epoch 39/270
11/11 [==============================] - 0s 18ms/step - loss: 47.2742
Epoch 40/270
11/11 [==============================] - 0s 14ms/step - loss: 44.0467
Epoch 41/270
11/11 [==============================] - 0s 16ms/step - loss: 47.6662
Epoch 42/270
11/11 [==============================] - 0s 14ms/step - loss: 43.6803
Epoch 43/270
11/11 [==============================] - 0s 13ms/step - loss: 42.1242
Epoch 44/270
11/11 [==============================] - 0s 15ms/step - loss: 41.4374
Epoch 45/270
11/11 [==============================] - 0s 16ms/step - loss: 40.2269
Epoch 46/270
11/11 [==============================] - 0s 16ms/step - loss: 37.5255
Epoch 47/270
11/11 [==============================] - 0s 16ms/step - loss: 35.2751
Epoch 48/270
11/11 [==============================] - 0s 13ms/step - loss: 37.4971
Epoch 49/270
11/11 [==============================] - 0s 17ms/step - loss: 37.2348
Epoch 50/270
11/11 [==============================] - 0s 13ms/step - loss: 33.5555
Epoch 51/270
11/11 [==============================] - 0s 13ms/step - loss: 32.9116
Epoch 52/270
11/11 [==============================] - 0s 12ms/step - loss: 31.4052
Epoch 53/270
11/11 [==============================] - 0s 15ms/step - loss: 30.5090
Epoch 54/270
11/11 [==============================] - 0s 14ms/step - loss: 30.3692
Epoch 55/270
11/11 [==============================] - 0s 16ms/step - loss: 29.4681
```

```
Epoch 56/270
11/11 [==============================] - 0s 13ms/step - loss: 29.9676
Epoch 57/270
11/11 [==============================] - 0s 14ms/step - loss: 28.5081
Epoch 58/270
11/11 [==============================] - 0s 9ms/step - loss: 30.0567
Epoch 59/270
11/11 [==============================] - 0s 16ms/step - loss: 29.8794
Epoch 60/270
11/11 [==============================] - 0s 16ms/step - loss: 26.3013
Epoch 61/270
11/11 [==============================] - 0s 21ms/step - loss: 25.5577
Epoch 62/270
11/11 [==============================] - 0s 15ms/step - loss: 22.9683
Epoch 63/270
11/11 [==============================] - 0s 10ms/step - loss: 23.7246
Epoch 64/270
11/11 [==============================] - 0s 14ms/step - loss: 21.1440
Epoch 65/270
11/11 [==============================] - 0s 13ms/step - loss: 20.9670
Epoch 66/270
11/11 [==============================] - 0s 21ms/step - loss: 19.0781
Epoch 67/270
11/11 [==============================] - 0s 18ms/step - loss: 19.1240
Epoch 68/270
11/11 [==============================] - 0s 25ms/step - loss: 19.0597
Epoch 69/270
11/11 [==============================] - 0s 26ms/step - loss: 19.7743
Epoch 70/270
11/11 [==============================] - 0s 23ms/step - loss: 19.6724
Epoch 71/270
11/11 [==============================] - 0s 14ms/step - loss: 20.3869
Epoch 72/270
11/11 [==============================] - 0s 14ms/step - loss: 17.7225
Epoch 73/270
11/11 [==============================] - 0s 17ms/step - loss: 17.0944
Epoch 74/270
11/11 [==============================] - 0s 21ms/step - loss: 17.1283
Epoch 75/270
11/11 [==============================] - 0s 25ms/step - loss: 17.1935
Epoch 76/270
11/11 [==============================] - 0s 11ms/step - loss: 14.9186
Epoch 77/270
11/11 [==============================] - 0s 14ms/step - loss: 14.1671
Epoch 78/270
11/11 [==============================] - 0s 10ms/step - loss: 13.5260
Epoch 79/270
11/11 [==============================] - 0s 10ms/step - loss: 13.5312
Epoch 80/270
11/11 [==============================] - 0s 11ms/step - loss: 14.6921
Epoch 81/270
11/11 [==============================] - 0s 17ms/step - loss: 16.2102
Epoch 82/270
11/11 [==============================] - 0s 12ms/step - loss: 18.2459
Epoch 83/270
11/11 [==============================] - 0s 24ms/step - loss: 15.5253
Epoch 84/270
11/11 [==============================] - 0s 16ms/step - loss: 14.5326
Epoch 85/270
11/11 [==============================] - 0s 17ms/step - loss: 12.6719
Epoch 86/270
```

```
11/11 [==============================] - 0s 17ms/step - loss: 12.3003
Epoch 87/270
11/11 [==============================] - 0s 16ms/step - loss: 14.2960
Epoch 88/270
11/11 [==============================] - 0s 16ms/step - loss: 13.9652
Epoch 89/270
11/11 [==============================] - 0s 15ms/step - loss: 13.3261
Epoch 90/270
11/11 [==============================] - 0s 14ms/step - loss: 14.1460
Epoch 91/270
11/11 [==============================] - 0s 15ms/step - loss: 14.2360
Epoch 92/270
11/11 [==============================] - 0s 16ms/step - loss: 14.0113
Epoch 93/270
11/11 [==============================] - 0s 11ms/step - loss: 11.7602
Epoch 94/270
11/11 [==============================] - 0s 13ms/step - loss: 10.1869
Epoch 95/270
11/11 [==============================] - 0s 9ms/step - loss: 10.3399
Epoch 96/270
11/11 [==============================] - 0s 14ms/step - loss: 9.5811
Epoch 97/270
11/11 [==============================] - 0s 13ms/step - loss: 9.3728
Epoch 98/270
11/11 [==============================] - 0s 11ms/step - loss: 9.4379
Epoch 99/270
11/11 [==============================] - 0s 14ms/step - loss: 9.1713
Epoch 100/270
11/11 [==============================] - 0s 11ms/step - loss: 8.1080
Epoch 101/270
11/11 [==============================] - 0s 10ms/step - loss: 7.7278
Epoch 102/270
11/11 [==============================] - 0s 12ms/step - loss: 7.2569
Epoch 103/270
11/11 [==============================] - 0s 14ms/step - loss: 6.3661
Epoch 104/270
11/11 [==============================] - 0s 15ms/step - loss: 6.9429
Epoch 105/270
11/11 [==============================] - 0s 17ms/step - loss: 6.6333
Epoch 106/270
11/11 [==============================] - 0s 15ms/step - loss: 6.2244
Epoch 107/270
11/11 [==============================] - 0s 17ms/step - loss: 6.0377
Epoch 108/270
11/11 [==============================] - 0s 19ms/step - loss: 6.3528
Epoch 109/270
11/11 [==============================] - 0s 15ms/step - loss: 5.7384
Epoch 110/270
11/11 [==============================] - 0s 23ms/step - loss: 5.7329
Epoch 111/270
11/11 [==============================] - 0s 16ms/step - loss: 5.9157
Epoch 112/270
11/11 [==============================] - 0s 14ms/step - loss: 5.9066
Epoch 113/270
11/11 [==============================] - 0s 24ms/step - loss: 5.4589
Epoch 114/270
11/11 [==============================] - 0s 22ms/step - loss: 5.2756
Epoch 115/270
11/11 [==============================] - 0s 23ms/step - loss: 5.5346
Epoch 116/270
11/11 [==============================] - 0s 19ms/step - loss: 5.4644
```

```
Epoch 117/270
11/11 [==============================] - 0s 17ms/step - loss: 5.5491
Epoch 118/270
11/11 [==============================] - 0s 17ms/step - loss: 5.8692
Epoch 119/270
11/11 [==============================] - 0s 17ms/step - loss: 5.4131
Epoch 120/270
11/11 [==============================] - 0s 8ms/step - loss: 6.5173
Epoch 121/270
11/11 [==============================] - 0s 8ms/step - loss: 6.1531
Epoch 122/270
11/11 [==============================] - 0s 8ms/step - loss: 5.0923
Epoch 123/270
11/11 [==============================] - 0s 15ms/step - loss: 5.0775
Epoch 124/270
11/11 [==============================] - 0s 15ms/step - loss: 5.6107
Epoch 125/270
11/11 [==============================] - 0s 11ms/step - loss: 5.2319
Epoch 126/270
11/11 [==============================] - 0s 10ms/step - loss: 4.5071
Epoch 127/270
11/11 [==============================] - 0s 10ms/step - loss: 4.2322
Epoch 128/270
11/11 [==============================] - 0s 12ms/step - loss: 3.9047
Epoch 129/270
11/11 [==============================] - 0s 22ms/step - loss: 3.8007
Epoch 130/270
11/11 [==============================] - 0s 14ms/step - loss: 4.1145
Epoch 131/270
11/11 [==============================] - 0s 14ms/step - loss: 4.1193
Epoch 132/270
11/11 [==============================] - 0s 15ms/step - loss: 5.4460
Epoch 133/270
11/11 [==============================] - 0s 11ms/step - loss: 4.8898
Epoch 134/270
11/11 [==============================] - 0s 14ms/step - loss: 4.6160
Epoch 135/270
11/11 [==============================] - 0s 10ms/step - loss: 4.3635
Epoch 136/270
11/11 [==============================] - 0s 11ms/step - loss: 3.6137
Epoch 137/270
11/11 [==============================] - 0s 12ms/step - loss: 3.5136
Epoch 138/270
11/11 [==============================] - 0s 16ms/step - loss: 3.7201
Epoch 139/270
11/11 [==============================] - 0s 15ms/step - loss: 3.3019
Epoch 140/270
11/11 [==============================] - 0s 21ms/step - loss: 3.0435
Epoch 141/270
11/11 [==============================] - 0s 21ms/step - loss: 3.5808
Epoch 142/270
11/11 [==============================] - 0s 17ms/step - loss: 3.6933
Epoch 143/270
11/11 [==============================] - 0s 12ms/step - loss: 3.2902
Epoch 144/270
11/11 [==============================] - 0s 12ms/step - loss: 3.3236
Epoch 145/270
11/11 [==============================] - 0s 8ms/step - loss: 3.1283
Epoch 146/270
11/11 [==============================] - 0s 12ms/step - loss: 3.2458
Epoch 147/270
```

```
11/11 [==============================] - 0s 13ms/step - loss: 3.3781
Epoch 148/270
11/11 [==============================] - 0s 14ms/step - loss: 4.1862
Epoch 149/270
11/11 [==============================] - 0s 13ms/step - loss: 4.8095
Epoch 150/270
11/11 [==============================] - 0s 9ms/step - loss: 3.2886
Epoch 151/270
11/11 [==============================] - 0s 14ms/step - loss: 3.3113
Epoch 152/270
11/11 [==============================] - 0s 15ms/step - loss: 2.9000
Epoch 153/270
11/11 [==============================] - 0s 15ms/step - loss: 2.3735
Epoch 154/270
11/11 [==============================] - 0s 12ms/step - loss: 2.7480
Epoch 155/270
11/11 [==============================] - 0s 9ms/step - loss: 2.5040
Epoch 156/270
11/11 [==============================] - 0s 8ms/step - loss: 2.6470
Epoch 157/270
11/11 [==============================] - 0s 9ms/step - loss: 2.3286
Epoch 158/270
11/11 [==============================] - 0s 10ms/step - loss: 2.4056
Epoch 159/270
11/11 [==============================] - 0s 8ms/step - loss: 2.6289
Epoch 160/270
11/11 [==============================] - 0s 13ms/step - loss: 2.5036
Epoch 161/270
11/11 [==============================] - 0s 15ms/step - loss: 2.1711
Epoch 162/270
11/11 [==============================] - 0s 7ms/step - loss: 2.0478
Epoch 163/270
11/11 [==============================] - 0s 7ms/step - loss: 2.1208
Epoch 164/270
11/11 [==============================] - 0s 18ms/step - loss: 1.9509
Epoch 165/270
11/11 [==============================] - 0s 21ms/step - loss: 2.1799
Epoch 166/270
11/11 [==============================] - 0s 13ms/step - loss: 2.2357
Epoch 167/270
11/11 [==============================] - 0s 13ms/step - loss: 2.0266
Epoch 168/270
11/11 [==============================] - 0s 12ms/step - loss: 2.2701
Epoch 169/270
11/11 [==============================] - 0s 11ms/step - loss: 1.8919
Epoch 170/270
11/11 [==============================] - 0s 12ms/step - loss: 1.9845
Epoch 171/270
11/11 [==============================] - 0s 20ms/step - loss: 1.7114
Epoch 172/270
11/11 [==============================] - 0s 8ms/step - loss: 1.5856
Epoch 173/270
11/11 [==============================] - 0s 9ms/step - loss: 1.7537
Epoch 174/270
11/11 [==============================] - 0s 13ms/step - loss: 1.6768
Epoch 175/270
11/11 [==============================] - 0s 8ms/step - loss: 2.0203
Epoch 176/270
11/11 [==============================] - 0s 8ms/step - loss: 2.3385
Epoch 177/270
11/11 [==============================] - 0s 8ms/step - loss: 2.8262
```

```
Epoch 178/270
11/11 [==============================] - 0s 13ms/step - loss: 2.4448
Epoch 179/270
11/11 [==============================] - 0s 11ms/step - loss: 2.7377
Epoch 180/270
11/11 [==============================] - 0s 14ms/step - loss: 2.3172
Epoch 181/270
11/11 [==============================] - 0s 9ms/step - loss: 2.7921
Epoch 182/270
11/11 [==============================] - 0s 10ms/step - loss: 2.1911
Epoch 183/270
11/11 [==============================] - 0s 9ms/step - loss: 1.9112
Epoch 184/270
11/11 [==============================] - 0s 10ms/step - loss: 1.6703
Epoch 185/270
11/11 [==============================] - 0s 10ms/step - loss: 1.4290
Epoch 186/270
11/11 [==============================] - 0s 10ms/step - loss: 1.6608
Epoch 187/270
11/11 [==============================] - 0s 9ms/step - loss: 1.5566
Epoch 188/270
11/11 [==============================] - 0s 14ms/step - loss: 1.4968
Epoch 189/270
11/11 [==============================] - 0s 8ms/step - loss: 1.8455
Epoch 190/270
11/11 [==============================] - 0s 13ms/step - loss: 1.7161
Epoch 191/270
11/11 [==============================] - 0s 12ms/step - loss: 1.4103
Epoch 192/270
11/11 [==============================] - 0s 9ms/step - loss: 1.6213
Epoch 193/270
11/11 [==============================] - 0s 13ms/step - loss: 1.5486
Epoch 194/270
11/11 [==============================] - 0s 12ms/step - loss: 1.2336
Epoch 195/270
11/11 [==============================] - 0s 13ms/step - loss: 1.3603
Epoch 196/270
11/11 [==============================] - 0s 12ms/step - loss: 1.8084
Epoch 197/270
11/11 [==============================] - 0s 11ms/step - loss: 1.6243
Epoch 198/270
11/11 [==============================] - 0s 10ms/step - loss: 1.4694
Epoch 199/270
11/11 [==============================] - 0s 9ms/step - loss: 1.5765
Epoch 200/270
11/11 [==============================] - 0s 12ms/step - loss: 1.5467
Epoch 201/270
11/11 [==============================] - 0s 18ms/step - loss: 1.7986
Epoch 202/270
11/11 [==============================] - 0s 16ms/step - loss: 1.4440
Epoch 203/270
11/11 [==============================] - 0s 17ms/step - loss: 1.4022
Epoch 204/270
11/11 [==============================] - 0s 9ms/step - loss: 1.7669
Epoch 205/270
11/11 [==============================] - 0s 9ms/step - loss: 1.7742
Epoch 206/270
11/11 [==============================] - 0s 10ms/step - loss: 1.7698
Epoch 207/270
11/11 [==============================] - 0s 10ms/step - loss: 1.2327
Epoch 208/270
```

```
11/11 [==============================] - 0s 12ms/step - loss: 1.0540
Epoch 209/270
11/11 [==============================] - 0s 13ms/step - loss: 0.9016
Epoch 210/270
11/11 [==============================] - 0s 14ms/step - loss: 0.9225
Epoch 211/270
11/11 [==============================] - 0s 10ms/step - loss: 0.9258
Epoch 212/270
11/11 [==============================] - 0s 11ms/step - loss: 0.9266
Epoch 213/270
11/11 [==============================] - 0s 14ms/step - loss: 1.0321
Epoch 214/270
11/11 [==============================] - 0s 15ms/step - loss: 0.6536
Epoch 215/270
11/11 [==============================] - 0s 8ms/step - loss: 0.6755
Epoch 216/270
11/11 [==============================] - 0s 8ms/step - loss: 0.5145
Epoch 217/270
11/11 [==============================] - 0s 7ms/step - loss: 0.4971
Epoch 218/270
11/11 [==============================] - 0s 7ms/step - loss: 0.4084
Epoch 219/270
11/11 [==============================] - 0s 16ms/step - loss: 0.4608
Epoch 220/270
11/11 [==============================] - 0s 15ms/step - loss: 0.4290
Epoch 221/270
11/11 [==============================] - 0s 13ms/step - loss: 0.3711
Epoch 222/270
11/11 [==============================] - 0s 12ms/step - loss: 0.3424
Epoch 223/270
11/11 [==============================] - 0s 10ms/step - loss: 0.3423
Epoch 224/270
11/11 [==============================] - 0s 7ms/step - loss: 0.3531
Epoch 225/270
11/11 [==============================] - 0s 7ms/step - loss: 0.3680
Epoch 226/270
11/11 [==============================] - 0s 7ms/step - loss: 0.4306
Epoch 227/270
11/11 [==============================] - 0s 8ms/step - loss: 0.4298
Epoch 228/270
11/11 [==============================] - 0s 7ms/step - loss: 0.4478
Epoch 229/270
11/11 [==============================] - 0s 7ms/step - loss: 0.4949
Epoch 230/270
11/11 [==============================] - 0s 7ms/step - loss: 0.5012
Epoch 231/270
11/11 [==============================] - 0s 7ms/step - loss: 0.6813
Epoch 232/270
11/11 [==============================] - 0s 7ms/step - loss: 0.6199
Epoch 233/270
11/11 [==============================] - 0s 7ms/step - loss: 0.5246
Epoch 234/270
11/11 [==============================] - 0s 7ms/step - loss: 0.4311
Epoch 235/270
11/11 [==============================] - 0s 6ms/step - loss: 0.5134
Epoch 236/270
11/11 [==============================] - 0s 7ms/step - loss: 0.6863
Epoch 237/270
11/11 [==============================] - 0s 8ms/step - loss: 0.6510
Epoch 238/270
11/11 [==============================] - 0s 7ms/step - loss: 0.6235
```

```
Epoch 239/270
11/11 [==============================] - 0s 7ms/step - loss: 0.7012
Epoch 240/270
11/11 [==============================] - 0s 7ms/step - loss: 0.8484
Epoch 241/270
11/11 [==============================] - 0s 6ms/step - loss: 0.9059
Epoch 242/270
11/11 [==============================] - 0s 7ms/step - loss: 1.1155
Epoch 243/270
11/11 [==============================] - 0s 7ms/step - loss: 1.1052
Epoch 244/270
11/11 [==============================] - 0s 8ms/step - loss: 1.1063
Epoch 245/270
11/11 [==============================] - 0s 7ms/step - loss: 0.9563
Epoch 246/270
11/11 [==============================] - 0s 7ms/step - loss: 1.3592
Epoch 247/270
11/11 [==============================] - 0s 8ms/step - loss: 1.8176
Epoch 248/270
11/11 [==============================] - 0s 7ms/step - loss: 1.2860
Epoch 249/270
11/11 [==============================] - 0s 8ms/step - loss: 0.9385
Epoch 250/270
11/11 [==============================] - 0s 7ms/step - loss: 1.0946
Epoch 251/270
11/11 [==============================] - 0s 7ms/step - loss: 1.1278
Epoch 252/270
11/11 [==============================] - 0s 9ms/step - loss: 1.0096
Epoch 253/270
11/11 [==============================] - 0s 7ms/step - loss: 0.6754
Epoch 254/270
11/11 [==============================] - 0s 8ms/step - loss: 0.4418
Epoch 255/270
11/11 [==============================] - 0s 6ms/step - loss: 0.3721
Epoch 256/270
11/11 [==============================] - 0s 8ms/step - loss: 0.4590
Epoch 257/270
11/11 [==============================] - 0s 8ms/step - loss: 0.5538
Epoch 258/270
11/11 [==============================] - 0s 7ms/step - loss: 0.5963
Epoch 259/270
11/11 [==============================] - 0s 7ms/step - loss: 0.7353
Epoch 260/270
11/11 [==============================] - 0s 7ms/step - loss: 0.6743
Epoch 261/270
11/11 [==============================] - 0s 7ms/step - loss: 0.6618
Epoch 262/270
11/11 [==============================] - 0s 7ms/step - loss: 0.8400
Epoch 263/270
11/11 [==============================] - 0s 7ms/step - loss: 0.6688
Epoch 264/270
11/11 [==============================] - 0s 8ms/step - loss: 0.4166
Epoch 265/270
11/11 [==============================] - 0s 7ms/step - loss: 0.4778
Epoch 266/270
11/11 [==============================] - 0s 7ms/step - loss: 0.6304
Epoch 267/270
11/11 [==============================] - 0s 7ms/step - loss: 0.7470
Epoch 268/270
11/11 [==============================] - 0s 7ms/step - loss: 0.7111
Epoch 269/270
```

```
11/11 [==============================] - 0s 7ms/step - loss: 0.6338
Epoch 270/270
11/11 [==============================] - 0s 8ms/step - loss: 0.5026
WARNING:tensorflow:5 out of the last 5 calls to <function Model.make_predic
t_function.<locals>.predict_function at 0x7ff4279505f0> triggered tf.functi
on retracing. Tracing is expensive and the excessive number of tracings cou
ld be due to (1) creating @tf.function repeatedly in a loop, (2) passing te
nsors with different shapes, (3) passing Python objects instead of tensors.
For (1), please define your @tf.function outside of the loop. For (2), @tf.
function has experimental_relax_shapes=True option that relaxes argument sh
apes that can avoid unnecessary retracing. For (3), please refer to https:/
/www.tensorflow.org/guide/function#controlling_retracing and https://www.te
nsorflow.org/api_docs/python/tf/function for  more details.
>expected=-1.0, predicted=2.9
Epoch 1/270
11/11 [==============================] - 1s 8ms/step - loss: 135.8195
Epoch 2/270
11/11 [==============================] - 0s 7ms/step - loss: 133.3380
Epoch 3/270
11/11 [==============================] - 0s 7ms/step - loss: 130.3855
Epoch 4/270
11/11 [==============================] - 0s 7ms/step - loss: 122.8079
Epoch 5/270
11/11 [==============================] - 0s 7ms/step - loss: 112.9143
Epoch 6/270
11/11 [==============================] - 0s 7ms/step - loss: 113.4137
Epoch 7/270
11/11 [==============================] - 0s 7ms/step - loss: 104.8689
Epoch 8/270
11/11 [==============================] - 0s 7ms/step - loss: 94.8206
Epoch 9/270
11/11 [==============================] - 0s 7ms/step - loss: 93.0459
Epoch 10/270
11/11 [==============================] - 0s 7ms/step - loss: 90.8410
Epoch 11/270
11/11 [==============================] - 0s 6ms/step - loss: 86.3477
Epoch 12/270
11/11 [==============================] - 0s 7ms/step - loss: 82.8085
Epoch 13/270
11/11 [==============================] - 0s 9ms/step - loss: 80.4427
Epoch 14/270
11/11 [==============================] - 0s 7ms/step - loss: 79.2489
Epoch 15/270
11/11 [==============================] - 0s 7ms/step - loss: 77.4782
Epoch 16/270
11/11 [==============================] - 0s 7ms/step - loss: 75.8138
Epoch 17/270
11/11 [==============================] - 0s 7ms/step - loss: 75.2870
Epoch 18/270
11/11 [==============================] - 0s 7ms/step - loss: 73.0472
Epoch 19/270
11/11 [==============================] - 0s 7ms/step - loss: 71.9752
Epoch 20/270
11/11 [==============================] - 0s 7ms/step - loss: 76.4191
Epoch 21/270
11/11 [==============================] - 0s 7ms/step - loss: 71.4076
Epoch 22/270
11/11 [==============================] - 0s 8ms/step - loss: 72.8954
Epoch 23/270
11/11 [==============================] - 0s 7ms/step - loss: 69.0594
Epoch 24/270
```

```
11/11 [==============================] - 0s 6ms/step - loss: 66.9342
Epoch 25/270
11/11 [==============================] - 0s 7ms/step - loss: 67.7277
Epoch 26/270
11/11 [==============================] - 0s 7ms/step - loss: 65.7099
Epoch 27/270
11/11 [==============================] - 0s 7ms/step - loss: 63.2041
Epoch 28/270
11/11 [==============================] - 0s 7ms/step - loss: 61.7438
Epoch 29/270
11/11 [==============================] - 0s 7ms/step - loss: 60.5342
Epoch 30/270
11/11 [==============================] - 0s 7ms/step - loss: 62.7449
Epoch 31/270
11/11 [==============================] - 0s 6ms/step - loss: 60.2691
Epoch 32/270
11/11 [==============================] - 0s 7ms/step - loss: 60.4216
Epoch 33/270
11/11 [==============================] - 0s 6ms/step - loss: 58.9518
Epoch 34/270
11/11 [==============================] - 0s 8ms/step - loss: 56.9868
Epoch 35/270
11/11 [==============================] - 0s 6ms/step - loss: 54.3817
Epoch 36/270
11/11 [==============================] - 0s 6ms/step - loss: 54.1425
Epoch 37/270
11/11 [==============================] - 0s 7ms/step - loss: 51.3841
Epoch 38/270
11/11 [==============================] - 0s 6ms/step - loss: 50.7474
Epoch 39/270
11/11 [==============================] - 0s 7ms/step - loss: 50.1565
Epoch 40/270
11/11 [==============================] - 0s 7ms/step - loss: 48.7021
Epoch 41/270
11/11 [==============================] - 0s 7ms/step - loss: 49.5423
Epoch 42/270
11/11 [==============================] - 0s 8ms/step - loss: 46.1719
Epoch 43/270
11/11 [==============================] - 0s 8ms/step - loss: 44.2181
Epoch 44/270
11/11 [==============================] - 0s 9ms/step - loss: 45.5374
Epoch 45/270
11/11 [==============================] - 0s 7ms/step - loss: 48.4659
Epoch 46/270
11/11 [==============================] - 0s 7ms/step - loss: 47.7756
Epoch 47/270
11/11 [==============================] - 0s 7ms/step - loss: 48.9632
Epoch 48/270
11/11 [==============================] - 0s 7ms/step - loss: 47.1849
Epoch 49/270
11/11 [==============================] - 0s 7ms/step - loss: 42.3369
Epoch 50/270
11/11 [==============================] - 0s 8ms/step - loss: 41.2694
Epoch 51/270
11/11 [==============================] - 0s 7ms/step - loss: 41.9008
Epoch 52/270
11/11 [==============================] - 0s 8ms/step - loss: 36.7871
Epoch 53/270
11/11 [==============================] - 0s 7ms/step - loss: 38.3498
Epoch 54/270
11/11 [==============================] - 0s 7ms/step - loss: 39.1097
```

```
Epoch 55/270
11/11 [==============================] - 0s 7ms/step - loss: 36.3681
Epoch 56/270
11/11 [==============================] - 0s 7ms/step - loss: 36.2216
Epoch 57/270
11/11 [==============================] - 0s 7ms/step - loss: 40.0217
Epoch 58/270
11/11 [==============================] - 0s 7ms/step - loss: 35.6635
Epoch 59/270
11/11 [==============================] - 0s 7ms/step - loss: 35.1558
Epoch 60/270
11/11 [==============================] - 0s 7ms/step - loss: 33.9860
Epoch 61/270
11/11 [==============================] - 0s 7ms/step - loss: 30.9117
Epoch 62/270
11/11 [==============================] - 0s 7ms/step - loss: 29.7320
Epoch 63/270
11/11 [==============================] - 0s 9ms/step - loss: 28.5332
Epoch 64/270
11/11 [==============================] - 0s 11ms/step - loss: 25.5814
Epoch 65/270
11/11 [==============================] - 0s 13ms/step - loss: 24.7542
Epoch 66/270
11/11 [==============================] - 0s 11ms/step - loss: 24.8758
Epoch 67/270
11/11 [==============================] - 0s 15ms/step - loss: 22.9299
Epoch 68/270
11/11 [==============================] - 0s 15ms/step - loss: 22.3520
Epoch 69/270
11/11 [==============================] - 0s 21ms/step - loss: 22.2901
Epoch 70/270
11/11 [==============================] - 0s 12ms/step - loss: 21.6780
Epoch 71/270
11/11 [==============================] - 0s 17ms/step - loss: 22.7037
Epoch 72/270
11/11 [==============================] - 0s 13ms/step - loss: 22.1761
Epoch 73/270
11/11 [==============================] - 0s 12ms/step - loss: 19.9705
Epoch 74/270
11/11 [==============================] - 0s 11ms/step - loss: 18.9752
Epoch 75/270
11/11 [==============================] - 0s 13ms/step - loss: 20.1786
Epoch 76/270
11/11 [==============================] - 0s 12ms/step - loss: 20.9014
Epoch 77/270
11/11 [==============================] - 0s 10ms/step - loss: 17.9945
Epoch 78/270
11/11 [==============================] - 0s 14ms/step - loss: 16.1281
Epoch 79/270
11/11 [==============================] - 0s 12ms/step - loss: 16.2640
Epoch 80/270
11/11 [==============================] - 0s 7ms/step - loss: 15.9582
Epoch 81/270
11/11 [==============================] - 0s 11ms/step - loss: 15.4740
Epoch 82/270
11/11 [==============================] - 0s 15ms/step - loss: 17.2195
Epoch 83/270
11/11 [==============================] - 0s 11ms/step - loss: 15.3896
Epoch 84/270
11/11 [==============================] - 0s 7ms/step - loss: 14.0101
Epoch 85/270
```

```
11/11 [==============================] - 0s 7ms/step - loss: 12.9974
Epoch 86/270
11/11 [==============================] - 0s 8ms/step - loss: 12.0252
Epoch 87/270
11/11 [==============================] - 0s 12ms/step - loss: 11.6624
Epoch 88/270
11/11 [==============================] - 0s 10ms/step - loss: 10.7599
Epoch 89/270
11/11 [==============================] - 0s 14ms/step - loss: 10.5792
Epoch 90/270
11/11 [==============================] - 0s 10ms/step - loss: 9.8829
Epoch 91/270
11/11 [==============================] - 0s 8ms/step - loss: 10.6486
Epoch 92/270
11/11 [==============================] - 0s 9ms/step - loss: 11.5916
Epoch 93/270
11/11 [==============================] - 0s 8ms/step - loss: 15.5197
Epoch 94/270
11/11 [==============================] - 0s 9ms/step - loss: 15.3787
Epoch 95/270
11/11 [==============================] - 0s 7ms/step - loss: 13.1108
Epoch 96/270
11/11 [==============================] - 0s 12ms/step - loss: 10.1513
Epoch 97/270
11/11 [==============================] - 0s 8ms/step - loss: 9.2297
Epoch 98/270
11/11 [==============================] - 0s 10ms/step - loss: 8.6588
Epoch 99/270
11/11 [==============================] - 0s 14ms/step - loss: 8.0897
Epoch 100/270
11/11 [==============================] - 0s 11ms/step - loss: 7.3136
Epoch 101/270
11/11 [==============================] - 0s 13ms/step - loss: 7.0796
Epoch 102/270
11/11 [==============================] - 0s 9ms/step - loss: 6.6915
Epoch 103/270
11/11 [==============================] - 0s 14ms/step - loss: 6.9600
Epoch 104/270
11/11 [==============================] - 0s 9ms/step - loss: 6.8542
Epoch 105/270
11/11 [==============================] - 0s 10ms/step - loss: 6.6701
Epoch 106/270
11/11 [==============================] - 0s 9ms/step - loss: 6.1709
Epoch 107/270
11/11 [==============================] - 0s 9ms/step - loss: 5.8886
Epoch 108/270
11/11 [==============================] - 0s 7ms/step - loss: 5.7108
Epoch 109/270
11/11 [==============================] - 0s 7ms/step - loss: 7.0419
Epoch 110/270
11/11 [==============================] - 0s 7ms/step - loss: 7.4874
Epoch 111/270
11/11 [==============================] - 0s 13ms/step - loss: 7.0015
Epoch 112/270
11/11 [==============================] - 0s 12ms/step - loss: 6.5902
Epoch 113/270
11/11 [==============================] - 0s 10ms/step - loss: 6.5476
Epoch 114/270
11/11 [==============================] - 0s 12ms/step - loss: 5.7836
Epoch 115/270
11/11 [==============================] - 0s 8ms/step - loss: 5.9107
```

```
Epoch 116/270
11/11 [==============================] - 0s 8ms/step - loss: 5.1907
Epoch 117/270
11/11 [==============================] - 0s 7ms/step - loss: 5.2901
Epoch 118/270
11/11 [==============================] - 0s 8ms/step - loss: 4.8541
Epoch 119/270
11/11 [==============================] - 0s 12ms/step - loss: 4.6485
Epoch 120/270
11/11 [==============================] - 0s 13ms/step - loss: 5.8360
Epoch 121/270
11/11 [==============================] - 0s 13ms/step - loss: 5.6722
Epoch 122/270
11/11 [==============================] - 0s 13ms/step - loss: 5.4331
Epoch 123/270
11/11 [==============================] - 0s 13ms/step - loss: 5.4371
Epoch 124/270
11/11 [==============================] - 0s 16ms/step - loss: 6.0259
Epoch 125/270
11/11 [==============================] - 0s 12ms/step - loss: 6.0174
Epoch 126/270
11/11 [==============================] - 0s 13ms/step - loss: 6.3069
Epoch 127/270
11/11 [==============================] - 0s 12ms/step - loss: 5.5821
Epoch 128/270
11/11 [==============================] - 0s 10ms/step - loss: 5.0315
Epoch 129/270
11/11 [==============================] - 0s 7ms/step - loss: 4.5136
Epoch 130/270
11/11 [==============================] - 0s 8ms/step - loss: 4.1628
Epoch 131/270
11/11 [==============================] - 0s 9ms/step - loss: 4.0858
Epoch 132/270
11/11 [==============================] - 0s 12ms/step - loss: 3.8265
Epoch 133/270
11/11 [==============================] - 0s 10ms/step - loss: 3.5886
Epoch 134/270
11/11 [==============================] - 0s 13ms/step - loss: 3.3318
Epoch 135/270
11/11 [==============================] - 0s 12ms/step - loss: 3.4714
Epoch 136/270
11/11 [==============================] - 0s 9ms/step - loss: 3.3160
Epoch 137/270
11/11 [==============================] - 0s 10ms/step - loss: 2.6974
Epoch 138/270
11/11 [==============================] - 0s 13ms/step - loss: 2.7392
Epoch 139/270
11/11 [==============================] - 0s 9ms/step - loss: 2.6740
Epoch 140/270
11/11 [==============================] - 0s 10ms/step - loss: 3.1533
Epoch 141/270
11/11 [==============================] - 0s 13ms/step - loss: 2.6630
Epoch 142/270
11/11 [==============================] - 0s 13ms/step - loss: 2.9799
Epoch 143/270
11/11 [==============================] - 0s 8ms/step - loss: 3.1041
Epoch 144/270
11/11 [==============================] - 0s 7ms/step - loss: 3.2444
Epoch 145/270
11/11 [==============================] - 0s 11ms/step - loss: 3.2760
Epoch 146/270
```

```
11/11 [==============================] - 0s 11ms/step - loss: 3.0410
Epoch 147/270
11/11 [==============================] - 0s 7ms/step - loss: 3.3368
Epoch 148/270
11/11 [==============================] - 0s 8ms/step - loss: 2.9572
Epoch 149/270
11/11 [==============================] - 0s 13ms/step - loss: 2.5633
Epoch 150/270
11/11 [==============================] - 0s 13ms/step - loss: 2.6237
Epoch 151/270
11/11 [==============================] - 0s 13ms/step - loss: 2.7644
Epoch 152/270
11/11 [==============================] - 0s 10ms/step - loss: 2.9759
Epoch 153/270
11/11 [==============================] - 0s 8ms/step - loss: 2.5742
Epoch 154/270
11/11 [==============================] - 0s 9ms/step - loss: 2.2317
Epoch 155/270
11/11 [==============================] - 0s 9ms/step - loss: 2.1735
Epoch 156/270
11/11 [==============================] - 0s 7ms/step - loss: 2.1831
Epoch 157/270
11/11 [==============================] - 0s 7ms/step - loss: 1.7087
Epoch 158/270
11/11 [==============================] - 0s 7ms/step - loss: 1.8444
Epoch 159/270
11/11 [==============================] - 0s 7ms/step - loss: 1.7556
Epoch 160/270
11/11 [==============================] - 0s 8ms/step - loss: 1.5034
Epoch 161/270
11/11 [==============================] - 0s 9ms/step - loss: 1.4494
Epoch 162/270
11/11 [==============================] - 0s 8ms/step - loss: 1.4444
Epoch 163/270
11/11 [==============================] - 0s 13ms/step - loss: 1.5674
Epoch 164/270
11/11 [==============================] - 0s 12ms/step - loss: 1.6527
Epoch 165/270
11/11 [==============================] - 0s 7ms/step - loss: 1.4380
Epoch 166/270
11/11 [==============================] - 0s 7ms/step - loss: 1.3250
Epoch 167/270
11/11 [==============================] - 0s 7ms/step - loss: 1.2481
Epoch 168/270
11/11 [==============================] - 0s 8ms/step - loss: 1.3026
Epoch 169/270
11/11 [==============================] - 0s 9ms/step - loss: 1.3020
Epoch 170/270
11/11 [==============================] - 0s 8ms/step - loss: 1.0803
Epoch 171/270
11/11 [==============================] - 0s 8ms/step - loss: 1.0283
Epoch 172/270
11/11 [==============================] - 0s 9ms/step - loss: 0.9746
Epoch 173/270
11/11 [==============================] - 0s 8ms/step - loss: 0.9141
Epoch 174/270
11/11 [==============================] - 0s 13ms/step - loss: 0.9469
Epoch 175/270
11/11 [==============================] - 0s 12ms/step - loss: 0.9723
Epoch 176/270
11/11 [==============================] - 0s 11ms/step - loss: 0.9827
```

```
Epoch 177/270
11/11 [==============================] - 0s 12ms/step - loss: 0.9982
Epoch 178/270
11/11 [==============================] - 0s 10ms/step - loss: 0.9989
Epoch 179/270
11/11 [==============================] - 0s 10ms/step - loss: 1.0416
Epoch 180/270
11/11 [==============================] - 0s 13ms/step - loss: 1.1796
Epoch 181/270
11/11 [==============================] - 0s 8ms/step - loss: 1.2588
Epoch 182/270
11/11 [==============================] - 0s 7ms/step - loss: 1.3137
Epoch 183/270
11/11 [==============================] - 0s 7ms/step - loss: 1.2982
Epoch 184/270
11/11 [==============================] - 0s 11ms/step - loss: 1.3647
Epoch 185/270
11/11 [==============================] - 0s 11ms/step - loss: 1.2838
Epoch 186/270
11/11 [==============================] - 0s 9ms/step - loss: 1.2687
Epoch 187/270
11/11 [==============================] - 0s 11ms/step - loss: 1.3321
Epoch 188/270
11/11 [==============================] - 0s 19ms/step - loss: 1.5563
Epoch 189/270
11/11 [==============================] - 0s 19ms/step - loss: 1.4253
Epoch 190/270
11/11 [==============================] - 0s 13ms/step - loss: 1.2302
Epoch 191/270
11/11 [==============================] - 0s 13ms/step - loss: 1.1346
Epoch 192/270
11/11 [==============================] - 0s 10ms/step - loss: 1.0961
Epoch 193/270
11/11 [==============================] - 0s 8ms/step - loss: 1.3483
Epoch 194/270
11/11 [==============================] - 0s 12ms/step - loss: 1.2989
Epoch 195/270
11/11 [==============================] - 0s 8ms/step - loss: 1.2690
Epoch 196/270
11/11 [==============================] - 0s 9ms/step - loss: 1.0519
Epoch 197/270
11/11 [==============================] - 0s 9ms/step - loss: 1.1591
Epoch 198/270
11/11 [==============================] - 0s 9ms/step - loss: 0.8929
Epoch 199/270
11/11 [==============================] - 0s 9ms/step - loss: 0.7447
Epoch 200/270
11/11 [==============================] - 0s 10ms/step - loss: 0.7325
Epoch 201/270
11/11 [==============================] - 0s 9ms/step - loss: 0.7581
Epoch 202/270
11/11 [==============================] - 0s 18ms/step - loss: 0.5920
Epoch 203/270
11/11 [==============================] - 0s 15ms/step - loss: 0.5837
Epoch 204/270
11/11 [==============================] - 0s 16ms/step - loss: 0.5815
Epoch 205/270
11/11 [==============================] - 0s 8ms/step - loss: 0.5590
Epoch 206/270
11/11 [==============================] - 0s 9ms/step - loss: 0.5528
Epoch 207/270
```

```
11/11 [==============================] - 0s 16ms/step - loss: 0.4952
Epoch 208/270
11/11 [==============================] - 0s 12ms/step - loss: 0.5324
Epoch 209/270
11/11 [==============================] - 0s 12ms/step - loss: 0.4835
Epoch 210/270
11/11 [==============================] - 0s 12ms/step - loss: 0.4896
Epoch 211/270
11/11 [==============================] - 0s 13ms/step - loss: 0.5191
Epoch 212/270
11/11 [==============================] - 0s 9ms/step - loss: 0.5258
Epoch 213/270
11/11 [==============================] - 0s 10ms/step - loss: 0.6815
Epoch 214/270
11/11 [==============================] - 0s 8ms/step - loss: 0.6351
Epoch 215/270
11/11 [==============================] - 0s 8ms/step - loss: 0.5887
Epoch 216/270
11/11 [==============================] - 0s 10ms/step - loss: 0.8428
Epoch 217/270
11/11 [==============================] - 0s 9ms/step - loss: 0.8593
Epoch 218/270
11/11 [==============================] - 0s 13ms/step - loss: 0.6856
Epoch 219/270
11/11 [==============================] - 0s 13ms/step - loss: 0.6175
Epoch 220/270
11/11 [==============================] - 0s 13ms/step - loss: 0.6395
Epoch 221/270
11/11 [==============================] - 0s 11ms/step - loss: 0.7291
Epoch 222/270
11/11 [==============================] - 0s 11ms/step - loss: 0.7257
Epoch 223/270
11/11 [==============================] - 0s 9ms/step - loss: 0.9093
Epoch 224/270
11/11 [==============================] - 0s 8ms/step - loss: 0.8241
Epoch 225/270
11/11 [==============================] - 0s 9ms/step - loss: 1.1207
Epoch 226/270
11/11 [==============================] - 0s 14ms/step - loss: 1.0876
Epoch 227/270
11/11 [==============================] - 0s 7ms/step - loss: 1.3479
Epoch 228/270
11/11 [==============================] - 0s 9ms/step - loss: 1.2223
Epoch 229/270
11/11 [==============================] - 0s 8ms/step - loss: 0.9914
Epoch 230/270
11/11 [==============================] - 0s 7ms/step - loss: 0.7796
Epoch 231/270
11/11 [==============================] - 0s 7ms/step - loss: 0.8127
Epoch 232/270
11/11 [==============================] - 0s 9ms/step - loss: 0.6428
Epoch 233/270
11/11 [==============================] - 0s 10ms/step - loss: 0.5522
Epoch 234/270
11/11 [==============================] - 0s 16ms/step - loss: 0.3976
Epoch 235/270
11/11 [==============================] - 0s 15ms/step - loss: 0.3923
Epoch 236/270
11/11 [==============================] - 0s 9ms/step - loss: 0.3855
Epoch 237/270
11/11 [==============================] - 0s 11ms/step - loss: 0.3740
```

```
Epoch 238/270
11/11 [==============================] - 0s 9ms/step - loss: 0.5195
Epoch 239/270
11/11 [==============================] - 0s 9ms/step - loss: 0.6137
Epoch 240/270
11/11 [==============================] - 0s 13ms/step - loss: 0.5643
Epoch 241/270
11/11 [==============================] - 0s 12ms/step - loss: 0.4610
Epoch 242/270
11/11 [==============================] - 0s 10ms/step - loss: 0.3629
Epoch 243/270
11/11 [==============================] - 0s 8ms/step - loss: 0.3036
Epoch 244/270
11/11 [==============================] - 0s 16ms/step - loss: 0.3723
Epoch 245/270
11/11 [==============================] - 0s 14ms/step - loss: 0.3962
Epoch 246/270
11/11 [==============================] - 0s 10ms/step - loss: 0.3911
Epoch 247/270
11/11 [==============================] - 0s 8ms/step - loss: 0.3457
Epoch 248/270
11/11 [==============================] - 0s 8ms/step - loss: 0.3560
Epoch 249/270
11/11 [==============================] - 0s 13ms/step - loss: 0.3579
Epoch 250/270
11/11 [==============================] - 0s 15ms/step - loss: 0.3399
Epoch 251/270
11/11 [==============================] - 0s 12ms/step - loss: 0.3493
Epoch 252/270
11/11 [==============================] - 0s 10ms/step - loss: 0.3408
Epoch 253/270
11/11 [==============================] - 0s 10ms/step - loss: 0.4107
Epoch 254/270
11/11 [==============================] - 0s 10ms/step - loss: 0.3966
Epoch 255/270
11/11 [==============================] - 0s 7ms/step - loss: 0.4976
Epoch 256/270
11/11 [==============================] - 0s 11ms/step - loss: 0.5363
Epoch 257/270
11/11 [==============================] - 0s 9ms/step - loss: 0.4643
Epoch 258/270
11/11 [==============================] - 0s 10ms/step - loss: 0.4400
Epoch 259/270
11/11 [==============================] - 0s 12ms/step - loss: 0.5119
Epoch 260/270
11/11 [==============================] - 0s 12ms/step - loss: 0.5264
Epoch 261/270
11/11 [==============================] - 0s 12ms/step - loss: 0.4357
Epoch 262/270
11/11 [==============================] - 0s 12ms/step - loss: 0.3645
Epoch 263/270
11/11 [==============================] - 0s 10ms/step - loss: 0.3037
Epoch 264/270
11/11 [==============================] - 0s 8ms/step - loss: 0.3114
Epoch 265/270
11/11 [==============================] - 0s 9ms/step - loss: 0.3626
Epoch 266/270
11/11 [==============================] - 0s 10ms/step - loss: 0.4457
Epoch 267/270
11/11 [==============================] - 0s 10ms/step - loss: 0.4492
Epoch 268/270
```

```
11/11 [==============================] - 0s 8ms/step - loss: 0.3846
Epoch 269/270
11/11 [==============================] - 0s 15ms/step - loss: 0.2869
Epoch 270/270
11/11 [==============================] - 0s 13ms/step - loss: 0.2646
WARNING:tensorflow:6 out of the last 6 calls to <function Model.make_predic
t_function.<locals>.predict_function at 0x7ff43243e950> triggered tf.functi
on retracing. Tracing is expensive and the excessive number of tracings cou
ld be due to (1) creating @tf.function repeatedly in a loop, (2) passing te
nsors with different shapes, (3) passing Python objects instead of tensors.
For (1), please define your @tf.function outside of the loop. For (2), @tf.
function has experimental_relax_shapes=True option that relaxes argument sh
apes that can avoid unnecessary retracing. For (3), please refer to https:/
/www.tensorflow.org/guide/function#controlling_retracing and https://www.te
nsorflow.org/api_docs/python/tf/function for  more details.
>expected=5.0, predicted=7.6
Epoch 1/270
11/11 [==============================] - 1s 9ms/step - loss: 136.2608
Epoch 2/270
11/11 [==============================] - 0s 6ms/step - loss: 133.9913
Epoch 3/270
11/11 [==============================] - 0s 6ms/step - loss: 131.1366
Epoch 4/270
11/11 [==============================] - 0s 7ms/step - loss: 126.3600
Epoch 5/270
11/11 [==============================] - 0s 7ms/step - loss: 110.1224
Epoch 6/270
11/11 [==============================] - 0s 7ms/step - loss: 113.3436
Epoch 7/270
11/11 [==============================] - 0s 7ms/step - loss: 99.5180
Epoch 8/270
11/11 [==============================] - 0s 7ms/step - loss: 93.2710
Epoch 9/270
11/11 [==============================] - 0s 10ms/step - loss: 89.3020
Epoch 10/270
11/11 [==============================] - 0s 13ms/step - loss: 87.9093
Epoch 11/270
11/11 [==============================] - 0s 9ms/step - loss: 85.0809
Epoch 12/270
11/11 [==============================] - 0s 13ms/step - loss: 82.9574
Epoch 13/270
11/11 [==============================] - 0s 16ms/step - loss: 83.4414
Epoch 14/270
11/11 [==============================] - 0s 14ms/step - loss: 86.1175
Epoch 15/270
11/11 [==============================] - 0s 11ms/step - loss: 80.0754
Epoch 16/270
11/11 [==============================] - 0s 15ms/step - loss: 78.5546
Epoch 17/270
11/11 [==============================] - 0s 18ms/step - loss: 78.8571
Epoch 18/270
11/11 [==============================] - 0s 15ms/step - loss: 79.9490
Epoch 19/270
11/11 [==============================] - 0s 11ms/step - loss: 76.3911
Epoch 20/270
11/11 [==============================] - 0s 13ms/step - loss: 75.5078
Epoch 21/270
11/11 [==============================] - 0s 11ms/step - loss: 74.2676
Epoch 22/270
11/11 [==============================] - 0s 16ms/step - loss: 74.0433
Epoch 23/270
```

```
11/11 [==============================] - 0s 14ms/step - loss: 70.4575
Epoch 24/270
11/11 [==============================] - 0s 16ms/step - loss: 69.8818
Epoch 25/270
11/11 [==============================] - 0s 14ms/step - loss: 70.2895
Epoch 26/270
11/11 [==============================] - 0s 16ms/step - loss: 68.9094
Epoch 27/270
11/11 [==============================] - 0s 12ms/step - loss: 67.1564
Epoch 28/270
11/11 [==============================] - 0s 29ms/step - loss: 68.6819
Epoch 29/270
11/11 [==============================] - 0s 13ms/step - loss: 66.2255
Epoch 30/270
11/11 [==============================] - 0s 16ms/step - loss: 64.4067
Epoch 31/270
11/11 [==============================] - 0s 12ms/step - loss: 62.4861
Epoch 32/270
11/11 [==============================] - 0s 17ms/step - loss: 60.8393
Epoch 33/270
11/11 [==============================] - 0s 20ms/step - loss: 59.4384
Epoch 34/270
11/11 [==============================] - 0s 14ms/step - loss: 59.3127
Epoch 35/270
11/11 [==============================] - 0s 11ms/step - loss: 59.3802
Epoch 36/270
11/11 [==============================] - 0s 19ms/step - loss: 61.9640
Epoch 37/270
11/11 [==============================] - 0s 17ms/step - loss: 57.0732
Epoch 38/270
11/11 [==============================] - 0s 13ms/step - loss: 55.9078
Epoch 39/270
11/11 [==============================] - 0s 13ms/step - loss: 53.4872
Epoch 40/270
11/11 [==============================] - 0s 12ms/step - loss: 53.0478
Epoch 41/270
11/11 [==============================] - 0s 12ms/step - loss: 54.5133
Epoch 42/270
11/11 [==============================] - 0s 10ms/step - loss: 51.2197
Epoch 43/270
11/11 [==============================] - 0s 12ms/step - loss: 50.5831
Epoch 44/270
11/11 [==============================] - 0s 8ms/step - loss: 50.5566
Epoch 45/270
11/11 [==============================] - 0s 13ms/step - loss: 52.1526
Epoch 46/270
11/11 [==============================] - 0s 10ms/step - loss: 49.7401
Epoch 47/270
11/11 [==============================] - 0s 12ms/step - loss: 47.2915
Epoch 48/270
11/11 [==============================] - 0s 15ms/step - loss: 46.3286
Epoch 49/270
11/11 [==============================] - 0s 10ms/step - loss: 46.2353
Epoch 50/270
11/11 [==============================] - 0s 17ms/step - loss: 44.1586
Epoch 51/270
11/11 [==============================] - 0s 13ms/step - loss: 43.5262
Epoch 52/270
11/11 [==============================] - 0s 24ms/step - loss: 41.9592
Epoch 53/270
11/11 [==============================] - 0s 12ms/step - loss: 42.8605
```

```
Epoch 54/270
11/11 [==============================] - 0s 13ms/step - loss: 42.7459
Epoch 55/270
11/11 [==============================] - 0s 15ms/step - loss: 39.7439
Epoch 56/270
11/11 [==============================] - 0s 21ms/step - loss: 39.0918
Epoch 57/270
11/11 [==============================] - 0s 25ms/step - loss: 37.8810
Epoch 58/270
11/11 [==============================] - 0s 19ms/step - loss: 37.0440
Epoch 59/270
11/11 [==============================] - 0s 19ms/step - loss: 37.7727
Epoch 60/270
11/11 [==============================] - 0s 17ms/step - loss: 34.9896
Epoch 61/270
11/11 [==============================] - 0s 18ms/step - loss: 34.4638
Epoch 62/270
11/11 [==============================] - 0s 17ms/step - loss: 33.1636
Epoch 63/270
11/11 [==============================] - 0s 26ms/step - loss: 33.8946
Epoch 64/270
11/11 [==============================] - 0s 19ms/step - loss: 32.9889
Epoch 65/270
11/11 [==============================] - 0s 22ms/step - loss: 30.9111
Epoch 66/270
11/11 [==============================] - 0s 14ms/step - loss: 34.5375
Epoch 67/270
11/11 [==============================] - 0s 10ms/step - loss: 29.4549
Epoch 68/270
11/11 [==============================] - 0s 13ms/step - loss: 28.7642
Epoch 69/270
11/11 [==============================] - 0s 10ms/step - loss: 27.0253
Epoch 70/270
11/11 [==============================] - 0s 9ms/step - loss: 26.1243
Epoch 71/270
11/11 [==============================] - 0s 10ms/step - loss: 24.1872
Epoch 72/270
11/11 [==============================] - 0s 11ms/step - loss: 26.9756
Epoch 73/270
11/11 [==============================] - 0s 12ms/step - loss: 24.8487
Epoch 74/270
11/11 [==============================] - 0s 12ms/step - loss: 23.2140
Epoch 75/270
11/11 [==============================] - 0s 12ms/step - loss: 22.9578
Epoch 76/270
11/11 [==============================] - 0s 7ms/step - loss: 21.4198
Epoch 77/270
11/11 [==============================] - 0s 10ms/step - loss: 22.0600
Epoch 78/270
11/11 [==============================] - 0s 14ms/step - loss: 21.6269
Epoch 79/270
11/11 [==============================] - 0s 12ms/step - loss: 21.3418
Epoch 80/270
11/11 [==============================] - 0s 15ms/step - loss: 19.5243
Epoch 81/270
11/11 [==============================] - 0s 14ms/step - loss: 17.4547
Epoch 82/270
11/11 [==============================] - 0s 15ms/step - loss: 17.7689
Epoch 83/270
11/11 [==============================] - 0s 10ms/step - loss: 17.2982
Epoch 84/270
```

```
11/11 [==============================] - 0s 7ms/step - loss: 20.2788
Epoch 85/270
11/11 [==============================] - 0s 7ms/step - loss: 18.4452
Epoch 86/270
11/11 [==============================] - 0s 18ms/step - loss: 16.0805
Epoch 87/270
11/11 [==============================] - 0s 12ms/step - loss: 15.2690
Epoch 88/270
11/11 [==============================] - 0s 12ms/step - loss: 14.3360
Epoch 89/270
11/11 [==============================] - 0s 12ms/step - loss: 12.9774
Epoch 90/270
11/11 [==============================] - 0s 12ms/step - loss: 12.9552
Epoch 91/270
11/11 [==============================] - 0s 10ms/step - loss: 15.2368
Epoch 92/270
11/11 [==============================] - 0s 12ms/step - loss: 13.5970
Epoch 93/270
11/11 [==============================] - 0s 10ms/step - loss: 13.0944
Epoch 94/270
11/11 [==============================] - 0s 11ms/step - loss: 13.9147
Epoch 95/270
11/11 [==============================] - 0s 7ms/step - loss: 16.3605
Epoch 96/270
11/11 [==============================] - 0s 7ms/step - loss: 13.3809
Epoch 97/270
11/11 [==============================] - 0s 11ms/step - loss: 12.4625
Epoch 98/270
11/11 [==============================] - 0s 13ms/step - loss: 12.3685
Epoch 99/270
11/11 [==============================] - 0s 11ms/step - loss: 10.5477
Epoch 100/270
11/11 [==============================] - 0s 12ms/step - loss: 11.9157
Epoch 101/270
11/11 [==============================] - 0s 12ms/step - loss: 11.1108
Epoch 102/270
11/11 [==============================] - 0s 13ms/step - loss: 11.8031
Epoch 103/270
11/11 [==============================] - 0s 13ms/step - loss: 10.5514
Epoch 104/270
11/11 [==============================] - 0s 11ms/step - loss: 9.7403
Epoch 105/270
11/11 [==============================] - 0s 15ms/step - loss: 10.0747
Epoch 106/270
11/11 [==============================] - 0s 12ms/step - loss: 9.5316
Epoch 107/270
11/11 [==============================] - 0s 10ms/step - loss: 9.9918
Epoch 108/270
11/11 [==============================] - 0s 11ms/step - loss: 8.1737
Epoch 109/270
11/11 [==============================] - 0s 19ms/step - loss: 7.5156
Epoch 110/270
11/11 [==============================] - 0s 14ms/step - loss: 6.6834
Epoch 111/270
11/11 [==============================] - 0s 13ms/step - loss: 6.4592
Epoch 112/270
11/11 [==============================] - 0s 11ms/step - loss: 6.0149
Epoch 113/270
11/11 [==============================] - 0s 10ms/step - loss: 5.6637
Epoch 114/270
11/11 [==============================] - 0s 11ms/step - loss: 5.1605
```

```
Epoch 115/270
11/11 [==============================] - 0s 15ms/step - loss: 6.2622
Epoch 116/270
11/11 [==============================] - 0s 15ms/step - loss: 7.3050
Epoch 117/270
11/11 [==============================] - 0s 8ms/step - loss: 6.7979
Epoch 118/270
11/11 [==============================] - 0s 11ms/step - loss: 6.9541
Epoch 119/270
11/11 [==============================] - 0s 12ms/step - loss: 7.9208
Epoch 120/270
11/11 [==============================] - 0s 12ms/step - loss: 7.2048
Epoch 121/270
11/11 [==============================] - 0s 13ms/step - loss: 7.0504
Epoch 122/270
11/11 [==============================] - 0s 11ms/step - loss: 8.1666
Epoch 123/270
11/11 [==============================] - 0s 13ms/step - loss: 7.5346
Epoch 124/270
11/11 [==============================] - 0s 13ms/step - loss: 6.9058
Epoch 125/270
11/11 [==============================] - 0s 15ms/step - loss: 6.8083
Epoch 126/270
11/11 [==============================] - 0s 12ms/step - loss: 6.1830
Epoch 127/270
11/11 [==============================] - 0s 12ms/step - loss: 4.7303
Epoch 128/270
11/11 [==============================] - 0s 9ms/step - loss: 4.4649
Epoch 129/270
11/11 [==============================] - 0s 10ms/step - loss: 3.9326
Epoch 130/270
11/11 [==============================] - 0s 8ms/step - loss: 4.3898
Epoch 131/270
11/11 [==============================] - 0s 10ms/step - loss: 3.7580
Epoch 132/270
11/11 [==============================] - 0s 9ms/step - loss: 3.1586
Epoch 133/270
11/11 [==============================] - 0s 16ms/step - loss: 3.1124
Epoch 134/270
11/11 [==============================] - 0s 26ms/step - loss: 3.2377
Epoch 135/270
11/11 [==============================] - 0s 8ms/step - loss: 3.0337
Epoch 136/270
11/11 [==============================] - 0s 22ms/step - loss: 3.1094
Epoch 137/270
11/11 [==============================] - 0s 16ms/step - loss: 2.8915
Epoch 138/270
11/11 [==============================] - 0s 16ms/step - loss: 2.7213
Epoch 139/270
11/11 [==============================] - 0s 15ms/step - loss: 2.8150
Epoch 140/270
11/11 [==============================] - 0s 24ms/step - loss: 2.5021
Epoch 141/270
11/11 [==============================] - 0s 23ms/step - loss: 2.8899
Epoch 142/270
11/11 [==============================] - 0s 18ms/step - loss: 2.8251
Epoch 143/270
11/11 [==============================] - 0s 17ms/step - loss: 2.2593
Epoch 144/270
11/11 [==============================] - 0s 18ms/step - loss: 2.4127
Epoch 145/270
```

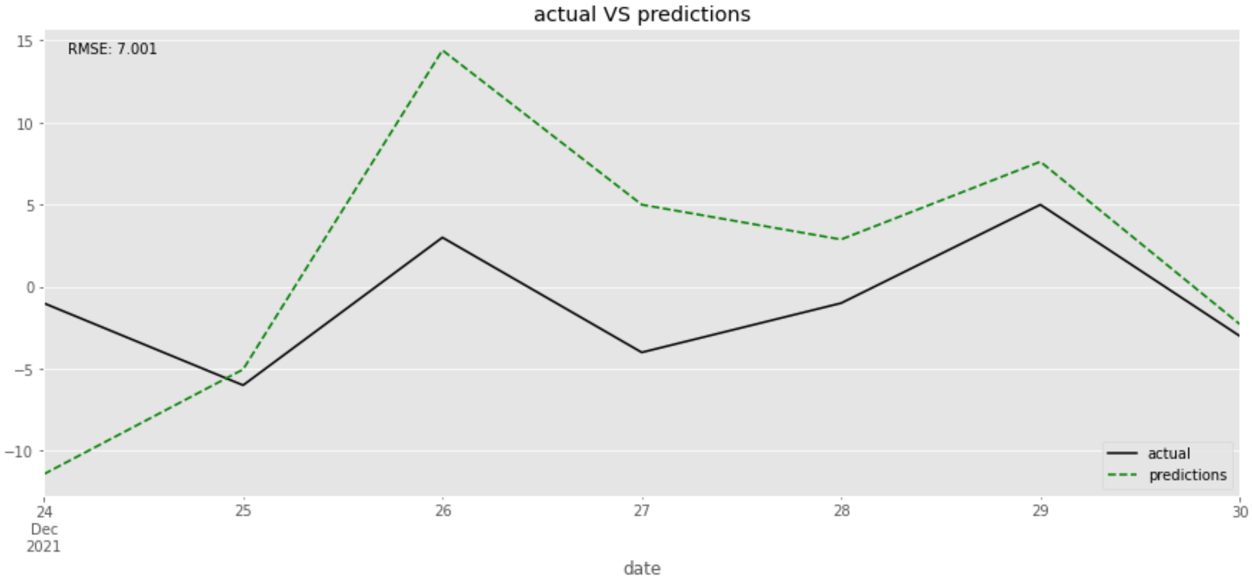
```
11/11 [==============================] - 0s 16ms/step - loss: 2.5384
Epoch 146/270
11/11 [==============================] - 0s 18ms/step - loss: 2.8507
Epoch 147/270
11/11 [==============================] - 0s 22ms/step - loss: 2.9940
Epoch 148/270
11/11 [==============================] - 0s 10ms/step - loss: 2.4993
Epoch 149/270
11/11 [==============================] - 0s 17ms/step - loss: 2.4967
Epoch 150/270
11/11 [==============================] - 0s 11ms/step - loss: 2.3800
Epoch 151/270
11/11 [==============================] - 0s 11ms/step - loss: 2.6124
Epoch 152/270
11/11 [==============================] - 0s 12ms/step - loss: 2.6074
Epoch 153/270
11/11 [==============================] - 0s 14ms/step - loss: 2.5089
Epoch 154/270
11/11 [==============================] - 0s 12ms/step - loss: 2.9648
Epoch 155/270
11/11 [==============================] - 0s 7ms/step - loss: 3.3562
Epoch 156/270
11/11 [==============================] - 0s 6ms/step - loss: 3.1790
Epoch 157/270
11/11 [==============================] - 0s 9ms/step - loss: 2.6810
Epoch 158/270
11/11 [==============================] - 0s 14ms/step - loss: 2.1497
Epoch 159/270
11/11 [==============================] - 0s 11ms/step - loss: 1.9607
Epoch 160/270
11/11 [==============================] - 0s 16ms/step - loss: 1.4672
Epoch 161/270
11/11 [==============================] - 0s 13ms/step - loss: 1.4884
Epoch 162/270
11/11 [==============================] - 0s 14ms/step - loss: 1.3247
Epoch 163/270
11/11 [==============================] - 0s 12ms/step - loss: 1.0692
Epoch 164/270
11/11 [==============================] - 0s 12ms/step - loss: 1.1199
Epoch 165/270
11/11 [==============================] - 0s 12ms/step - loss: 1.2022
Epoch 166/270
11/11 [==============================] - 0s 11ms/step - loss: 1.5112
Epoch 167/270
11/11 [==============================] - 0s 13ms/step - loss: 1.8728
Epoch 168/270
11/11 [==============================] - 0s 8ms/step - loss: 1.4288
Epoch 169/270
11/11 [==============================] - 0s 14ms/step - loss: 1.4200
Epoch 170/270
11/11 [==============================] - 0s 9ms/step - loss: 1.3828
Epoch 171/270
11/11 [==============================] - 0s 8ms/step - loss: 1.5466
Epoch 172/270
11/11 [==============================] - 0s 9ms/step - loss: 1.5532
Epoch 173/270
11/11 [==============================] - 0s 11ms/step - loss: 1.4742
Epoch 174/270
11/11 [==============================] - 0s 7ms/step - loss: 1.2181
Epoch 175/270
11/11 [==============================] - 0s 12ms/step - loss: 1.2608
```

```
Epoch 176/270
11/11 [==============================] - 0s 10ms/step - loss: 1.0684
Epoch 177/270
11/11 [==============================] - 0s 10ms/step - loss: 1.1180
Epoch 178/270
11/11 [==============================] - 0s 12ms/step - loss: 0.9660
Epoch 179/270
11/11 [==============================] - 0s 9ms/step - loss: 0.8230
Epoch 180/270
11/11 [==============================] - 0s 11ms/step - loss: 0.7402
Epoch 181/270
11/11 [==============================] - 0s 10ms/step - loss: 0.8098
Epoch 182/270
11/11 [==============================] - 0s 10ms/step - loss: 0.8543
Epoch 183/270
11/11 [==============================] - 0s 9ms/step - loss: 0.7050
Epoch 184/270
11/11 [==============================] - 0s 12ms/step - loss: 0.7277
Epoch 185/270
11/11 [==============================] - 0s 9ms/step - loss: 0.6413
Epoch 186/270
11/11 [==============================] - 0s 7ms/step - loss: 0.8349
Epoch 187/270
11/11 [==============================] - 0s 7ms/step - loss: 0.7783
Epoch 188/270
11/11 [==============================] - 0s 7ms/step - loss: 0.8545
Epoch 189/270
11/11 [==============================] - 0s 7ms/step - loss: 0.8829
Epoch 190/270
11/11 [==============================] - 0s 13ms/step - loss: 1.3336
Epoch 191/270
11/11 [==============================] - 0s 10ms/step - loss: 1.1850
Epoch 192/270
11/11 [==============================] - 0s 8ms/step - loss: 1.4661
Epoch 193/270
11/11 [==============================] - 0s 7ms/step - loss: 1.7466
Epoch 194/270
11/11 [==============================] - 0s 7ms/step - loss: 1.5726
Epoch 195/270
11/11 [==============================] - 0s 8ms/step - loss: 1.5817
Epoch 196/270
11/11 [==============================] - 0s 8ms/step - loss: 1.3162
Epoch 197/270
11/11 [==============================] - 0s 8ms/step - loss: 1.2759
Epoch 198/270
11/11 [==============================] - 0s 7ms/step - loss: 1.1439
Epoch 199/270
11/11 [==============================] - 0s 14ms/step - loss: 1.0703
Epoch 200/270
11/11 [==============================] - 0s 14ms/step - loss: 0.7493
Epoch 201/270
11/11 [==============================] - 0s 16ms/step - loss: 0.6902
Epoch 202/270
11/11 [==============================] - 0s 11ms/step - loss: 0.7732
Epoch 203/270
11/11 [==============================] - 0s 12ms/step - loss: 0.6129
Epoch 204/270
11/11 [==============================] - 0s 10ms/step - loss: 0.6898
Epoch 205/270
11/11 [==============================] - 0s 10ms/step - loss: 0.6691
Epoch 206/270
```

```
11/11 [==============================] - 0s 13ms/step - loss: 0.5953
Epoch 207/270
11/11 [==============================] - 0s 12ms/step - loss: 0.6209
Epoch 208/270
11/11 [==============================] - 0s 11ms/step - loss: 0.5013
Epoch 209/270
11/11 [==============================] - 0s 12ms/step - loss: 0.5214
Epoch 210/270
11/11 [==============================] - 0s 8ms/step - loss: 0.5119
Epoch 211/270
11/11 [==============================] - 0s 9ms/step - loss: 0.4772
Epoch 212/270
11/11 [==============================] - 0s 8ms/step - loss: 0.4944
Epoch 213/270
11/11 [==============================] - 0s 13ms/step - loss: 0.5515
Epoch 214/270
11/11 [==============================] - 0s 15ms/step - loss: 0.6482
Epoch 215/270
11/11 [==============================] - 0s 12ms/step - loss: 0.6719
Epoch 216/270
11/11 [==============================] - 0s 9ms/step - loss: 0.7854
Epoch 217/270
11/11 [==============================] - 0s 11ms/step - loss: 0.7095
Epoch 218/270
11/11 [==============================] - 0s 9ms/step - loss: 0.6875
Epoch 219/270
11/11 [==============================] - 0s 10ms/step - loss: 0.9584
Epoch 220/270
11/11 [==============================] - 0s 13ms/step - loss: 1.0251
Epoch 221/270
11/11 [==============================] - 0s 13ms/step - loss: 0.9299
Epoch 222/270
11/11 [==============================] - 0s 11ms/step - loss: 0.9490
Epoch 223/270
11/11 [==============================] - 0s 10ms/step - loss: 1.0664
Epoch 224/270
11/11 [==============================] - 0s 10ms/step - loss: 0.7057
Epoch 225/270
11/11 [==============================] - 0s 8ms/step - loss: 0.5480
Epoch 226/270
11/11 [==============================] - 0s 7ms/step - loss: 0.7509
Epoch 227/270
11/11 [==============================] - 0s 9ms/step - loss: 0.7715
Epoch 228/270
11/11 [==============================] - 0s 8ms/step - loss: 0.6207
Epoch 229/270
11/11 [==============================] - 0s 8ms/step - loss: 0.4967
Epoch 230/270
11/11 [==============================] - 0s 12ms/step - loss: 0.4260
Epoch 231/270
11/11 [==============================] - 0s 9ms/step - loss: 0.3830
Epoch 232/270
11/11 [==============================] - 0s 9ms/step - loss: 0.3255
Epoch 233/270
11/11 [==============================] - 0s 15ms/step - loss: 0.2750
Epoch 234/270
11/11 [==============================] - 0s 12ms/step - loss: 0.3431
Epoch 235/270
11/11 [==============================] - 0s 7ms/step - loss: 0.3430
Epoch 236/270
11/11 [==============================] - 0s 8ms/step - loss: 0.4935
```

```
Epoch 237/270
11/11 [==============================] - 0s 10ms/step - loss: 0.6315
Epoch 238/270
11/11 [==============================] - 0s 14ms/step - loss: 0.5998
Epoch 239/270
11/11 [==============================] - 0s 9ms/step - loss: 0.9037
Epoch 240/270
11/11 [==============================] - 0s 9ms/step - loss: 0.7451
Epoch 241/270
11/11 [==============================] - 0s 17ms/step - loss: 0.8021
Epoch 242/270
11/11 [==============================] - 0s 16ms/step - loss: 0.9316
Epoch 243/270
11/11 [==============================] - 0s 18ms/step - loss: 1.0129
Epoch 244/270
11/11 [==============================] - 0s 9ms/step - loss: 0.8437
Epoch 245/270
11/11 [==============================] - 0s 8ms/step - loss: 0.6932
Epoch 246/270
11/11 [==============================] - 0s 10ms/step - loss: 0.8750
Epoch 247/270
11/11 [==============================] - 0s 9ms/step - loss: 1.0716
Epoch 248/270
11/11 [==============================] - 0s 7ms/step - loss: 0.9381
Epoch 249/270
11/11 [==============================] - 0s 8ms/step - loss: 0.7890
Epoch 250/270
11/11 [==============================] - 0s 8ms/step - loss: 0.6574
Epoch 251/270
11/11 [==============================] - 0s 8ms/step - loss: 0.6379
Epoch 252/270
11/11 [==============================] - 0s 8ms/step - loss: 0.5902
Epoch 253/270
11/11 [==============================] - 0s 13ms/step - loss: 0.4243
Epoch 254/270
11/11 [==============================] - 0s 7ms/step - loss: 0.5179
Epoch 255/270
11/11 [==============================] - 0s 7ms/step - loss: 0.5190
Epoch 256/270
11/11 [==============================] - 0s 7ms/step - loss: 0.5730
Epoch 257/270
11/11 [==============================] - 0s 7ms/step - loss: 0.5465
Epoch 258/270
11/11 [==============================] - 0s 7ms/step - loss: 0.6086
Epoch 259/270
11/11 [==============================] - 0s 7ms/step - loss: 1.1065
Epoch 260/270
11/11 [==============================] - 0s 7ms/step - loss: 1.2692
Epoch 261/270
11/11 [==============================] - 0s 8ms/step - loss: 1.1396
Epoch 262/270
11/11 [==============================] - 0s 8ms/step - loss: 1.1326
Epoch 263/270
11/11 [==============================] - 0s 7ms/step - loss: 0.9457
Epoch 264/270
11/11 [==============================] - 0s 8ms/step - loss: 0.9739
Epoch 265/270
11/11 [==============================] - 0s 6ms/step - loss: 0.6620
Epoch 266/270
11/11 [==============================] - 0s 7ms/step - loss: 0.5258
Epoch 267/270
```

```
11/11 [==============================] - 0s 7ms/step - loss: 0.4866
Epoch 268/270
11/11 [==============================] - 0s 6ms/step - loss: 0.5507
Epoch 269/270
11/11 [==============================] - 0s 8ms/step - loss: 0.5219
Epoch 270/270
11/11 [==============================] - 0s 8ms/step - loss: 0.4380
>expected=-3.0, predicted=-2.3
```



В нашем случае мы определили модель с 70 единицами LSTM в скрытом слое и выходным слоем, который предсказывает одно числовое значение.

Обучилась модель с использованием эффективной версии стохастического градиентного спуска 'adam' и функцией потерь RMSE.

Stacked LSTM

Несколько скрытых слоев LSTM могут быть сложены друг на друга в так называемой модели Stacked LSTM.

Уровень LSTM требует трехмерного ввода, и LSTM по умолчанию будет возвращать двумерный вывод.

Мы можем решить эту проблему, установив аргумент return_sequences=True на слое. Это позволяет нам иметь 3D-выход со скрытого слоя LSTM в качестве входных данных на следующий.

Измените функцию `lstm_forecast` задав модель Stacked LSTM.

In [126…

```
config = (70, 'relu', 'adam', 'mse', 1, 170, 1)
# lstm-прогноз на шаг вперёд
def lstm_forecast(train,
                  features_test, # строка признаков для валидаии
                  target, # имя колонки датафрейма целевого признака
                  config):
    # определяем конфигурацию
    units, activation, optimizer, loss, n_features, epochs, verbose = confi
    # выделяем целевой признак из train
    features_train, target_train = train.drop(columns=[target]), train[targ
    # преобразуем датафреймы в объекты numpy (нам нужен определённый форма
    features_train_arr = features_train.to_numpy()
    features_test_arr = features_test.to_numpy()
    target_train_arr = target_train.to_numpy()
    #target_test_arr = target_test.to_numpy()
    # Модель принимает тренировочные данные в таком формате: (samples, tim
    # Изменим форму входных данных.
    n_steps = features_train_arr.shape[1]
    features_train_arr = features_train_arr.reshape((features_train.shape[(
    features_test_arr = features_test_arr.reshape((1, n_steps, n_features))
    # определяем модель
    model_stacked_LSTM = Sequential()
    model_stacked_LSTM.add(LSTM(20, activation='relu', return_sequences=Tru
    model_stacked_LSTM.add(LSTM(50, activation='relu'))
    model_stacked_LSTM.add(Dense(1))
    model_stacked_LSTM.compile(optimizer='adam', loss='mse')
    # обучаем модель, на выходе получаем обученную модель с минимальной MS
    model_stacked_LSTM.fit(features_train_arr, target_train_arr, epochs=epo
    # делаем прогноз на шаг вперед
    prediction = model_stacked_LSTM.predict(features_test_arr)
    #prediction = pd.DataFrame(prediction[0], columns=['prediction'], inde
    #prediction = prediction.reshape((features_train.shape[0], n_steps))
    return prediction[0]
```

In [127…

```
error_stckd, val, pred_stckd = walk_forward_validation(data, 7, 'quantity',
```

```
Epoch 1/170
11/11 [==============================] - 3s 8ms/step - loss: 137.1902
Epoch 2/170
11/11 [==============================] - 0s 7ms/step - loss: 135.5139
Epoch 3/170
11/11 [==============================] - 0s 8ms/step - loss: 132.8358
Epoch 4/170
11/11 [==============================] - 0s 8ms/step - loss: 118.3568
Epoch 5/170
11/11 [==============================] - 0s 8ms/step - loss: 104.8174
Epoch 6/170
11/11 [==============================] - 0s 8ms/step - loss: 102.3691
Epoch 7/170
11/11 [==============================] - 0s 9ms/step - loss: 97.1637
Epoch 8/170
11/11 [==============================] - 0s 8ms/step - loss: 90.9513
Epoch 9/170
11/11 [==============================] - 0s 8ms/step - loss: 86.9675
Epoch 10/170
```

```
11/11 [==============================] - 0s 8ms/step - loss: 86.0830
Epoch 11/170
11/11 [==============================] - 0s 8ms/step - loss: 83.9873
Epoch 12/170
11/11 [==============================] - 0s 8ms/step - loss: 86.2191
Epoch 13/170
11/11 [==============================] - 0s 8ms/step - loss: 83.2076
Epoch 14/170
11/11 [==============================] - 0s 8ms/step - loss: 81.7272
Epoch 15/170
11/11 [==============================] - 0s 7ms/step - loss: 80.2282
Epoch 16/170
11/11 [==============================] - 0s 7ms/step - loss: 79.3397
Epoch 17/170
11/11 [==============================] - 0s 7ms/step - loss: 78.9820
Epoch 18/170
11/11 [==============================] - 0s 8ms/step - loss: 75.3957
Epoch 19/170
11/11 [==============================] - 0s 8ms/step - loss: 75.7271
Epoch 20/170
11/11 [==============================] - 0s 7ms/step - loss: 73.0112
Epoch 21/170
11/11 [==============================] - 0s 8ms/step - loss: 77.6178
Epoch 22/170
11/11 [==============================] - 0s 7ms/step - loss: 74.5553
Epoch 23/170
11/11 [==============================] - 0s 7ms/step - loss: 73.8948
Epoch 24/170
11/11 [==============================] - 0s 7ms/step - loss: 69.4619
Epoch 25/170
11/11 [==============================] - 0s 7ms/step - loss: 71.0258
Epoch 26/170
11/11 [==============================] - 0s 7ms/step - loss: 71.1662
Epoch 27/170
11/11 [==============================] - 0s 8ms/step - loss: 68.0960
Epoch 28/170
11/11 [==============================] - 0s 8ms/step - loss: 69.3429
Epoch 29/170
11/11 [==============================] - 0s 8ms/step - loss: 66.5874
Epoch 30/170
11/11 [==============================] - 0s 9ms/step - loss: 67.3181
Epoch 31/170
11/11 [==============================] - 0s 7ms/step - loss: 63.0875
Epoch 32/170
11/11 [==============================] - 0s 8ms/step - loss: 62.4527
Epoch 33/170
11/11 [==============================] - 0s 8ms/step - loss: 60.1006
Epoch 34/170
11/11 [==============================] - 0s 8ms/step - loss: 58.9655
Epoch 35/170
11/11 [==============================] - 0s 7ms/step - loss: 60.5822
Epoch 36/170
11/11 [==============================] - 0s 7ms/step - loss: 58.3750
Epoch 37/170
11/11 [==============================] - 0s 8ms/step - loss: 55.8823
Epoch 38/170
11/11 [==============================] - 0s 7ms/step - loss: 55.8438
Epoch 39/170
11/11 [==============================] - 0s 7ms/step - loss: 55.9824
Epoch 40/170
11/11 [==============================] - 0s 8ms/step - loss: 54.8987
```

```
Epoch 41/170
11/11 [==============================] - 0s 9ms/step - loss: 53.2568
Epoch 42/170
11/11 [==============================] - 0s 7ms/step - loss: 52.5426
Epoch 43/170
11/11 [==============================] - 0s 7ms/step - loss: 52.5098
Epoch 44/170
11/11 [==============================] - 0s 7ms/step - loss: 50.7076
Epoch 45/170
11/11 [==============================] - 0s 8ms/step - loss: 50.3370
Epoch 46/170
11/11 [==============================] - 0s 8ms/step - loss: 49.8922
Epoch 47/170
11/11 [==============================] - 0s 8ms/step - loss: 49.5566
Epoch 48/170
11/11 [==============================] - 0s 14ms/step - loss: 49.1735
Epoch 49/170
11/11 [==============================] - 0s 8ms/step - loss: 47.0899
Epoch 50/170
11/11 [==============================] - 0s 8ms/step - loss: 49.1775
Epoch 51/170
11/11 [==============================] - 0s 13ms/step - loss: 49.3697
Epoch 52/170
11/11 [==============================] - 0s 15ms/step - loss: 50.7579
Epoch 53/170
11/11 [==============================] - 0s 12ms/step - loss: 47.7149
Epoch 54/170
11/11 [==============================] - 0s 13ms/step - loss: 45.3023
Epoch 55/170
11/11 [==============================] - 0s 13ms/step - loss: 45.2233
Epoch 56/170
11/11 [==============================] - 0s 12ms/step - loss: 47.7460
Epoch 57/170
11/11 [==============================] - 0s 14ms/step - loss: 47.8855
Epoch 58/170
11/11 [==============================] - 0s 18ms/step - loss: 44.0126
Epoch 59/170
11/11 [==============================] - 0s 13ms/step - loss: 42.3071
Epoch 60/170
11/11 [==============================] - 0s 14ms/step - loss: 41.4665
Epoch 61/170
11/11 [==============================] - 0s 12ms/step - loss: 43.3823
Epoch 62/170
11/11 [==============================] - 0s 13ms/step - loss: 46.5273
Epoch 63/170
11/11 [==============================] - 0s 13ms/step - loss: 47.1436
Epoch 64/170
11/11 [==============================] - 0s 13ms/step - loss: 40.9902
Epoch 65/170
11/11 [==============================] - 0s 12ms/step - loss: 38.6126
Epoch 66/170
11/11 [==============================] - 0s 16ms/step - loss: 36.4318
Epoch 67/170
11/11 [==============================] - 0s 18ms/step - loss: 36.6710
Epoch 68/170
11/11 [==============================] - 0s 15ms/step - loss: 35.6996
Epoch 69/170
11/11 [==============================] - 0s 13ms/step - loss: 35.7104
Epoch 70/170
11/11 [==============================] - 0s 14ms/step - loss: 34.5008
Epoch 71/170
```

```
11/11 [==============================] - 0s 14ms/step - loss: 37.7472
Epoch 72/170
11/11 [==============================] - 0s 15ms/step - loss: 33.8846
Epoch 73/170
11/11 [==============================] - 0s 14ms/step - loss: 33.1385
Epoch 74/170
11/11 [==============================] - 0s 12ms/step - loss: 31.7295
Epoch 75/170
11/11 [==============================] - 0s 12ms/step - loss: 31.3845
Epoch 76/170
11/11 [==============================] - 0s 13ms/step - loss: 30.7817
Epoch 77/170
11/11 [==============================] - 0s 11ms/step - loss: 30.8360
Epoch 78/170
11/11 [==============================] - 0s 9ms/step - loss: 29.7382
Epoch 79/170
11/11 [==============================] - 0s 8ms/step - loss: 27.9215
Epoch 80/170
11/11 [==============================] - 0s 12ms/step - loss: 28.8724
Epoch 81/170
11/11 [==============================] - 0s 13ms/step - loss: 30.5112
Epoch 82/170
11/11 [==============================] - 0s 14ms/step - loss: 28.1220
Epoch 83/170
11/11 [==============================] - 0s 12ms/step - loss: 24.5267
Epoch 84/170
11/11 [==============================] - 0s 13ms/step - loss: 24.4230
Epoch 85/170
11/11 [==============================] - 0s 11ms/step - loss: 24.8064
Epoch 86/170
11/11 [==============================] - 0s 13ms/step - loss: 23.3602
Epoch 87/170
11/11 [==============================] - 0s 13ms/step - loss: 24.2008
Epoch 88/170
11/11 [==============================] - 0s 14ms/step - loss: 25.0220
Epoch 89/170
11/11 [==============================] - 0s 16ms/step - loss: 21.9089
Epoch 90/170
11/11 [==============================] - 0s 14ms/step - loss: 19.1437
Epoch 91/170
11/11 [==============================] - 0s 17ms/step - loss: 21.4430
Epoch 92/170
11/11 [==============================] - 0s 17ms/step - loss: 20.8594
Epoch 93/170
11/11 [==============================] - 0s 16ms/step - loss: 19.5122
Epoch 94/170
11/11 [==============================] - 0s 15ms/step - loss: 16.6681
Epoch 95/170
11/11 [==============================] - 0s 17ms/step - loss: 18.5891
Epoch 96/170
11/11 [==============================] - 0s 18ms/step - loss: 18.9250
Epoch 97/170
11/11 [==============================] - 0s 19ms/step - loss: 16.6953
Epoch 98/170
11/11 [==============================] - 0s 14ms/step - loss: 16.7195
Epoch 99/170
11/11 [==============================] - 0s 15ms/step - loss: 15.4830
Epoch 100/170
11/11 [==============================] - 0s 16ms/step - loss: 17.4386
Epoch 101/170
11/11 [==============================] - 0s 15ms/step - loss: 16.5328
```

```
Epoch 102/170
11/11 [==============================] - 0s 21ms/step - loss: 16.7077
Epoch 103/170
11/11 [==============================] - 0s 20ms/step - loss: 15.9089
Epoch 104/170
11/11 [==============================] - 0s 16ms/step - loss: 14.0778
Epoch 105/170
11/11 [==============================] - 0s 15ms/step - loss: 12.7862
Epoch 106/170
11/11 [==============================] - 0s 14ms/step - loss: 13.6738
Epoch 107/170
11/11 [==============================] - 0s 13ms/step - loss: 12.2417
Epoch 108/170
11/11 [==============================] - 0s 14ms/step - loss: 10.9211
Epoch 109/170
11/11 [==============================] - 0s 16ms/step - loss: 10.1047
Epoch 110/170
11/11 [==============================] - 0s 14ms/step - loss: 9.1998
Epoch 111/170
11/11 [==============================] - 0s 13ms/step - loss: 8.9637
Epoch 112/170
11/11 [==============================] - 0s 14ms/step - loss: 8.3566
Epoch 113/170
11/11 [==============================] - 0s 13ms/step - loss: 9.0652
Epoch 114/170
11/11 [==============================] - 0s 14ms/step - loss: 8.9392
Epoch 115/170
11/11 [==============================] - 0s 17ms/step - loss: 8.2536
Epoch 116/170
11/11 [==============================] - 0s 14ms/step - loss: 8.0427
Epoch 117/170
11/11 [==============================] - 0s 13ms/step - loss: 8.6756
Epoch 118/170
11/11 [==============================] - 0s 19ms/step - loss: 7.8276
Epoch 119/170
11/11 [==============================] - 0s 14ms/step - loss: 7.8392
Epoch 120/170
11/11 [==============================] - 0s 17ms/step - loss: 9.5452
Epoch 121/170
11/11 [==============================] - 0s 14ms/step - loss: 8.9385
Epoch 122/170
11/11 [==============================] - 0s 14ms/step - loss: 8.1336
Epoch 123/170
11/11 [==============================] - 0s 13ms/step - loss: 7.4542
Epoch 124/170
11/11 [==============================] - 0s 13ms/step - loss: 7.1814
Epoch 125/170
11/11 [==============================] - 0s 16ms/step - loss: 6.6380
Epoch 126/170
11/11 [==============================] - 0s 15ms/step - loss: 6.0300
Epoch 127/170
11/11 [==============================] - 0s 12ms/step - loss: 5.8143
Epoch 128/170
11/11 [==============================] - 0s 15ms/step - loss: 6.0475
Epoch 129/170
11/11 [==============================] - 0s 13ms/step - loss: 5.8102
Epoch 130/170
11/11 [==============================] - 0s 14ms/step - loss: 6.0908
Epoch 131/170
11/11 [==============================] - 0s 16ms/step - loss: 5.7849
Epoch 132/170
```

```
11/11 [==============================] - 0s 18ms/step - loss: 6.0062
Epoch 133/170
11/11 [==============================] - 0s 14ms/step - loss: 6.8393
Epoch 134/170
11/11 [==============================] - 0s 14ms/step - loss: 6.7025
Epoch 135/170
11/11 [==============================] - 0s 13ms/step - loss: 6.5807
Epoch 136/170
11/11 [==============================] - 0s 13ms/step - loss: 5.7955
Epoch 137/170
11/11 [==============================] - 0s 13ms/step - loss: 5.9086
Epoch 138/170
11/11 [==============================] - 0s 12ms/step - loss: 5.9291
Epoch 139/170
11/11 [==============================] - 0s 14ms/step - loss: 7.6565
Epoch 140/170
11/11 [==============================] - 0s 13ms/step - loss: 7.9390
Epoch 141/170
11/11 [==============================] - 0s 14ms/step - loss: 8.1827
Epoch 142/170
11/11 [==============================] - 0s 13ms/step - loss: 7.7548
Epoch 143/170
11/11 [==============================] - 0s 16ms/step - loss: 6.4548
Epoch 144/170
11/11 [==============================] - 0s 13ms/step - loss: 6.3378
Epoch 145/170
11/11 [==============================] - 0s 14ms/step - loss: 5.5178
Epoch 146/170
11/11 [==============================] - 0s 14ms/step - loss: 4.7727
Epoch 147/170
11/11 [==============================] - 0s 14ms/step - loss: 5.0703
Epoch 148/170
11/11 [==============================] - 0s 12ms/step - loss: 4.8885
Epoch 149/170
11/11 [==============================] - 0s 12ms/step - loss: 4.8895
Epoch 150/170
11/11 [==============================] - 0s 13ms/step - loss: 5.5679
Epoch 151/170
11/11 [==============================] - 0s 12ms/step - loss: 4.8782
Epoch 152/170
11/11 [==============================] - 0s 9ms/step - loss: 4.3522
Epoch 153/170
11/11 [==============================] - 0s 7ms/step - loss: 3.6566
Epoch 154/170
11/11 [==============================] - 0s 10ms/step - loss: 3.9798
Epoch 155/170
11/11 [==============================] - 0s 15ms/step - loss: 5.1568
Epoch 156/170
11/11 [==============================] - 0s 13ms/step - loss: 5.3783
Epoch 157/170
11/11 [==============================] - 0s 14ms/step - loss: 5.0172
Epoch 158/170
11/11 [==============================] - 0s 13ms/step - loss: 4.4996
Epoch 159/170
11/11 [==============================] - 0s 14ms/step - loss: 3.9124
Epoch 160/170
11/11 [==============================] - 0s 12ms/step - loss: 3.6409
Epoch 161/170
11/11 [==============================] - 0s 12ms/step - loss: 3.2286
Epoch 162/170
11/11 [==============================] - 0s 13ms/step - loss: 3.5737
```

```
Epoch 163/170
11/11 [==============================] - 0s 12ms/step - loss: 3.1499
Epoch 164/170
11/11 [==============================] - 0s 12ms/step - loss: 2.8799
Epoch 165/170
11/11 [==============================] - 0s 11ms/step - loss: 2.9071
Epoch 166/170
11/11 [==============================] - 0s 11ms/step - loss: 3.5736
Epoch 167/170
11/11 [==============================] - 0s 12ms/step - loss: 3.6174
Epoch 168/170
11/11 [==============================] - 0s 12ms/step - loss: 3.1557
Epoch 169/170
11/11 [==============================] - 0s 13ms/step - loss: 3.3309
Epoch 170/170
11/11 [==============================] - 0s 11ms/step - loss: 3.6354
>expected=-1.0, predicted=-7.1
Epoch 1/170
11/11 [==============================] - 3s 8ms/step - loss: 136.7922
Epoch 2/170
11/11 [==============================] - 0s 8ms/step - loss: 135.7415
Epoch 3/170
11/11 [==============================] - 0s 8ms/step - loss: 134.2958
Epoch 4/170
11/11 [==============================] - 0s 7ms/step - loss: 129.0958
Epoch 5/170
11/11 [==============================] - 0s 8ms/step - loss: 106.4558
Epoch 6/170
11/11 [==============================] - 0s 7ms/step - loss: 97.9659
Epoch 7/170
11/11 [==============================] - 0s 7ms/step - loss: 94.7882
Epoch 8/170
11/11 [==============================] - 0s 8ms/step - loss: 91.9611
Epoch 9/170
11/11 [==============================] - 0s 8ms/step - loss: 86.8542
Epoch 10/170
11/11 [==============================] - 0s 8ms/step - loss: 86.9480
Epoch 11/170
11/11 [==============================] - 0s 9ms/step - loss: 85.3245
Epoch 12/170
11/11 [==============================] - 0s 7ms/step - loss: 84.7918
Epoch 13/170
11/11 [==============================] - 0s 8ms/step - loss: 83.4330
Epoch 14/170
11/11 [==============================] - 0s 8ms/step - loss: 82.8804
Epoch 15/170
11/11 [==============================] - 0s 8ms/step - loss: 83.5787
Epoch 16/170
11/11 [==============================] - 0s 7ms/step - loss: 83.0188
Epoch 17/170
11/11 [==============================] - 0s 8ms/step - loss: 84.7114
Epoch 18/170
11/11 [==============================] - 0s 8ms/step - loss: 81.8551
Epoch 19/170
11/11 [==============================] - 0s 7ms/step - loss: 78.4001
Epoch 20/170
11/11 [==============================] - 0s 8ms/step - loss: 80.1121
Epoch 21/170
11/11 [==============================] - 0s 8ms/step - loss: 78.8210
Epoch 22/170
11/11 [==============================] - 0s 9ms/step - loss: 74.8479
```

```
Epoch 23/170
11/11 [==============================] - 0s 8ms/step - loss: 75.3396
Epoch 24/170
11/11 [==============================] - 0s 8ms/step - loss: 75.5058
Epoch 25/170
11/11 [==============================] - 0s 8ms/step - loss: 75.1856
Epoch 26/170
11/11 [==============================] - 0s 7ms/step - loss: 71.6468
Epoch 27/170
11/11 [==============================] - 0s 8ms/step - loss: 70.7572
Epoch 28/170
11/11 [==============================] - 0s 8ms/step - loss: 71.5010
Epoch 29/170
11/11 [==============================] - 0s 8ms/step - loss: 67.2309
Epoch 30/170
11/11 [==============================] - 0s 8ms/step - loss: 66.9684
Epoch 31/170
11/11 [==============================] - 0s 8ms/step - loss: 63.2786
Epoch 32/170
11/11 [==============================] - 0s 7ms/step - loss: 66.5722
Epoch 33/170
11/11 [==============================] - 0s 8ms/step - loss: 66.4680
Epoch 34/170
11/11 [==============================] - 0s 8ms/step - loss: 62.6491
Epoch 35/170
11/11 [==============================] - 0s 8ms/step - loss: 61.9362
Epoch 36/170
11/11 [==============================] - 0s 7ms/step - loss: 62.0442
Epoch 37/170
11/11 [==============================] - 0s 8ms/step - loss: 57.0985
Epoch 38/170
11/11 [==============================] - 0s 8ms/step - loss: 56.1443
Epoch 39/170
11/11 [==============================] - 0s 9ms/step - loss: 55.2515
Epoch 40/170
11/11 [==============================] - 0s 15ms/step - loss: 53.2247
Epoch 41/170
11/11 [==============================] - 0s 13ms/step - loss: 50.7696
Epoch 42/170
11/11 [==============================] - 0s 14ms/step - loss: 51.4594
Epoch 43/170
11/11 [==============================] - 0s 14ms/step - loss: 49.8336
Epoch 44/170
11/11 [==============================] - 0s 13ms/step - loss: 48.0421
Epoch 45/170
11/11 [==============================] - 0s 13ms/step - loss: 45.9129
Epoch 46/170
11/11 [==============================] - 0s 13ms/step - loss: 48.2077
Epoch 47/170
11/11 [==============================] - 0s 12ms/step - loss: 45.2986
Epoch 48/170
11/11 [==============================] - 0s 13ms/step - loss: 46.3915
Epoch 49/170
11/11 [==============================] - 0s 14ms/step - loss: 45.8001
Epoch 50/170
11/11 [==============================] - 0s 12ms/step - loss: 40.8364
Epoch 51/170
11/11 [==============================] - 0s 12ms/step - loss: 40.1022
Epoch 52/170
11/11 [==============================] - 0s 14ms/step - loss: 37.2752
Epoch 53/170
```

```
11/11 [==============================] - 0s 13ms/step - loss: 37.1455
Epoch 54/170
11/11 [==============================] - 0s 12ms/step - loss: 40.8885
Epoch 55/170
11/11 [==============================] - 0s 11ms/step - loss: 39.8796
Epoch 56/170
11/11 [==============================] - 0s 15ms/step - loss: 34.9153
Epoch 57/170
11/11 [==============================] - 0s 13ms/step - loss: 37.1046
Epoch 58/170
11/11 [==============================] - 0s 13ms/step - loss: 38.8239
Epoch 59/170
11/11 [==============================] - 0s 13ms/step - loss: 36.4497
Epoch 60/170
11/11 [==============================] - 0s 13ms/step - loss: 33.6993
Epoch 61/170
11/11 [==============================] - 0s 12ms/step - loss: 29.2639
Epoch 62/170
11/11 [==============================] - 0s 14ms/step - loss: 29.1271
Epoch 63/170
11/11 [==============================] - 0s 14ms/step - loss: 28.8293
Epoch 64/170
11/11 [==============================] - 0s 14ms/step - loss: 27.3052
Epoch 65/170
11/11 [==============================] - 0s 13ms/step - loss: 26.5974
Epoch 66/170
11/11 [==============================] - 0s 14ms/step - loss: 25.4773
Epoch 67/170
11/11 [==============================] - 0s 14ms/step - loss: 24.9999
Epoch 68/170
11/11 [==============================] - 0s 13ms/step - loss: 26.6967
Epoch 69/170
11/11 [==============================] - 0s 13ms/step - loss: 25.3628
Epoch 70/170
11/11 [==============================] - 0s 13ms/step - loss: 26.5753
Epoch 71/170
11/11 [==============================] - 0s 14ms/step - loss: 29.5263
Epoch 72/170
11/11 [==============================] - 0s 13ms/step - loss: 25.2075
Epoch 73/170
11/11 [==============================] - 0s 14ms/step - loss: 22.7442
Epoch 74/170
11/11 [==============================] - 0s 12ms/step - loss: 22.4754
Epoch 75/170
11/11 [==============================] - 0s 13ms/step - loss: 22.0121
Epoch 76/170
11/11 [==============================] - 0s 14ms/step - loss: 20.4754
Epoch 77/170
11/11 [==============================] - 0s 15ms/step - loss: 19.8917
Epoch 78/170
11/11 [==============================] - 0s 8ms/step - loss: 19.5581
Epoch 79/170
11/11 [==============================] - 0s 9ms/step - loss: 19.6847
Epoch 80/170
11/11 [==============================] - 0s 12ms/step - loss: 20.0523
Epoch 81/170
11/11 [==============================] - 0s 15ms/step - loss: 20.9602
Epoch 82/170
11/11 [==============================] - 0s 15ms/step - loss: 20.2498
Epoch 83/170
11/11 [==============================] - 0s 14ms/step - loss: 18.7422
```

```
Epoch 84/170
11/11 [==============================] - 0s 13ms/step - loss: 18.2413
Epoch 85/170
11/11 [==============================] - 0s 13ms/step - loss: 18.3531
Epoch 86/170
11/11 [==============================] - 0s 14ms/step - loss: 16.9456
Epoch 87/170
11/11 [==============================] - 0s 12ms/step - loss: 17.6263
Epoch 88/170
11/11 [==============================] - 0s 13ms/step - loss: 18.7374
Epoch 89/170
11/11 [==============================] - 0s 13ms/step - loss: 18.9121
Epoch 90/170
11/11 [==============================] - 0s 13ms/step - loss: 19.8463
Epoch 91/170
11/11 [==============================] - 0s 13ms/step - loss: 18.1771
Epoch 92/170
11/11 [==============================] - 0s 14ms/step - loss: 18.2521
Epoch 93/170
11/11 [==============================] - 0s 14ms/step - loss: 18.4459
Epoch 94/170
11/11 [==============================] - 0s 13ms/step - loss: 16.2369
Epoch 95/170
11/11 [==============================] - 0s 13ms/step - loss: 17.3129
Epoch 96/170
11/11 [==============================] - 0s 14ms/step - loss: 17.0284
Epoch 97/170
11/11 [==============================] - 0s 13ms/step - loss: 16.1044
Epoch 98/170
11/11 [==============================] - 0s 13ms/step - loss: 15.3137
Epoch 99/170
11/11 [==============================] - 0s 13ms/step - loss: 13.5776
Epoch 100/170
11/11 [==============================] - 0s 13ms/step - loss: 12.5503
Epoch 101/170
11/11 [==============================] - 0s 14ms/step - loss: 12.6748
Epoch 102/170
11/11 [==============================] - 0s 14ms/step - loss: 12.1108
Epoch 103/170
11/11 [==============================] - 0s 15ms/step - loss: 12.4211
Epoch 104/170
11/11 [==============================] - 0s 12ms/step - loss: 14.5960
Epoch 105/170
11/11 [==============================] - 0s 13ms/step - loss: 12.0923
Epoch 106/170
11/11 [==============================] - 0s 13ms/step - loss: 10.9891
Epoch 107/170
11/11 [==============================] - 0s 14ms/step - loss: 10.6617
Epoch 108/170
11/11 [==============================] - 0s 12ms/step - loss: 9.8693
Epoch 109/170
11/11 [==============================] - 0s 13ms/step - loss: 9.6826
Epoch 110/170
11/11 [==============================] - 0s 14ms/step - loss: 9.6793
Epoch 111/170
11/11 [==============================] - 0s 12ms/step - loss: 9.9462
Epoch 112/170
11/11 [==============================] - 0s 12ms/step - loss: 10.1901
Epoch 113/170
11/11 [==============================] - 0s 13ms/step - loss: 10.5034
Epoch 114/170
```

```
11/11 [==============================] - 0s 13ms/step - loss: 10.3968
Epoch 115/170
11/11 [==============================] - 0s 15ms/step - loss: 14.4328
Epoch 116/170
11/11 [==============================] - 0s 14ms/step - loss: 17.6840
Epoch 117/170
11/11 [==============================] - 0s 15ms/step - loss: 14.9749
Epoch 118/170
11/11 [==============================] - 0s 14ms/step - loss: 12.6588
Epoch 119/170
11/11 [==============================] - 0s 12ms/step - loss: 11.5050
Epoch 120/170
11/11 [==============================] - 0s 13ms/step - loss: 9.9430
Epoch 121/170
11/11 [==============================] - 0s 12ms/step - loss: 8.3159
Epoch 122/170
11/11 [==============================] - 0s 12ms/step - loss: 8.4580
Epoch 123/170
11/11 [==============================] - 0s 14ms/step - loss: 7.9658
Epoch 124/170
11/11 [==============================] - 0s 9ms/step - loss: 7.5517
Epoch 125/170
11/11 [==============================] - 0s 8ms/step - loss: 7.6074
Epoch 126/170
11/11 [==============================] - 0s 8ms/step - loss: 7.3728
Epoch 127/170
11/11 [==============================] - 0s 8ms/step - loss: 7.8293
Epoch 128/170
11/11 [==============================] - 0s 8ms/step - loss: 8.1544
Epoch 129/170
11/11 [==============================] - 0s 8ms/step - loss: 9.5334
Epoch 130/170
11/11 [==============================] - 0s 7ms/step - loss: 8.7070
Epoch 131/170
11/11 [==============================] - 0s 8ms/step - loss: 7.5353
Epoch 132/170
11/11 [==============================] - 0s 8ms/step - loss: 7.3117
Epoch 133/170
11/11 [==============================] - 0s 8ms/step - loss: 6.7556
Epoch 134/170
11/11 [==============================] - 0s 9ms/step - loss: 6.4228
Epoch 135/170
11/11 [==============================] - 0s 8ms/step - loss: 5.3360
Epoch 136/170
11/11 [==============================] - 0s 7ms/step - loss: 5.1639
Epoch 137/170
11/11 [==============================] - 0s 8ms/step - loss: 5.2737
Epoch 138/170
11/11 [==============================] - 0s 8ms/step - loss: 5.3406
Epoch 139/170
11/11 [==============================] - 0s 8ms/step - loss: 5.4524
Epoch 140/170
11/11 [==============================] - 0s 8ms/step - loss: 5.0072
Epoch 141/170
11/11 [==============================] - 0s 8ms/step - loss: 4.8055
Epoch 142/170
11/11 [==============================] - 0s 8ms/step - loss: 4.3858
Epoch 143/170
11/11 [==============================] - 0s 9ms/step - loss: 4.1793
Epoch 144/170
11/11 [==============================] - 0s 8ms/step - loss: 4.4419
```

```
Epoch 145/170
11/11 [==============================] - 0s 9ms/step - loss: 4.9393
Epoch 146/170
11/11 [==============================] - 0s 8ms/step - loss: 4.6582
Epoch 147/170
11/11 [==============================] - 0s 9ms/step - loss: 4.8250
Epoch 148/170
11/11 [==============================] - 0s 8ms/step - loss: 4.9415
Epoch 149/170
11/11 [==============================] - 0s 9ms/step - loss: 5.0232
Epoch 150/170
11/11 [==============================] - 0s 8ms/step - loss: 4.8242
Epoch 151/170
11/11 [==============================] - 0s 9ms/step - loss: 4.7400
Epoch 152/170
11/11 [==============================] - 0s 8ms/step - loss: 5.4161
Epoch 153/170
11/11 [==============================] - 0s 8ms/step - loss: 5.4438
Epoch 154/170
11/11 [==============================] - 0s 8ms/step - loss: 6.6592
Epoch 155/170
11/11 [==============================] - 0s 9ms/step - loss: 6.7903
Epoch 156/170
11/11 [==============================] - 0s 8ms/step - loss: 5.5872
Epoch 157/170
11/11 [==============================] - 0s 8ms/step - loss: 4.6088
Epoch 158/170
11/11 [==============================] - 0s 8ms/step - loss: 4.2971
Epoch 159/170
11/11 [==============================] - 0s 8ms/step - loss: 4.8688
Epoch 160/170
11/11 [==============================] - 0s 8ms/step - loss: 4.1179
Epoch 161/170
11/11 [==============================] - 0s 8ms/step - loss: 3.7425
Epoch 162/170
11/11 [==============================] - 0s 9ms/step - loss: 3.3284
Epoch 163/170
11/11 [==============================] - 0s 8ms/step - loss: 3.8473
Epoch 164/170
11/11 [==============================] - 0s 8ms/step - loss: 3.6584
Epoch 165/170
11/11 [==============================] - 0s 11ms/step - loss: 3.6931
Epoch 166/170
11/11 [==============================] - 0s 8ms/step - loss: 3.2570
Epoch 167/170
11/11 [==============================] - 0s 9ms/step - loss: 3.0660
Epoch 168/170
11/11 [==============================] - 0s 8ms/step - loss: 3.1412
Epoch 169/170
11/11 [==============================] - 0s 8ms/step - loss: 3.2467
Epoch 170/170
11/11 [==============================] - 0s 7ms/step - loss: 2.9257
>expected=-6.0, predicted=-6.3
Epoch 1/170
11/11 [==============================] - 2s 7ms/step - loss: 136.9821
Epoch 2/170
11/11 [==============================] - 0s 8ms/step - loss: 134.6905
Epoch 3/170
11/11 [==============================] - 0s 9ms/step - loss: 130.9245
Epoch 4/170
11/11 [==============================] - 0s 8ms/step - loss: 114.8807
```

```
Epoch 5/170
11/11 [==============================] - 0s 8ms/step - loss: 106.2801
Epoch 6/170
11/11 [==============================] - 0s 8ms/step - loss: 98.6239
Epoch 7/170
11/11 [==============================] - 0s 8ms/step - loss: 93.4418
Epoch 8/170
11/11 [==============================] - 0s 8ms/step - loss: 88.1873
Epoch 9/170
11/11 [==============================] - 0s 10ms/step - loss: 88.6248
Epoch 10/170
11/11 [==============================] - 0s 8ms/step - loss: 85.4467
Epoch 11/170
11/11 [==============================] - 0s 8ms/step - loss: 84.0447
Epoch 12/170
11/11 [==============================] - 0s 8ms/step - loss: 81.9136
Epoch 13/170
11/11 [==============================] - 0s 8ms/step - loss: 81.9848
Epoch 14/170
11/11 [==============================] - 0s 8ms/step - loss: 79.6505
Epoch 15/170
11/11 [==============================] - 0s 8ms/step - loss: 78.9202
Epoch 16/170
11/11 [==============================] - 0s 8ms/step - loss: 78.7017
Epoch 17/170
11/11 [==============================] - 0s 8ms/step - loss: 77.9149
Epoch 18/170
11/11 [==============================] - 0s 8ms/step - loss: 75.5089
Epoch 19/170
11/11 [==============================] - 0s 8ms/step - loss: 74.9694
Epoch 20/170
11/11 [==============================] - 0s 10ms/step - loss: 75.9028
Epoch 21/170
11/11 [==============================] - 0s 8ms/step - loss: 72.3666
Epoch 22/170
11/11 [==============================] - 0s 8ms/step - loss: 71.8471
Epoch 23/170
11/11 [==============================] - 0s 8ms/step - loss: 70.1045
Epoch 24/170
11/11 [==============================] - 0s 8ms/step - loss: 70.5118
Epoch 25/170
11/11 [==============================] - 0s 8ms/step - loss: 69.1349
Epoch 26/170
11/11 [==============================] - 0s 8ms/step - loss: 67.4129
Epoch 27/170
11/11 [==============================] - 0s 8ms/step - loss: 67.3995
Epoch 28/170
11/11 [==============================] - 0s 8ms/step - loss: 68.0560
Epoch 29/170
11/11 [==============================] - 0s 9ms/step - loss: 71.6432
Epoch 30/170
11/11 [==============================] - 0s 9ms/step - loss: 67.0525
Epoch 31/170
11/11 [==============================] - 0s 8ms/step - loss: 62.5319
Epoch 32/170
11/11 [==============================] - 0s 9ms/step - loss: 63.9268
Epoch 33/170
11/11 [==============================] - 0s 8ms/step - loss: 64.1817
Epoch 34/170
11/11 [==============================] - 0s 8ms/step - loss: 61.5390
Epoch 35/170
```

```
11/11 [==============================] - 0s 8ms/step - loss: 59.2901
Epoch 36/170
11/11 [==============================] - 0s 8ms/step - loss: 59.7642
Epoch 37/170
11/11 [==============================] - 0s 8ms/step - loss: 58.0699
Epoch 38/170
11/11 [==============================] - 0s 8ms/step - loss: 57.6443
Epoch 39/170
11/11 [==============================] - 0s 7ms/step - loss: 56.8934
Epoch 40/170
11/11 [==============================] - 0s 8ms/step - loss: 56.1938
Epoch 41/170
11/11 [==============================] - 0s 9ms/step - loss: 54.7162
Epoch 42/170
11/11 [==============================] - 0s 8ms/step - loss: 53.9221
Epoch 43/170
11/11 [==============================] - 0s 7ms/step - loss: 54.4489
Epoch 44/170
11/11 [==============================] - 0s 8ms/step - loss: 56.5301
Epoch 45/170
11/11 [==============================] - 0s 8ms/step - loss: 54.2568
Epoch 46/170
11/11 [==============================] - 0s 9ms/step - loss: 51.8959
Epoch 47/170
11/11 [==============================] - 0s 8ms/step - loss: 51.4346
Epoch 48/170
11/11 [==============================] - 0s 8ms/step - loss: 53.7531
Epoch 49/170
11/11 [==============================] - 0s 8ms/step - loss: 51.0920
Epoch 50/170
11/11 [==============================] - 0s 8ms/step - loss: 48.2345
Epoch 51/170
11/11 [==============================] - 0s 8ms/step - loss: 46.4342
Epoch 52/170
11/11 [==============================] - 0s 8ms/step - loss: 45.1988
Epoch 53/170
11/11 [==============================] - 0s 8ms/step - loss: 43.6339
Epoch 54/170
11/11 [==============================] - 0s 8ms/step - loss: 46.8463
Epoch 55/170
11/11 [==============================] - 0s 8ms/step - loss: 45.9578
Epoch 56/170
11/11 [==============================] - 0s 9ms/step - loss: 43.9442
Epoch 57/170
11/11 [==============================] - 0s 8ms/step - loss: 42.6218
Epoch 58/170
11/11 [==============================] - 0s 8ms/step - loss: 39.9681
Epoch 59/170
11/11 [==============================] - 0s 8ms/step - loss: 38.4195
Epoch 60/170
11/11 [==============================] - 0s 8ms/step - loss: 38.1484
Epoch 61/170
11/11 [==============================] - 0s 9ms/step - loss: 36.9722
Epoch 62/170
11/11 [==============================] - 0s 8ms/step - loss: 35.8852
Epoch 63/170
11/11 [==============================] - 0s 8ms/step - loss: 35.7777
Epoch 64/170
11/11 [==============================] - 0s 8ms/step - loss: 35.9842
Epoch 65/170
11/11 [==============================] - 0s 8ms/step - loss: 32.5610
```

```
Epoch 66/170
11/11 [==============================] - 0s 8ms/step - loss: 32.2787
Epoch 67/170
11/11 [==============================] - 0s 8ms/step - loss: 32.6133
Epoch 68/170
11/11 [==============================] - 0s 8ms/step - loss: 29.8129
Epoch 69/170
11/11 [==============================] - 0s 8ms/step - loss: 29.2837
Epoch 70/170
11/11 [==============================] - 0s 8ms/step - loss: 28.6446
Epoch 71/170
11/11 [==============================] - 0s 8ms/step - loss: 27.0434
Epoch 72/170
11/11 [==============================] - 0s 9ms/step - loss: 28.8563
Epoch 73/170
11/11 [==============================] - 0s 8ms/step - loss: 30.1276
Epoch 74/170
11/11 [==============================] - 0s 8ms/step - loss: 27.0565
Epoch 75/170
11/11 [==============================] - 0s 8ms/step - loss: 26.4167
Epoch 76/170
11/11 [==============================] - 0s 8ms/step - loss: 25.2639
Epoch 77/170
11/11 [==============================] - 0s 8ms/step - loss: 24.4315
Epoch 78/170
11/11 [==============================] - 0s 8ms/step - loss: 24.6641
Epoch 79/170
11/11 [==============================] - 0s 8ms/step - loss: 24.8457
Epoch 80/170
11/11 [==============================] - 0s 8ms/step - loss: 26.0244
Epoch 81/170
11/11 [==============================] - 0s 8ms/step - loss: 23.1917
Epoch 82/170
11/11 [==============================] - 0s 9ms/step - loss: 21.1351
Epoch 83/170
11/11 [==============================] - 0s 8ms/step - loss: 20.4750
Epoch 84/170
11/11 [==============================] - 0s 8ms/step - loss: 20.2469
Epoch 85/170
11/11 [==============================] - 0s 8ms/step - loss: 20.0673
Epoch 86/170
11/11 [==============================] - 0s 9ms/step - loss: 19.3529
Epoch 87/170
11/11 [==============================] - 0s 8ms/step - loss: 19.3023
Epoch 88/170
11/11 [==============================] - 0s 8ms/step - loss: 17.9760
Epoch 89/170
11/11 [==============================] - 0s 8ms/step - loss: 18.3501
Epoch 90/170
11/11 [==============================] - 0s 8ms/step - loss: 19.1715
Epoch 91/170
11/11 [==============================] - 0s 8ms/step - loss: 16.9444
Epoch 92/170
11/11 [==============================] - 0s 9ms/step - loss: 17.3037
Epoch 93/170
11/11 [==============================] - 0s 8ms/step - loss: 16.9330
Epoch 94/170
11/11 [==============================] - 0s 8ms/step - loss: 15.7510
Epoch 95/170
11/11 [==============================] - 0s 8ms/step - loss: 16.5921
Epoch 96/170
```

```
11/11 [==============================] - 0s 8ms/step - loss: 16.4179
Epoch 97/170
11/11 [==============================] - 0s 8ms/step - loss: 16.1156
Epoch 98/170
11/11 [==============================] - 0s 8ms/step - loss: 15.8124
Epoch 99/170
11/11 [==============================] - 0s 8ms/step - loss: 14.7867
Epoch 100/170
11/11 [==============================] - 0s 8ms/step - loss: 15.3349
Epoch 101/170
11/11 [==============================] - 0s 8ms/step - loss: 14.2619
Epoch 102/170
11/11 [==============================] - 0s 9ms/step - loss: 14.4157
Epoch 103/170
11/11 [==============================] - 0s 8ms/step - loss: 14.1577
Epoch 104/170
11/11 [==============================] - 0s 9ms/step - loss: 14.1226
Epoch 105/170
11/11 [==============================] - 0s 9ms/step - loss: 12.9111
Epoch 106/170
11/11 [==============================] - 0s 8ms/step - loss: 12.7082
Epoch 107/170
11/11 [==============================] - 0s 8ms/step - loss: 13.0407
Epoch 108/170
11/11 [==============================] - 0s 9ms/step - loss: 12.7096
Epoch 109/170
11/11 [==============================] - 0s 8ms/step - loss: 13.3329
Epoch 110/170
11/11 [==============================] - 0s 8ms/step - loss: 12.1966
Epoch 111/170
11/11 [==============================] - 0s 9ms/step - loss: 12.3503
Epoch 112/170
11/11 [==============================] - 0s 8ms/step - loss: 12.6674
Epoch 113/170
11/11 [==============================] - 0s 9ms/step - loss: 12.7974
Epoch 114/170
11/11 [==============================] - 0s 8ms/step - loss: 12.8959
Epoch 115/170
11/11 [==============================] - 0s 9ms/step - loss: 13.1054
Epoch 116/170
11/11 [==============================] - 0s 8ms/step - loss: 12.9869
Epoch 117/170
11/11 [==============================] - 0s 9ms/step - loss: 11.4656
Epoch 118/170
11/11 [==============================] - 0s 10ms/step - loss: 10.6961
Epoch 119/170
11/11 [==============================] - 0s 9ms/step - loss: 12.3129
Epoch 120/170
11/11 [==============================] - 0s 9ms/step - loss: 13.2228
Epoch 121/170
11/11 [==============================] - 0s 9ms/step - loss: 12.2366
Epoch 122/170
11/11 [==============================] - 0s 10ms/step - loss: 11.1654
Epoch 123/170
11/11 [==============================] - 0s 8ms/step - loss: 10.9362
Epoch 124/170
11/11 [==============================] - 0s 9ms/step - loss: 10.4089
Epoch 125/170
11/11 [==============================] - 0s 8ms/step - loss: 10.8151
Epoch 126/170
11/11 [==============================] - 0s 8ms/step - loss: 10.2027
```

```
Epoch 127/170
11/11 [==============================] - 0s 9ms/step - loss: 9.6617
Epoch 128/170
11/11 [==============================] - 0s 8ms/step - loss: 8.5744
Epoch 129/170
11/11 [==============================] - 0s 9ms/step - loss: 8.8418
Epoch 130/170
11/11 [==============================] - 0s 8ms/step - loss: 9.1388
Epoch 131/170
11/11 [==============================] - 0s 8ms/step - loss: 8.8782
Epoch 132/170
11/11 [==============================] - 0s 9ms/step - loss: 9.2161
Epoch 133/170
11/11 [==============================] - 0s 8ms/step - loss: 8.6523
Epoch 134/170
11/11 [==============================] - 0s 8ms/step - loss: 8.2781
Epoch 135/170
11/11 [==============================] - 0s 9ms/step - loss: 8.0233
Epoch 136/170
11/11 [==============================] - 0s 8ms/step - loss: 7.5848
Epoch 137/170
11/11 [==============================] - 0s 8ms/step - loss: 7.1745
Epoch 138/170
11/11 [==============================] - 0s 8ms/step - loss: 7.3615
Epoch 139/170
11/11 [==============================] - 0s 8ms/step - loss: 7.3792
Epoch 140/170
11/11 [==============================] - 0s 9ms/step - loss: 7.7936
Epoch 141/170
11/11 [==============================] - 0s 8ms/step - loss: 7.1288
Epoch 142/170
11/11 [==============================] - 0s 10ms/step - loss: 8.7184
Epoch 143/170
11/11 [==============================] - 0s 8ms/step - loss: 7.8995
Epoch 144/170
11/11 [==============================] - 0s 8ms/step - loss: 7.9072
Epoch 145/170
11/11 [==============================] - 0s 9ms/step - loss: 7.9531
Epoch 146/170
11/11 [==============================] - 0s 9ms/step - loss: 7.5837
Epoch 147/170
11/11 [==============================] - 0s 8ms/step - loss: 7.0242
Epoch 148/170
11/11 [==============================] - 0s 9ms/step - loss: 6.6705
Epoch 149/170
11/11 [==============================] - 0s 9ms/step - loss: 6.1336
Epoch 150/170
11/11 [==============================] - 0s 8ms/step - loss: 6.0049
Epoch 151/170
11/11 [==============================] - 0s 8ms/step - loss: 6.1417
Epoch 152/170
11/11 [==============================] - 0s 9ms/step - loss: 5.9634
Epoch 153/170
11/11 [==============================] - 0s 8ms/step - loss: 5.4537
Epoch 154/170
11/11 [==============================] - 0s 8ms/step - loss: 5.7396
Epoch 155/170
11/11 [==============================] - 0s 8ms/step - loss: 6.6102
Epoch 156/170
11/11 [==============================] - 0s 8ms/step - loss: 6.3518
Epoch 157/170
```

```
11/11 [==============================] - 0s 8ms/step - loss: 5.7514
Epoch 158/170
11/11 [==============================] - 0s 8ms/step - loss: 5.9378
Epoch 159/170
11/11 [==============================] - 0s 8ms/step - loss: 6.7639
Epoch 160/170
11/11 [==============================] - 0s 9ms/step - loss: 6.1243
Epoch 161/170
11/11 [==============================] - 0s 8ms/step - loss: 5.9421
Epoch 162/170
11/11 [==============================] - 0s 9ms/step - loss: 4.8840
Epoch 163/170
11/11 [==============================] - 0s 8ms/step - loss: 4.4783
Epoch 164/170
11/11 [==============================] - 0s 8ms/step - loss: 4.2795
Epoch 165/170
11/11 [==============================] - 0s 8ms/step - loss: 4.1152
Epoch 166/170
11/11 [==============================] - 0s 8ms/step - loss: 3.5553
Epoch 167/170
11/11 [==============================] - 0s 8ms/step - loss: 3.6826
Epoch 168/170
11/11 [==============================] - 0s 8ms/step - loss: 3.5094
Epoch 169/170
11/11 [==============================] - 0s 9ms/step - loss: 3.3521
Epoch 170/170
11/11 [==============================] - 0s 8ms/step - loss: 3.3314
>expected=3.0, predicted=10.8
Epoch 1/170
11/11 [==============================] - 3s 9ms/step - loss: 137.0322
Epoch 2/170
11/11 [==============================] - 0s 8ms/step - loss: 136.5268
Epoch 3/170
11/11 [==============================] - 0s 8ms/step - loss: 135.8970
Epoch 4/170
11/11 [==============================] - 0s 9ms/step - loss: 134.3502
Epoch 5/170
11/11 [==============================] - 0s 8ms/step - loss: 129.2968
Epoch 6/170
11/11 [==============================] - 0s 9ms/step - loss: 115.8155
Epoch 7/170
11/11 [==============================] - 0s 8ms/step - loss: 101.3307
Epoch 8/170
11/11 [==============================] - 0s 8ms/step - loss: 93.7957
Epoch 9/170
11/11 [==============================] - 0s 8ms/step - loss: 89.2279
Epoch 10/170
11/11 [==============================] - 0s 9ms/step - loss: 88.8331
Epoch 11/170
11/11 [==============================] - 0s 8ms/step - loss: 89.1741
Epoch 12/170
11/11 [==============================] - 0s 9ms/step - loss: 86.6750
Epoch 13/170
11/11 [==============================] - 0s 9ms/step - loss: 84.0676
Epoch 14/170
11/11 [==============================] - 0s 9ms/step - loss: 87.4163
Epoch 15/170
11/11 [==============================] - 0s 9ms/step - loss: 85.9627
Epoch 16/170
11/11 [==============================] - 0s 9ms/step - loss: 84.0499
Epoch 17/170
```

```
11/11 [==============================] - 0s 9ms/step - loss: 81.7401
Epoch 18/170
11/11 [==============================] - 0s 9ms/step - loss: 82.5270
Epoch 19/170
11/11 [==============================] - 0s 8ms/step - loss: 86.6849
Epoch 20/170
11/11 [==============================] - 0s 8ms/step - loss: 81.4320
Epoch 21/170
11/11 [==============================] - 0s 9ms/step - loss: 79.8404
Epoch 22/170
11/11 [==============================] - 0s 8ms/step - loss: 79.4519
Epoch 23/170
11/11 [==============================] - 0s 8ms/step - loss: 79.1219
Epoch 24/170
11/11 [==============================] - 0s 8ms/step - loss: 78.7736
Epoch 25/170
11/11 [==============================] - 0s 8ms/step - loss: 78.6853
Epoch 26/170
11/11 [==============================] - 0s 9ms/step - loss: 77.0670
Epoch 27/170
11/11 [==============================] - 0s 8ms/step - loss: 76.3327
Epoch 28/170
11/11 [==============================] - 0s 22ms/step - loss: 75.8650
Epoch 29/170
11/11 [==============================] - 0s 28ms/step - loss: 75.7961
Epoch 30/170
11/11 [==============================] - 0s 22ms/step - loss: 73.6463
Epoch 31/170
11/11 [==============================] - 0s 22ms/step - loss: 71.6285
Epoch 32/170
11/11 [==============================] - 0s 18ms/step - loss: 71.8212
Epoch 33/170
11/11 [==============================] - 0s 17ms/step - loss: 70.5839
Epoch 34/170
11/11 [==============================] - 0s 9ms/step - loss: 71.4713
Epoch 35/170
11/11 [==============================] - 0s 8ms/step - loss: 71.3037
Epoch 36/170
11/11 [==============================] - 0s 9ms/step - loss: 69.0890
Epoch 37/170
11/11 [==============================] - 0s 9ms/step - loss: 67.4491
Epoch 38/170
11/11 [==============================] - 0s 8ms/step - loss: 66.4613
Epoch 39/170
11/11 [==============================] - 0s 9ms/step - loss: 69.1536
Epoch 40/170
11/11 [==============================] - 0s 9ms/step - loss: 66.4045
Epoch 41/170
11/11 [==============================] - 0s 8ms/step - loss: 65.1327
Epoch 42/170
11/11 [==============================] - 0s 9ms/step - loss: 63.6893
Epoch 43/170
11/11 [==============================] - 0s 10ms/step - loss: 62.0016
Epoch 44/170
11/11 [==============================] - 0s 9ms/step - loss: 61.0644
Epoch 45/170
11/11 [==============================] - 0s 9ms/step - loss: 59.7963
Epoch 46/170
11/11 [==============================] - 0s 9ms/step - loss: 58.0531
Epoch 47/170
11/11 [==============================] - 0s 9ms/step - loss: 58.4830
```

```
Epoch 48/170
11/11 [==============================] - 0s 9ms/step - loss: 58.5895
Epoch 49/170
11/11 [==============================] - 0s 8ms/step - loss: 57.3328
Epoch 50/170
11/11 [==============================] - 0s 8ms/step - loss: 57.6049
Epoch 51/170
11/11 [==============================] - 0s 9ms/step - loss: 57.1211
Epoch 52/170
11/11 [==============================] - 0s 10ms/step - loss: 55.9811
Epoch 53/170
11/11 [==============================] - 0s 9ms/step - loss: 57.8609
Epoch 54/170
11/11 [==============================] - 0s 9ms/step - loss: 53.0422
Epoch 55/170
11/11 [==============================] - 0s 8ms/step - loss: 50.3541
Epoch 56/170
11/11 [==============================] - 0s 9ms/step - loss: 51.0248
Epoch 57/170
11/11 [==============================] - 0s 9ms/step - loss: 48.4482
Epoch 58/170
11/11 [==============================] - 0s 8ms/step - loss: 47.1356
Epoch 59/170
11/11 [==============================] - 0s 9ms/step - loss: 45.2734
Epoch 60/170
11/11 [==============================] - 0s 8ms/step - loss: 46.7866
Epoch 61/170
11/11 [==============================] - 0s 9ms/step - loss: 45.4405
Epoch 62/170
11/11 [==============================] - 0s 10ms/step - loss: 44.4435
Epoch 63/170
11/11 [==============================] - 0s 8ms/step - loss: 44.1552
Epoch 64/170
11/11 [==============================] - 0s 9ms/step - loss: 50.8095
Epoch 65/170
11/11 [==============================] - 0s 9ms/step - loss: 47.2070
Epoch 66/170
11/11 [==============================] - 0s 9ms/step - loss: 45.0522
Epoch 67/170
11/11 [==============================] - 0s 9ms/step - loss: 43.3680
Epoch 68/170
11/11 [==============================] - 0s 9ms/step - loss: 41.7265
Epoch 69/170
11/11 [==============================] - 0s 9ms/step - loss: 40.0364
Epoch 70/170
11/11 [==============================] - 0s 8ms/step - loss: 37.5118
Epoch 71/170
11/11 [==============================] - 0s 10ms/step - loss: 36.9439
Epoch 72/170
11/11 [==============================] - 0s 10ms/step - loss: 36.7783
Epoch 73/170
11/11 [==============================] - 0s 9ms/step - loss: 36.1337
Epoch 74/170
11/11 [==============================] - 0s 9ms/step - loss: 35.3801
Epoch 75/170
11/11 [==============================] - 0s 9ms/step - loss: 33.8367
Epoch 76/170
11/11 [==============================] - 0s 9ms/step - loss: 32.1999
Epoch 77/170
11/11 [==============================] - 0s 10ms/step - loss: 31.7433
Epoch 78/170
```

```
11/11 [==============================] - 0s 8ms/step - loss: 31.6324
Epoch 79/170
11/11 [==============================] - 0s 8ms/step - loss: 36.3794
Epoch 80/170
11/11 [==============================] - 0s 9ms/step - loss: 49.6766
Epoch 81/170
11/11 [==============================] - 0s 9ms/step - loss: 43.8543
Epoch 82/170
11/11 [==============================] - 0s 9ms/step - loss: 37.4069
Epoch 83/170
11/11 [==============================] - 0s 8ms/step - loss: 33.9135
Epoch 84/170
11/11 [==============================] - 0s 8ms/step - loss: 33.4693
Epoch 85/170
11/11 [==============================] - 0s 8ms/step - loss: 31.2986
Epoch 86/170
11/11 [==============================] - 0s 8ms/step - loss: 29.4022
Epoch 87/170
11/11 [==============================] - 0s 9ms/step - loss: 27.7433
Epoch 88/170
11/11 [==============================] - 0s 9ms/step - loss: 27.8355
Epoch 89/170
11/11 [==============================] - 0s 9ms/step - loss: 28.5314
Epoch 90/170
11/11 [==============================] - 0s 9ms/step - loss: 27.0267
Epoch 91/170
11/11 [==============================] - 0s 10ms/step - loss: 25.4692
Epoch 92/170
11/11 [==============================] - 0s 9ms/step - loss: 24.1938
Epoch 93/170
11/11 [==============================] - 0s 9ms/step - loss: 23.6760
Epoch 94/170
11/11 [==============================] - 0s 9ms/step - loss: 25.6833
Epoch 95/170
11/11 [==============================] - 0s 9ms/step - loss: 27.0559
Epoch 96/170
11/11 [==============================] - 0s 9ms/step - loss: 25.1558
Epoch 97/170
11/11 [==============================] - 0s 8ms/step - loss: 25.3884
Epoch 98/170
11/11 [==============================] - 0s 9ms/step - loss: 23.6338
Epoch 99/170
11/11 [==============================] - 0s 9ms/step - loss: 22.2077
Epoch 100/170
11/11 [==============================] - 0s 9ms/step - loss: 20.0316
Epoch 101/170
11/11 [==============================] - 0s 9ms/step - loss: 19.0960
Epoch 102/170
11/11 [==============================] - 0s 8ms/step - loss: 18.8323
Epoch 103/170
11/11 [==============================] - 0s 8ms/step - loss: 18.9114
Epoch 104/170
11/11 [==============================] - 0s 8ms/step - loss: 19.3249
Epoch 105/170
11/11 [==============================] - 0s 10ms/step - loss: 18.7907
Epoch 106/170
11/11 [==============================] - 0s 8ms/step - loss: 17.9530
Epoch 107/170
11/11 [==============================] - 0s 9ms/step - loss: 16.6455
Epoch 108/170
11/11 [==============================] - 0s 9ms/step - loss: 16.2684
```

```
Epoch 109/170
11/11 [==============================] - 0s 9ms/step - loss: 15.6418
Epoch 110/170
11/11 [==============================] - 0s 9ms/step - loss: 16.6311
Epoch 111/170
11/11 [==============================] - 0s 9ms/step - loss: 16.3374
Epoch 112/170
11/11 [==============================] - 0s 9ms/step - loss: 15.8630
Epoch 113/170
11/11 [==============================] - 0s 8ms/step - loss: 18.0151
Epoch 114/170
11/11 [==============================] - 0s 9ms/step - loss: 17.8169
Epoch 115/170
11/11 [==============================] - 0s 9ms/step - loss: 16.2113
Epoch 116/170
11/11 [==============================] - 0s 10ms/step - loss: 13.9945
Epoch 117/170
11/11 [==============================] - 0s 9ms/step - loss: 13.5641
Epoch 118/170
11/11 [==============================] - 0s 9ms/step - loss: 13.4745
Epoch 119/170
11/11 [==============================] - 0s 9ms/step - loss: 13.5745
Epoch 120/170
11/11 [==============================] - 0s 9ms/step - loss: 12.0626
Epoch 121/170
11/11 [==============================] - 0s 10ms/step - loss: 12.4631
Epoch 122/170
11/11 [==============================] - 0s 9ms/step - loss: 12.6479
Epoch 123/170
11/11 [==============================] - 0s 8ms/step - loss: 13.1632
Epoch 124/170
11/11 [==============================] - 0s 9ms/step - loss: 12.5227
Epoch 125/170
11/11 [==============================] - 0s 9ms/step - loss: 12.1399
Epoch 126/170
11/11 [==============================] - 0s 9ms/step - loss: 12.1998
Epoch 127/170
11/11 [==============================] - 0s 12ms/step - loss: 12.9464
Epoch 128/170
11/11 [==============================] - 0s 24ms/step - loss: 12.4910
Epoch 129/170
11/11 [==============================] - 0s 23ms/step - loss: 12.0914
Epoch 130/170
11/11 [==============================] - 0s 20ms/step - loss: 12.6571
Epoch 131/170
11/11 [==============================] - 0s 23ms/step - loss: 11.7671
Epoch 132/170
11/11 [==============================] - 0s 22ms/step - loss: 10.6196
Epoch 133/170
11/11 [==============================] - 0s 21ms/step - loss: 11.1828
Epoch 134/170
11/11 [==============================] - 0s 21ms/step - loss: 11.8030
Epoch 135/170
11/11 [==============================] - 0s 13ms/step - loss: 11.6851
Epoch 136/170
11/11 [==============================] - 0s 10ms/step - loss: 10.4650
Epoch 137/170
11/11 [==============================] - 0s 9ms/step - loss: 10.1864
Epoch 138/170
11/11 [==============================] - 0s 8ms/step - loss: 10.1971
Epoch 139/170
```

```
11/11 [==============================] - 0s 10ms/step - loss: 10.2562
Epoch 140/170
11/11 [==============================] - 0s 9ms/step - loss: 9.4766
Epoch 141/170
11/11 [==============================] - 0s 8ms/step - loss: 9.4639
Epoch 142/170
11/11 [==============================] - 0s 9ms/step - loss: 9.0796
Epoch 143/170
11/11 [==============================] - 0s 8ms/step - loss: 9.3741
Epoch 144/170
11/11 [==============================] - 0s 8ms/step - loss: 9.3031
Epoch 145/170
11/11 [==============================] - 0s 9ms/step - loss: 7.6630
Epoch 146/170
11/11 [==============================] - 0s 9ms/step - loss: 7.3648
Epoch 147/170
11/11 [==============================] - 0s 9ms/step - loss: 9.2046
Epoch 148/170
11/11 [==============================] - 0s 9ms/step - loss: 8.9365
Epoch 149/170
11/11 [==============================] - 0s 10ms/step - loss: 8.0007
Epoch 150/170
11/11 [==============================] - 0s 9ms/step - loss: 8.2774
Epoch 151/170
11/11 [==============================] - 0s 9ms/step - loss: 8.8945
Epoch 152/170
11/11 [==============================] - 0s 8ms/step - loss: 7.8985
Epoch 153/170
11/11 [==============================] - 0s 8ms/step - loss: 7.4502
Epoch 154/170
11/11 [==============================] - 0s 9ms/step - loss: 7.4441
Epoch 155/170
11/11 [==============================] - 0s 9ms/step - loss: 7.1543
Epoch 156/170
11/11 [==============================] - 0s 9ms/step - loss: 6.7888
Epoch 157/170
11/11 [==============================] - 0s 8ms/step - loss: 6.5663
Epoch 158/170
11/11 [==============================] - 0s 8ms/step - loss: 6.2547
Epoch 159/170
11/11 [==============================] - 0s 9ms/step - loss: 6.4053
Epoch 160/170
11/11 [==============================] - 0s 8ms/step - loss: 6.0455
Epoch 161/170
11/11 [==============================] - 0s 9ms/step - loss: 5.7704
Epoch 162/170
11/11 [==============================] - 0s 8ms/step - loss: 6.3419
Epoch 163/170
11/11 [==============================] - 0s 9ms/step - loss: 6.3474
Epoch 164/170
11/11 [==============================] - 0s 9ms/step - loss: 5.9936
Epoch 165/170
11/11 [==============================] - 0s 8ms/step - loss: 5.9581
Epoch 166/170
11/11 [==============================] - 0s 8ms/step - loss: 5.5473
Epoch 167/170
11/11 [==============================] - 0s 9ms/step - loss: 5.5295
Epoch 168/170
11/11 [==============================] - 0s 9ms/step - loss: 5.8638
Epoch 169/170
11/11 [==============================] - 0s 10ms/step - loss: 5.6706
```

```
Epoch 170/170
11/11 [==============================] - 0s 9ms/step - loss: 5.8423
>expected=-4.0, predicted=2.4
Epoch 1/170
11/11 [==============================] - 2s 8ms/step - loss: 136.9441
Epoch 2/170
11/11 [==============================] - 0s 10ms/step - loss: 135.5840
Epoch 3/170
11/11 [==============================] - 0s 9ms/step - loss: 133.3729
Epoch 4/170
11/11 [==============================] - 0s 9ms/step - loss: 127.1608
Epoch 5/170
11/11 [==============================] - 0s 8ms/step - loss: 109.3459
Epoch 6/170
11/11 [==============================] - 0s 8ms/step - loss: 105.9851
Epoch 7/170
11/11 [==============================] - 0s 8ms/step - loss: 96.5123
Epoch 8/170
11/11 [==============================] - 0s 9ms/step - loss: 89.7349
Epoch 9/170
11/11 [==============================] - 0s 9ms/step - loss: 89.1100
Epoch 10/170
11/11 [==============================] - 0s 9ms/step - loss: 87.5722
Epoch 11/170
11/11 [==============================] - 0s 8ms/step - loss: 89.2014
Epoch 12/170
11/11 [==============================] - 0s 10ms/step - loss: 85.5001
Epoch 13/170
11/11 [==============================] - 0s 11ms/step - loss: 85.1188
Epoch 14/170
11/11 [==============================] - 0s 9ms/step - loss: 83.3910
Epoch 15/170
11/11 [==============================] - 0s 9ms/step - loss: 83.5152
Epoch 16/170
11/11 [==============================] - 0s 9ms/step - loss: 81.5830
Epoch 17/170
11/11 [==============================] - 0s 9ms/step - loss: 80.6042
Epoch 18/170
11/11 [==============================] - 0s 8ms/step - loss: 79.8718
Epoch 19/170
11/11 [==============================] - 0s 9ms/step - loss: 78.9035
Epoch 20/170
11/11 [==============================] - 0s 9ms/step - loss: 77.2481
Epoch 21/170
11/11 [==============================] - 0s 11ms/step - loss: 79.9347
Epoch 22/170
11/11 [==============================] - 0s 9ms/step - loss: 78.4743
Epoch 23/170
11/11 [==============================] - 0s 9ms/step - loss: 75.2424
Epoch 24/170
11/11 [==============================] - 0s 9ms/step - loss: 72.8206
Epoch 25/170
11/11 [==============================] - 0s 9ms/step - loss: 72.1949
Epoch 26/170
11/11 [==============================] - 0s 8ms/step - loss: 74.9012
Epoch 27/170
11/11 [==============================] - 0s 8ms/step - loss: 72.9584
Epoch 28/170
11/11 [==============================] - 0s 8ms/step - loss: 71.3999
Epoch 29/170
11/11 [==============================] - 0s 8ms/step - loss: 68.4491
```

```
Epoch 30/170
11/11 [==============================] - 0s 9ms/step - loss: 67.6122
Epoch 31/170
11/11 [==============================] - 0s 9ms/step - loss: 65.7211
Epoch 32/170
11/11 [==============================] - 0s 9ms/step - loss: 66.7500
Epoch 33/170
11/11 [==============================] - 0s 9ms/step - loss: 67.2041
Epoch 34/170
11/11 [==============================] - 0s 8ms/step - loss: 63.5305
Epoch 35/170
11/11 [==============================] - 0s 9ms/step - loss: 63.4704
Epoch 36/170
11/11 [==============================] - 0s 9ms/step - loss: 61.4712
Epoch 37/170
11/11 [==============================] - 0s 8ms/step - loss: 61.4356
Epoch 38/170
11/11 [==============================] - 0s 8ms/step - loss: 66.0086
Epoch 39/170
11/11 [==============================] - 0s 9ms/step - loss: 65.9842
Epoch 40/170
11/11 [==============================] - 0s 9ms/step - loss: 59.3202
Epoch 41/170
11/11 [==============================] - 0s 9ms/step - loss: 58.5897
Epoch 42/170
11/11 [==============================] - 0s 9ms/step - loss: 59.4651
Epoch 43/170
11/11 [==============================] - 0s 8ms/step - loss: 55.8665
Epoch 44/170
11/11 [==============================] - 0s 9ms/step - loss: 53.9249
Epoch 45/170
11/11 [==============================] - 0s 9ms/step - loss: 53.0677
Epoch 46/170
11/11 [==============================] - 0s 8ms/step - loss: 52.8764
Epoch 47/170
11/11 [==============================] - 0s 8ms/step - loss: 50.9815
Epoch 48/170
11/11 [==============================] - 0s 8ms/step - loss: 49.9817
Epoch 49/170
11/11 [==============================] - 0s 8ms/step - loss: 47.6639
Epoch 50/170
11/11 [==============================] - 0s 9ms/step - loss: 47.0828
Epoch 51/170
11/11 [==============================] - 0s 8ms/step - loss: 47.5089
Epoch 52/170
11/11 [==============================] - 0s 8ms/step - loss: 46.6966
Epoch 53/170
11/11 [==============================] - 0s 9ms/step - loss: 43.3501
Epoch 54/170
11/11 [==============================] - 0s 9ms/step - loss: 44.5151
Epoch 55/170
11/11 [==============================] - 0s 9ms/step - loss: 42.8210
Epoch 56/170
11/11 [==============================] - 0s 9ms/step - loss: 44.5544
Epoch 57/170
11/11 [==============================] - 0s 9ms/step - loss: 39.8578
Epoch 58/170
11/11 [==============================] - 0s 9ms/step - loss: 38.9158
Epoch 59/170
11/11 [==============================] - 0s 9ms/step - loss: 37.3423
Epoch 60/170
```

```
11/11 [==============================] - 0s 10ms/step - loss: 38.0756
Epoch 61/170
11/11 [==============================] - 0s 9ms/step - loss: 37.2246
Epoch 62/170
11/11 [==============================] - 0s 8ms/step - loss: 34.3397
Epoch 63/170
11/11 [==============================] - 0s 8ms/step - loss: 35.9794
Epoch 64/170
11/11 [==============================] - 0s 8ms/step - loss: 35.7241
Epoch 65/170
11/11 [==============================] - 0s 9ms/step - loss: 36.5863
Epoch 66/170
11/11 [==============================] - 0s 8ms/step - loss: 32.0730
Epoch 67/170
11/11 [==============================] - 0s 8ms/step - loss: 31.9940
Epoch 68/170
11/11 [==============================] - 0s 8ms/step - loss: 32.2508
Epoch 69/170
11/11 [==============================] - 0s 9ms/step - loss: 30.5127
Epoch 70/170
11/11 [==============================] - 0s 9ms/step - loss: 29.0980
Epoch 71/170
11/11 [==============================] - 0s 8ms/step - loss: 30.7465
Epoch 72/170
11/11 [==============================] - 0s 10ms/step - loss: 30.5707
Epoch 73/170
11/11 [==============================] - 0s 9ms/step - loss: 29.7226
Epoch 74/170
11/11 [==============================] - 0s 8ms/step - loss: 28.0086
Epoch 75/170
11/11 [==============================] - 0s 8ms/step - loss: 28.4913
Epoch 76/170
11/11 [==============================] - 0s 8ms/step - loss: 27.3700
Epoch 77/170
11/11 [==============================] - 0s 9ms/step - loss: 25.3152
Epoch 78/170
11/11 [==============================] - 0s 9ms/step - loss: 25.2407
Epoch 79/170
11/11 [==============================] - 0s 9ms/step - loss: 27.1461
Epoch 80/170
11/11 [==============================] - 0s 9ms/step - loss: 24.6696
Epoch 81/170
11/11 [==============================] - 0s 8ms/step - loss: 23.5916
Epoch 82/170
11/11 [==============================] - 0s 8ms/step - loss: 26.6433
Epoch 83/170
11/11 [==============================] - 0s 8ms/step - loss: 23.9103
Epoch 84/170
11/11 [==============================] - 0s 9ms/step - loss: 22.6995
Epoch 85/170
11/11 [==============================] - 0s 9ms/step - loss: 20.8029
Epoch 86/170
11/11 [==============================] - 0s 8ms/step - loss: 19.7304
Epoch 87/170
11/11 [==============================] - 0s 9ms/step - loss: 22.0851
Epoch 88/170
11/11 [==============================] - 0s 9ms/step - loss: 19.9532
Epoch 89/170
11/11 [==============================] - 0s 9ms/step - loss: 18.7769
Epoch 90/170
11/11 [==============================] - 0s 9ms/step - loss: 18.6987
```

```
Epoch 91/170
11/11 [==============================] - 0s 8ms/step - loss: 17.1101
Epoch 92/170
11/11 [==============================] - 0s 9ms/step - loss: 16.6278
Epoch 93/170
11/11 [==============================] - 0s 9ms/step - loss: 16.4794
Epoch 94/170
11/11 [==============================] - 0s 9ms/step - loss: 16.1609
Epoch 95/170
11/11 [==============================] - 0s 9ms/step - loss: 17.0733
Epoch 96/170
11/11 [==============================] - 0s 9ms/step - loss: 14.9874
Epoch 97/170
11/11 [==============================] - 0s 9ms/step - loss: 14.9918
Epoch 98/170
11/11 [==============================] - 0s 9ms/step - loss: 14.4434
Epoch 99/170
11/11 [==============================] - 0s 9ms/step - loss: 14.4136
Epoch 100/170
11/11 [==============================] - 0s 8ms/step - loss: 12.7144
Epoch 101/170
11/11 [==============================] - 0s 10ms/step - loss: 13.3434
Epoch 102/170
11/11 [==============================] - 0s 9ms/step - loss: 13.1778
Epoch 103/170
11/11 [==============================] - 0s 9ms/step - loss: 12.5473
Epoch 104/170
11/11 [==============================] - 0s 9ms/step - loss: 12.6046
Epoch 105/170
11/11 [==============================] - 0s 10ms/step - loss: 12.7316
Epoch 106/170
11/11 [==============================] - 0s 10ms/step - loss: 13.0005
Epoch 107/170
11/11 [==============================] - 0s 9ms/step - loss: 12.7521
Epoch 108/170
11/11 [==============================] - 0s 11ms/step - loss: 15.8266
Epoch 109/170
11/11 [==============================] - 0s 9ms/step - loss: 15.8478
Epoch 110/170
11/11 [==============================] - 0s 9ms/step - loss: 14.0749
Epoch 111/170
11/11 [==============================] - 0s 9ms/step - loss: 13.7913
Epoch 112/170
11/11 [==============================] - 0s 9ms/step - loss: 12.8168
Epoch 113/170
11/11 [==============================] - 0s 9ms/step - loss: 11.7761
Epoch 114/170
11/11 [==============================] - 0s 9ms/step - loss: 10.6892
Epoch 115/170
11/11 [==============================] - 0s 9ms/step - loss: 10.6440
Epoch 116/170
11/11 [==============================] - 0s 9ms/step - loss: 9.4617
Epoch 117/170
11/11 [==============================] - 0s 9ms/step - loss: 9.1214
Epoch 118/170
11/11 [==============================] - 0s 10ms/step - loss: 8.2550
Epoch 119/170
11/11 [==============================] - 0s 9ms/step - loss: 8.5322
Epoch 120/170
11/11 [==============================] - 0s 8ms/step - loss: 8.1920
Epoch 121/170
```

```
11/11 [==============================] - 0s 9ms/step - loss: 7.8018
Epoch 122/170
11/11 [==============================] - 0s 9ms/step - loss: 8.0199
Epoch 123/170
11/11 [==============================] - 0s 8ms/step - loss: 7.2865
Epoch 124/170
11/11 [==============================] - 0s 8ms/step - loss: 7.1988
Epoch 125/170
11/11 [==============================] - 0s 9ms/step - loss: 7.3628
Epoch 126/170
11/11 [==============================] - 0s 9ms/step - loss: 6.6067
Epoch 127/170
11/11 [==============================] - 0s 10ms/step - loss: 6.2996
Epoch 128/170
11/11 [==============================] - 0s 9ms/step - loss: 6.6845
Epoch 129/170
11/11 [==============================] - 0s 9ms/step - loss: 6.9240
Epoch 130/170
11/11 [==============================] - 0s 9ms/step - loss: 6.6303
Epoch 131/170
11/11 [==============================] - 0s 9ms/step - loss: 6.6258
Epoch 132/170
11/11 [==============================] - 0s 9ms/step - loss: 6.6257
Epoch 133/170
11/11 [==============================] - 0s 9ms/step - loss: 5.8867
Epoch 134/170
11/11 [==============================] - 0s 9ms/step - loss: 6.7495
Epoch 135/170
11/11 [==============================] - 0s 8ms/step - loss: 7.8822
Epoch 136/170
11/11 [==============================] - 0s 10ms/step - loss: 6.8612
Epoch 137/170
11/11 [==============================] - 0s 10ms/step - loss: 6.0613
Epoch 138/170
11/11 [==============================] - 0s 9ms/step - loss: 6.3420
Epoch 139/170
11/11 [==============================] - 0s 9ms/step - loss: 7.5066
Epoch 140/170
11/11 [==============================] - 0s 9ms/step - loss: 6.5722
Epoch 141/170
11/11 [==============================] - 0s 9ms/step - loss: 5.9070
Epoch 142/170
11/11 [==============================] - 0s 9ms/step - loss: 5.6493
Epoch 143/170
11/11 [==============================] - 0s 8ms/step - loss: 4.5484
Epoch 144/170
11/11 [==============================] - 0s 8ms/step - loss: 4.3363
Epoch 145/170
11/11 [==============================] - 0s 9ms/step - loss: 4.2514
Epoch 146/170
11/11 [==============================] - 0s 9ms/step - loss: 4.5001
Epoch 147/170
11/11 [==============================] - 0s 9ms/step - loss: 4.0618
Epoch 148/170
11/11 [==============================] - 0s 9ms/step - loss: 4.9715
Epoch 149/170
11/11 [==============================] - 0s 9ms/step - loss: 5.1976
Epoch 150/170
11/11 [==============================] - 0s 10ms/step - loss: 5.3494
Epoch 151/170
11/11 [==============================] - 0s 9ms/step - loss: 5.1543
```

```
Epoch 152/170
11/11 [==============================] - 0s 8ms/step - loss: 5.4613
Epoch 153/170
11/11 [==============================] - 0s 9ms/step - loss: 5.2776
Epoch 154/170
11/11 [==============================] - 0s 9ms/step - loss: 5.3682
Epoch 155/170
11/11 [==============================] - 0s 8ms/step - loss: 4.5503
Epoch 156/170
11/11 [==============================] - 0s 9ms/step - loss: 4.2902
Epoch 157/170
11/11 [==============================] - 0s 10ms/step - loss: 3.8525
Epoch 158/170
11/11 [==============================] - 0s 9ms/step - loss: 3.1580
Epoch 159/170
11/11 [==============================] - 0s 9ms/step - loss: 3.1483
Epoch 160/170
11/11 [==============================] - 0s 8ms/step - loss: 3.0773
Epoch 161/170
11/11 [==============================] - 0s 10ms/step - loss: 3.2530
Epoch 162/170
11/11 [==============================] - 0s 9ms/step - loss: 3.4153
Epoch 163/170
11/11 [==============================] - 0s 9ms/step - loss: 3.8112
Epoch 164/170
11/11 [==============================] - 0s 8ms/step - loss: 3.4815
Epoch 165/170
11/11 [==============================] - 0s 9ms/step - loss: 3.2495
Epoch 166/170
11/11 [==============================] - 0s 9ms/step - loss: 2.8123
Epoch 167/170
11/11 [==============================] - 0s 9ms/step - loss: 2.9502
Epoch 168/170
11/11 [==============================] - 0s 9ms/step - loss: 3.1615
Epoch 169/170
11/11 [==============================] - 0s 9ms/step - loss: 4.1982
Epoch 170/170
11/11 [==============================] - 0s 9ms/step - loss: 3.6564
>expected=-1.0, predicted=11.7
Epoch 1/170
11/11 [==============================] - 2s 9ms/step - loss: 136.8255
Epoch 2/170
11/11 [==============================] - 0s 8ms/step - loss: 135.8551
Epoch 3/170
11/11 [==============================] - 0s 9ms/step - loss: 134.1516
Epoch 4/170
11/11 [==============================] - 0s 8ms/step - loss: 125.5711
Epoch 5/170
11/11 [==============================] - 0s 8ms/step - loss: 104.0372
Epoch 6/170
11/11 [==============================] - 0s 10ms/step - loss: 101.3148
Epoch 7/170
11/11 [==============================] - 0s 9ms/step - loss: 93.7174
Epoch 8/170
11/11 [==============================] - 0s 9ms/step - loss: 87.2622
Epoch 9/170
11/11 [==============================] - 0s 10ms/step - loss: 85.5527
Epoch 10/170
11/11 [==============================] - 0s 9ms/step - loss: 87.2772
Epoch 11/170
11/11 [==============================] - 0s 9ms/step - loss: 82.7443
```

```
Epoch 12/170
11/11 [==============================] - 0s 9ms/step - loss: 79.4163
Epoch 13/170
11/11 [==============================] - 0s 9ms/step - loss: 80.1583
Epoch 14/170
11/11 [==============================] - 0s 9ms/step - loss: 78.4918
Epoch 15/170
11/11 [==============================] - 0s 9ms/step - loss: 78.2853
Epoch 16/170
11/11 [==============================] - 0s 9ms/step - loss: 74.9126
Epoch 17/170
11/11 [==============================] - 0s 9ms/step - loss: 77.0913
Epoch 18/170
11/11 [==============================] - 0s 9ms/step - loss: 73.1734
Epoch 19/170
11/11 [==============================] - 0s 9ms/step - loss: 71.6462
Epoch 20/170
11/11 [==============================] - 0s 10ms/step - loss: 70.1795
Epoch 21/170
11/11 [==============================] - 0s 9ms/step - loss: 70.7429
Epoch 22/170
11/11 [==============================] - 0s 9ms/step - loss: 67.8168
Epoch 23/170
11/11 [==============================] - 0s 8ms/step - loss: 65.6053
Epoch 24/170
11/11 [==============================] - 0s 9ms/step - loss: 64.3813
Epoch 25/170
11/11 [==============================] - 0s 9ms/step - loss: 65.1045
Epoch 26/170
11/11 [==============================] - 0s 9ms/step - loss: 61.9194
Epoch 27/170
11/11 [==============================] - 0s 9ms/step - loss: 61.4151
Epoch 28/170
11/11 [==============================] - 0s 9ms/step - loss: 61.1330
Epoch 29/170
11/11 [==============================] - 0s 9ms/step - loss: 60.0415
Epoch 30/170
11/11 [==============================] - 0s 9ms/step - loss: 60.6533
Epoch 31/170
11/11 [==============================] - 0s 9ms/step - loss: 56.2296
Epoch 32/170
11/11 [==============================] - 0s 9ms/step - loss: 56.3462
Epoch 33/170
11/11 [==============================] - 0s 9ms/step - loss: 56.0790
Epoch 34/170
11/11 [==============================] - 0s 9ms/step - loss: 54.4311
Epoch 35/170
11/11 [==============================] - 0s 9ms/step - loss: 52.5087
Epoch 36/170
11/11 [==============================] - 0s 9ms/step - loss: 53.6813
Epoch 37/170
11/11 [==============================] - 0s 9ms/step - loss: 54.2477
Epoch 38/170
11/11 [==============================] - 0s 10ms/step - loss: 48.7737
Epoch 39/170
11/11 [==============================] - 0s 9ms/step - loss: 49.6127
Epoch 40/170
11/11 [==============================] - 0s 9ms/step - loss: 51.9941
Epoch 41/170
11/11 [==============================] - 0s 9ms/step - loss: 50.9619
Epoch 42/170
```

```
11/11 [==============================] - 0s 8ms/step - loss: 46.8195
Epoch 43/170
11/11 [==============================] - 0s 10ms/step - loss: 47.0459
Epoch 44/170
11/11 [==============================] - 0s 9ms/step - loss: 47.9241
Epoch 45/170
11/11 [==============================] - 0s 9ms/step - loss: 45.6059
Epoch 46/170
11/11 [==============================] - 0s 9ms/step - loss: 42.9467
Epoch 47/170
11/11 [==============================] - 0s 11ms/step - loss: 43.8740
Epoch 48/170
11/11 [==============================] - 0s 10ms/step - loss: 39.8418
Epoch 49/170
11/11 [==============================] - 0s 8ms/step - loss: 39.4509
Epoch 50/170
11/11 [==============================] - 0s 9ms/step - loss: 36.5000
Epoch 51/170
11/11 [==============================] - 0s 8ms/step - loss: 36.1485
Epoch 52/170
11/11 [==============================] - 0s 9ms/step - loss: 34.4593
Epoch 53/170
11/11 [==============================] - 0s 9ms/step - loss: 33.7295
Epoch 54/170
11/11 [==============================] - 0s 9ms/step - loss: 31.9742
Epoch 55/170
11/11 [==============================] - 0s 9ms/step - loss: 32.6913
Epoch 56/170
11/11 [==============================] - 0s 9ms/step - loss: 31.4794
Epoch 57/170
11/11 [==============================] - 0s 10ms/step - loss: 34.5457
Epoch 58/170
11/11 [==============================] - 0s 9ms/step - loss: 29.2117
Epoch 59/170
11/11 [==============================] - 0s 9ms/step - loss: 28.8347
Epoch 60/170
11/11 [==============================] - 0s 9ms/step - loss: 27.4924
Epoch 61/170
11/11 [==============================] - 0s 9ms/step - loss: 26.6284
Epoch 62/170
11/11 [==============================] - 0s 9ms/step - loss: 24.4781
Epoch 63/170
11/11 [==============================] - 0s 8ms/step - loss: 23.7325
Epoch 64/170
11/11 [==============================] - 0s 9ms/step - loss: 23.9906
Epoch 65/170
11/11 [==============================] - 0s 9ms/step - loss: 24.1214
Epoch 66/170
11/11 [==============================] - 0s 10ms/step - loss: 23.2655
Epoch 67/170
11/11 [==============================] - 0s 9ms/step - loss: 24.3749
Epoch 68/170
11/11 [==============================] - 0s 9ms/step - loss: 23.6397
Epoch 69/170
11/11 [==============================] - 0s 9ms/step - loss: 24.0224
Epoch 70/170
11/11 [==============================] - 0s 9ms/step - loss: 24.1354
Epoch 71/170
11/11 [==============================] - 0s 9ms/step - loss: 22.7434
Epoch 72/170
11/11 [==============================] - 0s 9ms/step - loss: 23.6125
```

```
Epoch 73/170
11/11 [==============================] - 0s 9ms/step - loss: 23.8074
Epoch 74/170
11/11 [==============================] - 0s 9ms/step - loss: 22.8392
Epoch 75/170
11/11 [==============================] - 0s 10ms/step - loss: 19.3678
Epoch 76/170
11/11 [==============================] - 0s 9ms/step - loss: 19.1507
Epoch 77/170
11/11 [==============================] - 0s 9ms/step - loss: 17.9189
Epoch 78/170
11/11 [==============================] - 0s 9ms/step - loss: 17.0721
Epoch 79/170
11/11 [==============================] - 0s 9ms/step - loss: 17.6988
Epoch 80/170
11/11 [==============================] - 0s 9ms/step - loss: 16.2665
Epoch 81/170
11/11 [==============================] - 0s 9ms/step - loss: 16.1780
Epoch 82/170
11/11 [==============================] - 0s 9ms/step - loss: 15.1942
Epoch 83/170
11/11 [==============================] - 0s 8ms/step - loss: 14.9965
Epoch 84/170
11/11 [==============================] - 0s 8ms/step - loss: 15.5434
Epoch 85/170
11/11 [==============================] - 0s 9ms/step - loss: 14.2004
Epoch 86/170
11/11 [==============================] - 0s 9ms/step - loss: 14.5631
Epoch 87/170
11/11 [==============================] - 0s 9ms/step - loss: 14.4453
Epoch 88/170
11/11 [==============================] - 0s 9ms/step - loss: 16.3723
Epoch 89/170
11/11 [==============================] - 0s 9ms/step - loss: 17.1345
Epoch 90/170
11/11 [==============================] - 0s 9ms/step - loss: 18.1638
Epoch 91/170
11/11 [==============================] - 0s 9ms/step - loss: 16.6957
Epoch 92/170
11/11 [==============================] - 0s 9ms/step - loss: 15.7367
Epoch 93/170
11/11 [==============================] - 0s 9ms/step - loss: 13.8773
Epoch 94/170
11/11 [==============================] - 0s 9ms/step - loss: 13.0140
Epoch 95/170
11/11 [==============================] - 0s 11ms/step - loss: 12.4368
Epoch 96/170
11/11 [==============================] - 0s 10ms/step - loss: 11.5931
Epoch 97/170
11/11 [==============================] - 0s 9ms/step - loss: 10.8156
Epoch 98/170
11/11 [==============================] - 0s 9ms/step - loss: 11.4379
Epoch 99/170
11/11 [==============================] - 0s 9ms/step - loss: 12.2235
Epoch 100/170
11/11 [==============================] - 0s 9ms/step - loss: 11.0125
Epoch 101/170
11/11 [==============================] - 0s 9ms/step - loss: 11.4532
Epoch 102/170
11/11 [==============================] - 0s 9ms/step - loss: 11.5302
Epoch 103/170
```

```
11/11 [==============================] - 0s 9ms/step - loss: 11.5866
Epoch 104/170
11/11 [==============================] - 0s 12ms/step - loss: 10.3049
Epoch 105/170
11/11 [==============================] - 0s 9ms/step - loss: 9.8875
Epoch 106/170
11/11 [==============================] - 0s 10ms/step - loss: 9.7321
Epoch 107/170
11/11 [==============================] - 0s 9ms/step - loss: 8.8114
Epoch 108/170
11/11 [==============================] - 0s 9ms/step - loss: 8.4731
Epoch 109/170
11/11 [==============================] - 0s 10ms/step - loss: 9.1044
Epoch 110/170
11/11 [==============================] - 0s 9ms/step - loss: 9.6317
Epoch 111/170
11/11 [==============================] - 0s 9ms/step - loss: 11.0477
Epoch 112/170
11/11 [==============================] - 0s 10ms/step - loss: 11.9473
Epoch 113/170
11/11 [==============================] - 0s 10ms/step - loss: 9.8365
Epoch 114/170
11/11 [==============================] - 0s 9ms/step - loss: 9.3669
Epoch 115/170
11/11 [==============================] - 0s 10ms/step - loss: 7.8984
Epoch 116/170
11/11 [==============================] - 0s 9ms/step - loss: 8.1308
Epoch 117/170
11/11 [==============================] - 0s 8ms/step - loss: 7.8551
Epoch 118/170
11/11 [==============================] - 0s 9ms/step - loss: 8.5356
Epoch 119/170
11/11 [==============================] - 0s 9ms/step - loss: 7.7876
Epoch 120/170
11/11 [==============================] - 0s 9ms/step - loss: 8.4789
Epoch 121/170
11/11 [==============================] - 0s 9ms/step - loss: 7.3253
Epoch 122/170
11/11 [==============================] - 0s 9ms/step - loss: 7.9264
Epoch 123/170
11/11 [==============================] - 0s 9ms/step - loss: 7.2523
Epoch 124/170
11/11 [==============================] - 0s 9ms/step - loss: 6.1212
Epoch 125/170
11/11 [==============================] - 0s 9ms/step - loss: 6.2315
Epoch 126/170
11/11 [==============================] - 0s 9ms/step - loss: 5.6235
Epoch 127/170
11/11 [==============================] - 0s 9ms/step - loss: 5.3270
Epoch 128/170
11/11 [==============================] - 0s 9ms/step - loss: 5.1422
Epoch 129/170
11/11 [==============================] - 0s 9ms/step - loss: 4.9527
Epoch 130/170
11/11 [==============================] - 0s 9ms/step - loss: 5.0314
Epoch 131/170
11/11 [==============================] - 0s 9ms/step - loss: 4.6106
Epoch 132/170
11/11 [==============================] - 0s 10ms/step - loss: 4.4514
Epoch 133/170
11/11 [==============================] - 0s 9ms/step - loss: 4.5020
```

```
Epoch 134/170
11/11 [==============================] - 0s 9ms/step - loss: 4.1799
Epoch 135/170
11/11 [==============================] - 0s 9ms/step - loss: 4.1991
Epoch 136/170
11/11 [==============================] - 0s 9ms/step - loss: 4.5550
Epoch 137/170
11/11 [==============================] - 0s 9ms/step - loss: 4.5163
Epoch 138/170
11/11 [==============================] - 0s 10ms/step - loss: 4.4765
Epoch 139/170
11/11 [==============================] - 0s 9ms/step - loss: 4.1645
Epoch 140/170
11/11 [==============================] - 0s 10ms/step - loss: 3.7895
Epoch 141/170
11/11 [==============================] - 0s 10ms/step - loss: 3.6538
Epoch 142/170
11/11 [==============================] - 0s 9ms/step - loss: 3.8120
Epoch 143/170
11/11 [==============================] - 0s 9ms/step - loss: 3.8711
Epoch 144/170
11/11 [==============================] - 0s 9ms/step - loss: 3.8130
Epoch 145/170
11/11 [==============================] - 0s 9ms/step - loss: 3.7213
Epoch 146/170
11/11 [==============================] - 0s 10ms/step - loss: 3.7015
Epoch 147/170
11/11 [==============================] - 0s 9ms/step - loss: 3.3661
Epoch 148/170
11/11 [==============================] - 0s 9ms/step - loss: 3.3531
Epoch 149/170
11/11 [==============================] - 0s 10ms/step - loss: 3.9980
Epoch 150/170
11/11 [==============================] - 0s 9ms/step - loss: 3.6741
Epoch 151/170
11/11 [==============================] - 0s 10ms/step - loss: 5.7825
Epoch 152/170
11/11 [==============================] - 0s 9ms/step - loss: 5.6186
Epoch 153/170
11/11 [==============================] - 0s 9ms/step - loss: 5.1382
Epoch 154/170
11/11 [==============================] - 0s 9ms/step - loss: 3.8078
Epoch 155/170
11/11 [==============================] - 0s 10ms/step - loss: 3.2329
Epoch 156/170
11/11 [==============================] - 0s 9ms/step - loss: 2.6672
Epoch 157/170
11/11 [==============================] - 0s 9ms/step - loss: 2.3913
Epoch 158/170
11/11 [==============================] - 0s 9ms/step - loss: 2.5854
Epoch 159/170
11/11 [==============================] - 0s 9ms/step - loss: 2.0485
Epoch 160/170
11/11 [==============================] - 0s 10ms/step - loss: 2.0835
Epoch 161/170
11/11 [==============================] - 0s 9ms/step - loss: 2.0946
Epoch 162/170
11/11 [==============================] - 0s 9ms/step - loss: 1.9263
Epoch 163/170
11/11 [==============================] - 0s 9ms/step - loss: 2.2911
Epoch 164/170
```

```
11/11 [==============================] - 0s 9ms/step - loss: 2.1750
Epoch 165/170
11/11 [==============================] - 0s 9ms/step - loss: 2.7883
Epoch 166/170
11/11 [==============================] - 0s 9ms/step - loss: 3.1628
Epoch 167/170
11/11 [==============================] - 0s 9ms/step - loss: 2.4988
Epoch 168/170
11/11 [==============================] - 0s 9ms/step - loss: 2.4246
Epoch 169/170
11/11 [==============================] - 0s 9ms/step - loss: 2.2479
Epoch 170/170
11/11 [==============================] - 0s 9ms/step - loss: 1.9276
>expected=5.0, predicted=12.9
Epoch 1/170
11/11 [==============================] - 2s 9ms/step - loss: 136.0082
Epoch 2/170
11/11 [==============================] - 0s 9ms/step - loss: 133.9918
Epoch 3/170
11/11 [==============================] - 0s 11ms/step - loss: 129.1789
Epoch 4/170
11/11 [==============================] - 0s 9ms/step - loss: 112.7410
Epoch 5/170
11/11 [==============================] - 0s 9ms/step - loss: 101.2826
Epoch 6/170
11/11 [==============================] - 0s 9ms/step - loss: 92.9112
Epoch 7/170
11/11 [==============================] - 0s 9ms/step - loss: 91.9844
Epoch 8/170
11/11 [==============================] - 0s 9ms/step - loss: 94.8181
Epoch 9/170
11/11 [==============================] - 0s 9ms/step - loss: 88.1956
Epoch 10/170
11/11 [==============================] - 0s 9ms/step - loss: 85.2765
Epoch 11/170
11/11 [==============================] - 0s 9ms/step - loss: 84.7733
Epoch 12/170
11/11 [==============================] - 0s 9ms/step - loss: 82.8650
Epoch 13/170
11/11 [==============================] - 0s 10ms/step - loss: 79.5250
Epoch 14/170
11/11 [==============================] - 0s 9ms/step - loss: 77.9912
Epoch 15/170
11/11 [==============================] - 0s 9ms/step - loss: 76.5318
Epoch 16/170
11/11 [==============================] - 0s 9ms/step - loss: 76.4741
Epoch 17/170
11/11 [==============================] - 0s 9ms/step - loss: 72.6263
Epoch 18/170
11/11 [==============================] - 0s 9ms/step - loss: 72.7732
Epoch 19/170
11/11 [==============================] - 0s 9ms/step - loss: 72.2034
Epoch 20/170
11/11 [==============================] - 0s 9ms/step - loss: 70.6964
Epoch 21/170
11/11 [==============================] - 0s 9ms/step - loss: 74.3346
Epoch 22/170
11/11 [==============================] - 0s 11ms/step - loss: 72.3186
Epoch 23/170
11/11 [==============================] - 0s 9ms/step - loss: 80.3034
Epoch 24/170
```

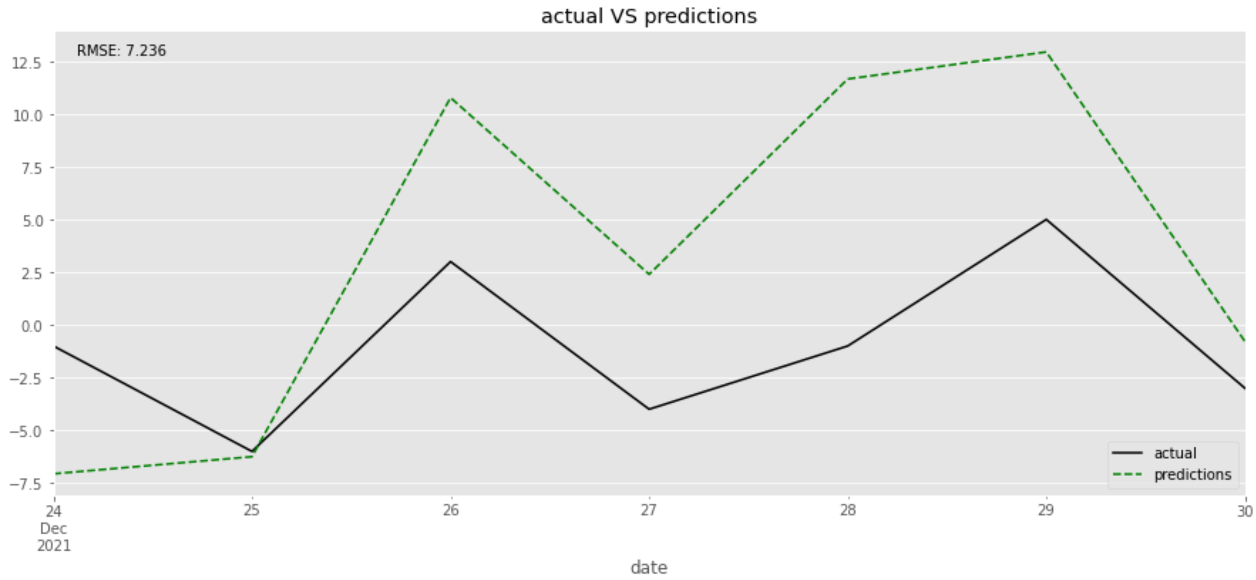
```
11/11 [==============================] - 0s 9ms/step - loss: 73.6235
Epoch 25/170
11/11 [==============================] - 0s 9ms/step - loss: 67.4619
Epoch 26/170
11/11 [==============================] - 0s 8ms/step - loss: 66.6242
Epoch 27/170
11/11 [==============================] - 0s 9ms/step - loss: 68.6243
Epoch 28/170
11/11 [==============================] - 0s 9ms/step - loss: 64.2503
Epoch 29/170
11/11 [==============================] - 0s 9ms/step - loss: 64.7594
Epoch 30/170
11/11 [==============================] - 0s 9ms/step - loss: 61.3865
Epoch 31/170
11/11 [==============================] - 0s 9ms/step - loss: 60.3932
Epoch 32/170
11/11 [==============================] - 0s 10ms/step - loss: 59.1282
Epoch 33/170
11/11 [==============================] - 0s 9ms/step - loss: 59.6433
Epoch 34/170
11/11 [==============================] - 0s 9ms/step - loss: 58.9089
Epoch 35/170
11/11 [==============================] - 0s 9ms/step - loss: 59.7682
Epoch 36/170
11/11 [==============================] - 0s 10ms/step - loss: 54.9082
Epoch 37/170
11/11 [==============================] - 0s 10ms/step - loss: 53.5691
Epoch 38/170
11/11 [==============================] - 0s 9ms/step - loss: 52.6867
Epoch 39/170
11/11 [==============================] - 0s 9ms/step - loss: 54.7593
Epoch 40/170
11/11 [==============================] - 0s 9ms/step - loss: 53.6214
Epoch 41/170
11/11 [==============================] - 0s 9ms/step - loss: 56.8685
Epoch 42/170
11/11 [==============================] - 0s 8ms/step - loss: 52.6210
Epoch 43/170
11/11 [==============================] - 0s 9ms/step - loss: 50.3178
Epoch 44/170
11/11 [==============================] - 0s 9ms/step - loss: 48.7696
Epoch 45/170
11/11 [==============================] - 0s 9ms/step - loss: 47.8082
Epoch 46/170
11/11 [==============================] - 0s 9ms/step - loss: 48.3426
Epoch 47/170
11/11 [==============================] - 0s 10ms/step - loss: 49.4072
Epoch 48/170
11/11 [==============================] - 0s 8ms/step - loss: 48.5173
Epoch 49/170
11/11 [==============================] - 0s 8ms/step - loss: 46.5931
Epoch 50/170
11/11 [==============================] - 0s 9ms/step - loss: 45.2613
Epoch 51/170
11/11 [==============================] - 0s 9ms/step - loss: 43.2396
Epoch 52/170
11/11 [==============================] - 0s 9ms/step - loss: 42.0594
Epoch 53/170
11/11 [==============================] - 0s 10ms/step - loss: 40.7453
Epoch 54/170
11/11 [==============================] - 0s 9ms/step - loss: 40.5641
```

```
Epoch 55/170
11/11 [==============================] - 0s 9ms/step - loss: 39.4437
Epoch 56/170
11/11 [==============================] - 0s 9ms/step - loss: 39.1970
Epoch 57/170
11/11 [==============================] - 0s 9ms/step - loss: 39.0253
Epoch 58/170
11/11 [==============================] - 0s 9ms/step - loss: 38.5043
Epoch 59/170
11/11 [==============================] - 0s 9ms/step - loss: 38.0320
Epoch 60/170
11/11 [==============================] - 0s 9ms/step - loss: 37.7090
Epoch 61/170
11/11 [==============================] - 0s 8ms/step - loss: 36.1624
Epoch 62/170
11/11 [==============================] - 0s 9ms/step - loss: 35.0726
Epoch 63/170
11/11 [==============================] - 0s 9ms/step - loss: 34.6827
Epoch 64/170
11/11 [==============================] - 0s 8ms/step - loss: 32.6579
Epoch 65/170
11/11 [==============================] - 0s 9ms/step - loss: 30.6184
Epoch 66/170
11/11 [==============================] - 0s 9ms/step - loss: 29.1312
Epoch 67/170
11/11 [==============================] - 0s 9ms/step - loss: 27.4196
Epoch 68/170
11/11 [==============================] - 0s 9ms/step - loss: 26.3987
Epoch 69/170
11/11 [==============================] - 0s 10ms/step - loss: 31.0720
Epoch 70/170
11/11 [==============================] - 0s 10ms/step - loss: 28.8718
Epoch 71/170
11/11 [==============================] - 0s 10ms/step - loss: 26.4256
Epoch 72/170
11/11 [==============================] - 0s 10ms/step - loss: 25.1002
Epoch 73/170
11/11 [==============================] - 0s 10ms/step - loss: 22.8951
Epoch 74/170
11/11 [==============================] - 0s 9ms/step - loss: 22.0645
Epoch 75/170
11/11 [==============================] - 0s 9ms/step - loss: 23.7763
Epoch 76/170
11/11 [==============================] - 0s 9ms/step - loss: 24.2809
Epoch 77/170
11/11 [==============================] - 0s 9ms/step - loss: 22.5468
Epoch 78/170
11/11 [==============================] - 0s 9ms/step - loss: 21.2940
Epoch 79/170
11/11 [==============================] - 0s 10ms/step - loss: 20.8980
Epoch 80/170
11/11 [==============================] - 0s 9ms/step - loss: 19.2460
Epoch 81/170
11/11 [==============================] - 0s 9ms/step - loss: 19.5574
Epoch 82/170
11/11 [==============================] - 0s 9ms/step - loss: 19.4195
Epoch 83/170
11/11 [==============================] - 0s 9ms/step - loss: 18.8821
Epoch 84/170
11/11 [==============================] - 0s 9ms/step - loss: 20.5361
Epoch 85/170
```

```
11/11 [==============================] - 0s 9ms/step - loss: 19.5317
Epoch 86/170
11/11 [==============================] - 0s 10ms/step - loss: 22.1420
Epoch 87/170
11/11 [==============================] - 0s 11ms/step - loss: 19.3037
Epoch 88/170
11/11 [==============================] - 0s 10ms/step - loss: 19.0897
Epoch 89/170
11/11 [==============================] - 0s 12ms/step - loss: 18.0737
Epoch 90/170
11/11 [==============================] - 0s 10ms/step - loss: 16.6930
Epoch 91/170
11/11 [==============================] - 0s 9ms/step - loss: 16.7877
Epoch 92/170
11/11 [==============================] - 0s 9ms/step - loss: 16.3230
Epoch 93/170
11/11 [==============================] - 0s 9ms/step - loss: 14.5886
Epoch 94/170
11/11 [==============================] - 0s 10ms/step - loss: 12.8837
Epoch 95/170
11/11 [==============================] - 0s 9ms/step - loss: 13.0388
Epoch 96/170
11/11 [==============================] - 0s 10ms/step - loss: 12.7771
Epoch 97/170
11/11 [==============================] - 0s 10ms/step - loss: 12.3034
Epoch 98/170
11/11 [==============================] - 0s 9ms/step - loss: 12.0222
Epoch 99/170
11/11 [==============================] - 0s 10ms/step - loss: 11.6995
Epoch 100/170
11/11 [==============================] - 0s 9ms/step - loss: 10.8706
Epoch 101/170
11/11 [==============================] - 0s 9ms/step - loss: 11.0891
Epoch 102/170
11/11 [==============================] - 0s 11ms/step - loss: 10.5539
Epoch 103/170
11/11 [==============================] - 0s 10ms/step - loss: 10.2724
Epoch 104/170
11/11 [==============================] - 0s 10ms/step - loss: 10.1942
Epoch 105/170
11/11 [==============================] - 0s 10ms/step - loss: 11.2400
Epoch 106/170
11/11 [==============================] - 0s 11ms/step - loss: 10.7698
Epoch 107/170
11/11 [==============================] - 0s 10ms/step - loss: 8.8509
Epoch 108/170
11/11 [==============================] - 0s 10ms/step - loss: 8.3749
Epoch 109/170
11/11 [==============================] - 0s 9ms/step - loss: 7.5422
Epoch 110/170
11/11 [==============================] - 0s 10ms/step - loss: 7.7847
Epoch 111/170
11/11 [==============================] - 0s 9ms/step - loss: 7.7501
Epoch 112/170
11/11 [==============================] - 0s 10ms/step - loss: 8.0399
Epoch 113/170
11/11 [==============================] - 0s 9ms/step - loss: 8.2703
Epoch 114/170
11/11 [==============================] - 0s 9ms/step - loss: 9.6079
Epoch 115/170
11/11 [==============================] - 0s 11ms/step - loss: 9.4668
```

```
Epoch 116/170
11/11 [==============================] - 0s 9ms/step - loss: 8.7669
Epoch 117/170
11/11 [==============================] - 0s 10ms/step - loss: 7.9227
Epoch 118/170
11/11 [==============================] - 0s 9ms/step - loss: 7.3300
Epoch 119/170
11/11 [==============================] - 0s 9ms/step - loss: 6.9692
Epoch 120/170
11/11 [==============================] - 0s 9ms/step - loss: 6.5441
Epoch 121/170
11/11 [==============================] - 0s 9ms/step - loss: 6.0252
Epoch 122/170
11/11 [==============================] - 0s 9ms/step - loss: 5.9194
Epoch 123/170
11/11 [==============================] - 0s 9ms/step - loss: 5.7709
Epoch 124/170
11/11 [==============================] - 0s 10ms/step - loss: 7.5968
Epoch 125/170
11/11 [==============================] - 0s 9ms/step - loss: 7.8318
Epoch 126/170
11/11 [==============================] - 0s 9ms/step - loss: 6.4395
Epoch 127/170
11/11 [==============================] - 0s 10ms/step - loss: 5.6071
Epoch 128/170
11/11 [==============================] - 0s 9ms/step - loss: 4.9140
Epoch 129/170
11/11 [==============================] - 0s 8ms/step - loss: 5.0426
Epoch 130/170
11/11 [==============================] - 0s 8ms/step - loss: 6.0918
Epoch 131/170
11/11 [==============================] - 0s 10ms/step - loss: 5.5508
Epoch 132/170
11/11 [==============================] - 0s 9ms/step - loss: 4.7248
Epoch 133/170
11/11 [==============================] - 0s 10ms/step - loss: 4.0475
Epoch 134/170
11/11 [==============================] - 0s 9ms/step - loss: 3.6565
Epoch 135/170
11/11 [==============================] - 0s 9ms/step - loss: 4.1491
Epoch 136/170
11/11 [==============================] - 0s 9ms/step - loss: 4.0705
Epoch 137/170
11/11 [==============================] - 0s 9ms/step - loss: 3.6827
Epoch 138/170
11/11 [==============================] - 0s 8ms/step - loss: 3.9969
Epoch 139/170
11/11 [==============================] - 0s 9ms/step - loss: 3.9203
Epoch 140/170
11/11 [==============================] - 0s 9ms/step - loss: 4.1166
Epoch 141/170
11/11 [==============================] - 0s 9ms/step - loss: 3.6723
Epoch 142/170
11/11 [==============================] - 0s 9ms/step - loss: 3.4723
Epoch 143/170
11/11 [==============================] - 0s 10ms/step - loss: 3.4879
Epoch 144/170
11/11 [==============================] - 0s 9ms/step - loss: 2.8722
Epoch 145/170
11/11 [==============================] - 0s 9ms/step - loss: 2.6231
Epoch 146/170
```

```
11/11 [==============================] - 0s 9ms/step - loss: 2.3351
Epoch 147/170
11/11 [==============================] - 0s 9ms/step - loss: 2.3459
Epoch 148/170
11/11 [==============================] - 0s 9ms/step - loss: 2.4278
Epoch 149/170
11/11 [==============================] - 0s 9ms/step - loss: 2.9751
Epoch 150/170
11/11 [==============================] - 0s 10ms/step - loss: 4.1685
Epoch 151/170
11/11 [==============================] - 0s 9ms/step - loss: 4.0113
Epoch 152/170
11/11 [==============================] - 0s 9ms/step - loss: 3.3415
Epoch 153/170
11/11 [==============================] - 0s 10ms/step - loss: 3.0671
Epoch 154/170
11/11 [==============================] - 0s 9ms/step - loss: 2.6456
Epoch 155/170
11/11 [==============================] - 0s 10ms/step - loss: 2.6544
Epoch 156/170
11/11 [==============================] - 0s 9ms/step - loss: 2.4191
Epoch 157/170
11/11 [==============================] - 0s 10ms/step - loss: 2.2592
Epoch 158/170
11/11 [==============================] - 0s 10ms/step - loss: 2.1016
Epoch 159/170
11/11 [==============================] - 0s 9ms/step - loss: 2.0275
Epoch 160/170
11/11 [==============================] - 0s 10ms/step - loss: 1.7658
Epoch 161/170
11/11 [==============================] - 0s 10ms/step - loss: 1.7433
Epoch 162/170
11/11 [==============================] - 0s 10ms/step - loss: 1.3994
Epoch 163/170
11/11 [==============================] - 0s 9ms/step - loss: 1.5082
Epoch 164/170
11/11 [==============================] - 0s 9ms/step - loss: 1.4819
Epoch 165/170
11/11 [==============================] - 0s 9ms/step - loss: 1.1670
Epoch 166/170
11/11 [==============================] - 0s 9ms/step - loss: 1.1065
Epoch 167/170
11/11 [==============================] - 0s 10ms/step - loss: 1.1516
Epoch 168/170
11/11 [==============================] - 0s 9ms/step - loss: 1.3091
Epoch 169/170
11/11 [==============================] - 0s 10ms/step - loss: 1.6394
Epoch 170/170
11/11 [==============================] - 0s 9ms/step - loss: 1.5452
>expected=-3.0, predicted=-0.8
```



Модель всё ещё далека от идеала.

Многошаговая LSTM

Ранее мы пользовались расширяющимся окном для предсказания на каждом следующем шаге, то есть делали прогноз на один день вперед.

Теперь сделаем модель, которая будет делать прогноз сразу на несколько шагов (дней) вперед.

Напишем функцию `split_sequence()` , которая принимает на вход последовательность, количество последних нескольких шагов на входе и на выходе.

Здесь, в отличие от предыдущих моделей, в качестве целевого признака используется последовательность значений, а не одно значение. Так как мы пользуемся нейронной сетью, то в выходном слое просто укажем соответствующее количество нейронов.

In [128…
```
# разбиваем последовательность
def split_sequence(sequence, n_steps_in, n_steps_out):
    features, target = list(), list()
    for i in range(len(sequence)):
        # находим конечный элемент
        end_ix = i + n_steps_in
        out_end_ix = end_ix + n_steps_out
        # проверяем, не вышли ли мы за пределы последовательности
        if out_end_ix > len(sequence):
            break
        # собираем входные и выходные последовательности
        seq_features, seq_target = sequence[i:end_ix], sequence[end_ix:out_
        features.append(seq_features)
        target.append(seq_target)
    return np.array(features), np.array(target)
```

Пусть в качестве признаков у нас будут 28 последних дней, а предсказывать мы будем каждые семь следующих.

In [129…
```
sales_diff = sales_q.diff().dropna()
```

In [224…
```
# выбираем количество шагов
n_steps_in, n_steps_out = 28, 7
# разбиваем на признаки и цель
features, target = split_sequence(sales_diff[:'2021-12-23'], n_steps_in, n_
# посмотрим, как будут выглядеть данные
for i in range(len(features)):
   print(features[i], target[i])
```

```
[ 26.  -5.   3.   5.   3.  -9. -11.  35.  -7. -22.   3.  12.  -8.   2.
  17. -16.   6.  -4.  27. -24.   4. -14.  20.   3. -25.  47. -43.   3.] [ 1
0.   5.  -8.   5.   6. -16.   4.]
[ -5.   3.   5.   3.  -9. -11.  35.  -7. -22.   3.  12.  -8.   2.  17.
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2.   6. -17.   2.  -3.  28. -23.]
[ -7.   8.  -1.  -6.  -1.   1.   0.  -1.  13. -17.   0.   5.  -5.  -4.
   0.  20. -18.  -1.  10.   3. -12.  -3.  10.   4. -13.   1.  -5.  12.] [
6. -17.   2.  -3.  28. -23. -12.]
[  8.  -1.  -6.  -1.   1.   0.  -1.  13. -17.   0.   5.  -5.  -4.   0.
  20. -18.  -1.  10.   3. -12.  -3.  10.   4. -13.   1.  -5.  12.   6.] [-1
7.   2.  -3.  28. -23. -12.   7.]
[ -1.  -6.  -1.   1.   0.  -1.  13. -17.   0.   5.  -5.  -4.   0.  20.
 -18.  -1.  10.   3. -12.  -3.  10.   4. -13.   1.  -5.  12.   6. -17.] [
2.  -3.  28. -23. -12.   7.   3.]
[ -6.  -1.   1.   0.  -1.  13. -17.   0.   5.  -5.  -4.   0.  20. -18.
  -1.  10.   3. -12.  -3.  10.   4. -13.   1.  -5.  12.   6. -17.   2.] [ -
3.  28. -23. -12.   7.   3.   4.]
[ -1.   1.   0.  -1.  13. -17.   0.   5.  -5.  -4.   0.  20. -18.  -1.
  10.   3. -12.  -3.  10.   4. -13.   1.  -5.  12.   6. -17.   2.  -3.] [ 2
8. -23. -12.   7.   3.   4.  14.]
[  1.   0.  -1.  13. -17.   0.   5.  -5.  -4.   0.  20. -18.  -1.  10.
   3. -12.  -3.  10.   4. -13.   1.  -5.  12.   6. -17.   2.  -3.  28.] [-2
3. -12.   7.   3.   4.  14.   4.]
[  0.  -1.  13. -17.   0.   5.  -5.  -4.   0.  20. -18.  -1.  10.   3.
 -12.  -3.  10.   4. -13.   1.  -5.  12.   6. -17.   2.  -3.  28. -23.] [-1
2.   7.   3.   4.  14.   4. -11.]
[ -1.  13. -17.   0.   5.  -5.  -4.   0.  20. -18.  -1.  10.   3. -12.
  -3.  10.   4. -13.   1.  -5.  12.   6. -17.   2.  -3.  28. -23. -12.] [
7.   3.   4.  14.   4. -11.  17.]
[ 13. -17.   0.   5.  -5.  -4.   0.  20. -18.  -1.  10.   3. -12.  -3.
  10.   4. -13.   1.  -5.  12.   6. -17.   2.  -3.  28. -23. -12.   7.] [
3.   4.  14.   4. -11.  17. -10.]
[-17.   0.   5.  -5.  -4.   0.  20. -18.  -1.  10.   3. -12.  -3.  10.
   4. -13.   1.  -5.  12.   6. -17.   2.  -3.  28. -23. -12.   7.   3.] [
4.  14.   4. -11.  17. -10. -26.]
[  0.   5.  -5.  -4.   0.  20. -18.  -1.  10.   3. -12.  -3.  10.   4.
 -13.   1.  -5.  12.   6. -17.   2.  -3.  28. -23. -12.   7.   3.   4.] [ 1
4.   4. -11.  17. -10. -26.   4.]
[  5.  -5.  -4.   0.  20. -18.  -1.  10.   3. -12.  -3.  10.   4. -13.
   1.  -5.  12.   6. -17.   2.  -3.  28. -23. -12.   7.   3.   4.  14.] [
4. -11.  17. -10. -26.   4.  -4.]
[ -5.  -4.   0.  20. -18.  -1.  10.   3. -12.  -3.  10.   4. -13.   1.
  -5.  12.   6. -17.   2.  -3.  28. -23. -12.   7.   3.   4.  14.   4.] [-1
1.  17. -10. -26.   4.  -4.   4.]
[ -4.   0.  20. -18.  -1.  10.   3. -12.  -3.  10.   4. -13.   1.  -5.
  12.   6. -17.   2.  -3.  28. -23. -12.   7.   3.   4.  14.   4. -11.] [ 1
```

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7. -10. -26.   4.  -4.   4.  13.]
[  0.  20. -18.  -1.  10.   3. -12.  -3.  10.   4. -13.   1.  -5.  12.
   6. -17.   2.  -3.  28. -23. -12.   7.   3.   4.  14.   4. -11.  17.] [-1
0. -26.   4.  -4.   4.  13.  -9.]
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6.   4.  -4.   4.  13.  -9.   2.]
[-18.  -1.  10.   3. -12.  -3.  10.   4. -13.   1.  -5.  12.   6. -17.
   2.  -3.  28. -23. -12.   7.   3.   4.  14.   4. -11.  17. -10. -26.] [ 4
. -4.  4. 13. -9.  2.  3.]
[ -1.  10.   3. -12.  -3.  10.   4. -13.   1.  -5.  12.   6. -17.   2.
  -3.  28. -23. -12.   7.   3.   4.  14.   4. -11.  17. -10. -26.   4.] [-4
.  4. 13. -9.  2.  3.  2.]
[ 10.   3. -12.  -3.  10.   4. -13.   1.  -5.  12.   6. -17.   2.  -3.
  28. -23. -12.   7.   3.   4.  14.   4. -11.  17. -10. -26.   4.  -4.] [ 4
. 13. -9.  2.  3.  2. -9.]
[  3. -12.  -3.  10.   4. -13.   1.  -5.  12.   6. -17.   2.  -3.  28.
 -23. -12.   7.   3.   4.  14.   4. -11.  17. -10. -26.   4.  -4.   4.] [13
. -9.  2.  3.  2. -9. 13.]
[-12.  -3.  10.   4. -13.   1.  -5.  12.   6. -17.   2.  -3.  28. -23.
 -12.   7.   3.   4.  14.   4. -11.  17. -10. -26.   4.  -4.   4.  13.] [-9
.  2.  3.  2. -9. 13. -7.]
[ -3.  10.   4. -13.   1.  -5.  12.   6. -17.   2.  -3.  28. -23. -12.
   7.   3.   4.  14.   4. -11.  17. -10. -26.   4.  -4.   4.  13.  -9.] [ 2
.  3.  2. -9. 13. -7.  7.]
[ 10.   4. -13.   1.  -5.  12.   6. -17.   2.  -3.  28. -23. -12.   7.
   3.   4.  14.   4. -11.  17. -10. -26.   4.  -4.   4.  13.  -9.   2.] [
3.   2.  -9.  13.  -7.   7. -10.]
[  4. -13.   1.  -5.  12.   6. -17.   2.  -3.  28. -23. -12.   7.   3.
   4.  14.   4. -11.  17. -10. -26.   4.  -4.   4.  13.  -9.   2.   3.] [
2.  -9.  13.  -7.   7. -10.  -7.]
[-13.   1.  -5.  12.   6. -17.   2.  -3.  28. -23. -12.   7.   3.   4.
  14.   4. -11.  17. -10. -26.   4.  -4.   4.  13.  -9.   2.   3.   2.] [ -
9.  13.  -7.   7. -10.  -7.   5.]
[  1.  -5.  12.   6. -17.   2.  -3.  28. -23. -12.   7.   3.   4.  14.
   4. -11.  17. -10. -26.   4.  -4.   4.  13.  -9.   2.   3.   2.  -9.] [ 1
3.  -7.   7. -10.  -7.   5.   0.]
[ -5.  12.   6. -17.   2.  -3.  28. -23. -12.   7.   3.   4.  14.   4.
 -11.  17. -10. -26.   4.  -4.   4.  13.  -9.   2.   3.   2.  -9.  13.] [ -
7.   7. -10.  -7.   5.   0.   6.]
[ 12.   6. -17.   2.  -3.  28. -23. -12.   7.   3.   4.  14.   4. -11.
  17. -10. -26.   4.  -4.   4.  13.  -9.   2.   3.   2.  -9.  13.  -7.] [
7. -10.  -7.   5.   0.   6.  -5.]
[  6. -17.   2.  -3.  28. -23. -12.   7.   3.   4.  14.   4. -11.  17.
 -10. -26.   4.  -4.   4.  13.  -9.   2.   3.   2.  -9.  13.  -7.   7.] [-1
0.  -7.   5.   0.   6.  -5.   7.]
[-17.   2.  -3.  28. -23. -12.   7.   3.   4.  14.   4. -11.  17. -10.
 -26.   4.  -4.   4.  13.  -9.   2.   3.   2.  -9.  13.  -7.   7. -10.] [-7
.  5.  0.  6. -5.  7.  2.]
[  2.  -3.  28. -23. -12.   7.   3.   4.  14.   4. -11.  17. -10. -26.
   4.  -4.   4.  13.  -9.   2.   3.   2.  -9.  13.  -7.   7. -10.  -7.] [
5.   0.   6.  -5.   7.   2. -11.]
[ -3.  28. -23. -12.   7.   3.   4.  14.   4. -11.  17. -10. -26.   4.
  -4.   4.  13.  -9.   2.   3.   2.  -9.  13.  -7.   7. -10.  -7.   5.] [
0.   6.  -5.   7.   2. -11.   8.]
[ 28. -23. -12.   7.   3.   4.  14.   4. -11.  17. -10. -26.   4.  -4.
   4.  13.  -9.   2.   3.   2.  -9.  13.  -7.   7. -10.  -7.   5.   0.] [
6.  -5.   7.   2. -11.   8. -11.]
[-23. -12.   7.   3.   4.  14.   4. -11.  17. -10. -26.   4.  -4.   4.
  13.  -9.   2.   3.   2.  -9.  13.  -7.   7. -10.  -7.   5.   0.   6.] [ -
5.   7.   2. -11.   8. -11.   6.]
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7.   2. -11.   8. -11.   6.  -5.]
[  7.   3.   4.  14.   4. -11.  17. -10. -26.   4.  -4.   4.  13.  -9.
   2.   3.   2.  -9.  13.  -7.   7. -10.  -7.   5.   0.   6.  -5.   7.] [
2. -11.   8. -11.   6.  -5.   7.]
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   3.   2.  -9.  13.  -7.   7. -10.  -7.   5.   0.   6.  -5.   7.   2.] [-1
1.   8. -11.   6.  -5.   7.  -7.]
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   2.  -9.  13.  -7.   7. -10.  -7.   5.   0.   6.  -5.   7.   2. -11.] [
8. -11.   6.  -5.   7.  -7.   6.]
[ 14.   4. -11.  17. -10. -26.   4.  -4.   4.  13.  -9.   2.   3.   2.
  -9.  13.  -7.   7. -10.  -7.   5.   0.   6.  -5.   7.   2. -11.   8.] [-1
1.   6.  -5.   7.  -7.   6.   0.]
[  4. -11.  17. -10. -26.   4.  -4.   4.  13.  -9.   2.   3.   2.  -9.
  13.  -7.   7. -10.  -7.   5.   0.   6.  -5.   7.   2. -11.   8. -11.] [
6.  -5.   7.  -7.   6.   0. -15.]
[-11.  17. -10. -26.   4.  -4.   4.  13.  -9.   2.   3.   2.  -9.  13.
  -7.   7. -10.  -7.   5.   0.   6.  -5.   7.   2. -11.   8. -11.   6.] [ -
5.   7.  -7.   6.   0. -15.   7.]
[ 17. -10. -26.   4.  -4.   4.  13.  -9.   2.   3.   2.  -9.  13.  -7.
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7.  -7.   6.   0. -15.   7.   9.]
[-10. -26.   4.  -4.   4.  13.  -9.   2.   3.   2.  -9.  13.  -7.   7.
 -10.  -7.   5.   0.   6.  -5.   7.   2. -11.   8. -11.   6.  -5.   7.] [ -
7.   6.   0. -15.   7.   9. -13.]
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[  4.  13.  -9.   2.   3.   2.  -9.  13.  -7.   7. -10.  -7.   5.   0.
   6.  -5.   7.   2. -11.   8. -11.   6.  -5.   7.  -7.   6.   0. -15.] [
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[ 13.  -9.   2.   3.   2.  -9.  13.  -7.   7. -10.  -7.   5.   0.   6.
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3.   3.   1.   8.  -2.   1.  -4.]
[  2.   3.   2.  -9.  13.  -7.   7. -10.  -7.   5.   0.   6.  -5.   7.
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[ -7.   7. -10.  -7.   5.   0.   6.  -5.   7.   2. -11.   8. -11.   6.
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1.   0.   0.   4.  -9.  19. -18.]
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0.   0.   4.  -9.  19. -18.  10.]
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0.   4.  -9.  19. -18.  10.  11.]
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   7.   9. -13.   3.   1.   8.  -2.   1.  -4.  -1.   0.   1.   0.   0.] [
4.  -9.  19. -18.  10.  11. -20.]
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9.  19. -18.  10.  11. -20.   1.]
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0.   1.   5.  -8.   5.   1.   3.]
[  6.  -5.   7.  -7.   6.   0. -15.   7.   9. -13.   3.   1.   8.  -2.
   1.  -4.  -1.   0.   1.   0.   0.   4.  -9.  19. -18.  10.  11. -20.] [ 1
.  5. -8.  5.  1.  3.  0.]
[ -5.   7.  -7.   6.   0. -15.   7.   9. -13.   3.   1.   8.  -2.   1.
  -4.  -1.   0.   1.   0.   0.   4.  -9.  19. -18.  10.  11. -20.   1.] [ 5
. -8.  5.  1.  3.  0. -4.]
[  7.  -7.   6.   0. -15.   7.   9. -13.   3.   1.   8.  -2.   1.  -4.
  -1.   0.   1.   0.   0.   4.  -9.  19. -18.  10.  11. -20.   1.   5.] [-8
.  5.  1.  3.  0. -4.  5.]
[ -7.   6.   0. -15.   7.   9. -13.   3.   1.   8.  -2.   1.  -4.  -1.
   0.   1.   0.   0.   4.  -9.  19. -18.  10.  11. -20.   1.   5.  -8.] [ 5
.  1.  3.  0. -4.  5. -4.]
[  6.   0. -15.   7.   9. -13.   3.   1.   8.  -2.   1.  -4.  -1.   0.
   1.   0.   0.   4.  -9.  19. -18.  10.  11. -20.   1.   5.  -8.   5.] [
1.   3.   0.  -4.   5.  -4. -10.]
[  0. -15.   7.   9. -13.   3.   1.   8.  -2.   1.  -4.  -1.   0.   1.
   0.   0.   4.  -9.  19. -18.  10.  11. -20.   1.   5.  -8.   5.   1.] [
3.   0.  -4.   5.  -4. -10.   8.]
[-15.   7.   9. -13.   3.   1.   8.  -2.   1.  -4.  -1.   0.   1.   0.
   0.   4.  -9.  19. -18.  10.  11. -20.   1.   5.  -8.   5.   1.   3.] [
0.  -4.   5.  -4. -10.   8.   0.]
[  7.   9. -13.   3.   1.   8.  -2.   1.  -4.  -1.   0.   1.   0.   0.
   4.  -9.  19. -18.  10.  11. -20.   1.   5.  -8.   5.   1.   3.   0.] [ -
```

```
4.   5.  -4. -10.   8.   0.   2.]
[  9. -13.   3.   1.   8.  -2.   1.  -4.  -1.   0.   1.   0.   0.   4.
  -9.  19. -18.  10.  11. -20.   1.   5.  -8.   5.   1.   3.   0.  -4.] [
5.  -4. -10.   8.   0.   2.  -5.]
[-13.   3.   1.   8.  -2.   1.  -4.  -1.   0.   1.   0.   0.   4.  -9.
  19. -18.  10.  11. -20.   1.   5.  -8.   5.   1.   3.   0.  -4.   5.] [ -
4. -10.   8.   0.   2.  -5.   4.]
[  3.   1.   8.  -2.   1.  -4.  -1.   0.   1.   0.   0.   4.  -9.  19.
 -18.  10.  11. -20.   1.   5.  -8.   5.   1.   3.   0.  -4.   5.  -4.] [-1
0.   8.   0.   2.  -5.   4.   3.]
[  1.   8.  -2.   1.  -4.  -1.   0.   1.   0.   0.   4.  -9.  19. -18.
  10.  11. -20.   1.   5.  -8.   5.   1.   3.   0.  -4.   5.  -4. -10.] [ 8
.  0.  2. -5.  4.  3. -7.]
[  8.  -2.   1.  -4.  -1.   0.   1.   0.   0.   4.  -9.  19. -18.  10.
  11. -20.   1.   5.  -8.   5.   1.   3.   0.  -4.   5.  -4. -10.   8.] [ 0
.  2. -5.  4.  3. -7.  3.]
[ -2.   1.  -4.  -1.   0.   1.   0.   0.   4.  -9.  19. -18.  10.  11.
 -20.   1.   5.  -8.   5.   1.   3.   0.  -4.   5.  -4. -10.   8.   0.] [ 2
. -5.  4.  3. -7.  3. -5.]
[  1.  -4.  -1.   0.   1.   0.   0.   4.  -9.  19. -18.  10.  11. -20.
   1.   5.  -8.   5.   1.   3.   0.  -4.   5.  -4. -10.   8.   0.   2.] [-5
.  4.  3. -7.  3. -5. -3.]
[ -4.  -1.   0.   1.   0.   0.   4.  -9.  19. -18.  10.  11. -20.   1.
   5.  -8.   5.   1.   3.   0.  -4.   5.  -4. -10.   8.   0.   2.  -5.] [ 4
.  3. -7.  3. -5. -3.  6.]
[ -1.   0.   1.   0.   0.   4.  -9.  19. -18.  10.  11. -20.   1.   5.
  -8.   5.   1.   3.   0.  -4.   5.  -4. -10.   8.   0.   2.  -5.   4.] [ 3
. -7.  3. -5. -3.  6.  5.]
[  0.   1.   0.   0.   4.  -9.  19. -18.  10.  11. -20.   1.   5.  -8.
   5.   1.   3.   0.  -4.   5.  -4. -10.   8.   0.   2.  -5.   4.   3.] [-7
.  3. -5. -3.  6.  5.  1.]
[  1.   0.   0.   4.  -9.  19. -18.  10.  11. -20.   1.   5.  -8.   5.
   1.   3.   0.  -4.   5.  -4. -10.   8.   0.   2.  -5.   4.   3.  -7.] [ 3
. -5. -3.  6.  5.  1. -9.]
[  0.   0.   4.  -9.  19. -18.  10.  11. -20.   1.   5.  -8.   5.   1.
   3.   0.  -4.   5.  -4. -10.   8.   0.   2.  -5.   4.   3.  -7.   3.] [-5
. -3.  6.  5.  1. -9. 11.]
[  0.   4.  -9.  19. -18.  10.  11. -20.   1.   5.  -8.   5.   1.   3.
   0.  -4.   5.  -4. -10.   8.   0.   2.  -5.   4.   3.  -7.   3.  -5.] [-3
.  6.  5.  1. -9. 11.  6.]
[  4.  -9.  19. -18.  10.  11. -20.   1.   5.  -8.   5.   1.   3.   0.
  -4.   5.  -4. -10.   8.   0.   2.  -5.   4.   3.  -7.   3.  -5.  -3.] [ 6
.  5.  1. -9. 11.  6. -8.]
[ -9.  19. -18.  10.  11. -20.   1.   5.  -8.   5.   1.   3.   0.  -4.
   5.  -4. -10.   8.   0.   2.  -5.   4.   3.  -7.   3.  -5.  -3.   6.] [ 5
.  1. -9. 11.  6. -8.  0.]
[ 19. -18.  10.  11. -20.   1.   5.  -8.   5.   1.   3.   0.  -4.   5.
  -4. -10.   8.   0.   2.  -5.   4.   3.  -7.   3.  -5.  -3.   6.   5.] [
1.  -9.  11.   6.  -8.   0. -10.]
[-18.  10.  11. -20.   1.   5.  -8.   5.   1.   3.   0.  -4.   5.  -4.
 -10.   8.   0.   2.  -5.   4.   3.  -7.   3.  -5.  -3.   6.   5.   1.] [ -
9.  11.   6.  -8.   0. -10.  17.]
[ 10.  11. -20.   1.   5.  -8.   5.   1.   3.   0.  -4.   5.  -4. -10.
   8.   0.   2.  -5.   4.   3.  -7.   3.  -5.  -3.   6.   5.   1.  -9.] [ 1
1.   6.  -8.   0. -10.  17. -15.]
[ 11. -20.   1.   5.  -8.   5.   1.   3.   0.  -4.   5.  -4. -10.   8.
   0.   2.  -5.   4.   3.  -7.   3.  -5.  -3.   6.   5.   1.  -9.  11.] [
6.  -8.   0. -10.  17. -15.  -4.]
[-20.   1.   5.  -8.   5.   1.   3.   0.  -4.   5.  -4. -10.   8.   0.
   2.  -5.   4.   3.  -7.   3.  -5.  -3.   6.   5.   1.  -9.  11.   6.] [ -
8.   0. -10.  17. -15.  -4.  14.]
```

```
[  1.   5.  -8.   5.   1.   3.   0.  -4.   5.  -4. -10.   8.   0.   2.
  -5.   4.   3.  -7.   3.  -5.  -3.   6.   5.   1.  -9.  11.   6.  -8.] [
0. -10.  17. -15.  -4.  14. -12.]
[  5.  -8.   5.   1.   3.   0.  -4.   5.  -4. -10.   8.   0.   2.  -5.
   4.   3.  -7.   3.  -5.  -3.   6.   5.   1.  -9.  11.   6.  -8.   0.] [-1
0.  17. -15.  -4.  14. -12.   3.]
[ -8.   5.   1.   3.   0.  -4.   5.  -4. -10.   8.   0.   2.  -5.   4.
   3.  -7.   3.  -5.  -3.   6.   5.   1.  -9.  11.   6.  -8.   0. -10.] [ 1
7. -15.  -4.  14. -12.   3.   8.]
[  5.   1.   3.   0.  -4.   5.  -4. -10.   8.   0.   2.  -5.   4.   3.
  -7.   3.  -5.  -3.   6.   5.   1.  -9.  11.   6.  -8.   0. -10.  17.] [-1
5.  -4.  14. -12.   3.   8. -13.]
[  1.   3.   0.  -4.   5.  -4. -10.   8.   0.   2.  -5.   4.   3.  -7.
   3.  -5.  -3.   6.   5.   1.  -9.  11.   6.  -8.   0. -10.  17. -15.] [ -
4.  14. -12.   3.   8. -13.   7.]
[  3.   0.  -4.   5.  -4. -10.   8.   0.   2.  -5.   4.   3.  -7.   3.
  -5.  -3.   6.   5.   1.  -9.  11.   6.  -8.   0. -10.  17. -15.  -4.] [ 1
4. -12.   3.   8. -13.   7.  -7.]
[  0.  -4.   5.  -4. -10.   8.   0.   2.  -5.   4.   3.  -7.   3.  -5.
  -3.   6.   5.   1.  -9.  11.   6.  -8.   0. -10.  17. -15.  -4.  14.] [-1
2.   3.   8. -13.   7.  -7.   2.]
[ -4.   5.  -4. -10.   8.   0.   2.  -5.   4.   3.  -7.   3.  -5.  -3.
   6.   5.   1.  -9.  11.   6.  -8.   0. -10.  17. -15.  -4.  14. -12.] [
3.   8. -13.   7.  -7.   2.   2.]
[  5.  -4. -10.   8.   0.   2.  -5.   4.   3.  -7.   3.  -5.  -3.   6.
   5.   1.  -9.  11.   6.  -8.   0. -10.  17. -15.  -4.  14. -12.   3.] [
8. -13.   7.  -7.   2.   2.   0.]
[ -4. -10.   8.   0.   2.  -5.   4.   3.  -7.   3.  -5.  -3.   6.   5.
   1.  -9.  11.   6.  -8.   0. -10.  17. -15.  -4.  14. -12.   3.   8.] [-1
3.   7.  -7.   2.   2.   0.  -4.]
[-10.   8.   0.   2.  -5.   4.   3.  -7.   3.  -5.  -3.   6.   5.   1.
  -9.  11.   6.  -8.   0. -10.  17. -15.  -4.  14. -12.   3.   8. -13.] [ 7
. -7.  2.  2.  0. -4.  7.]
[  8.   0.   2.  -5.   4.   3.  -7.   3.  -5.  -3.   6.   5.   1.  -9.
  11.   6.  -8.   0. -10.  17. -15.  -4.  14. -12.   3.   8. -13.   7.] [-7
.  2.  2.  0. -4.  7. -8.]
[  0.   2.  -5.   4.   3.  -7.   3.  -5.  -3.   6.   5.   1.  -9.  11.
   6.  -8.   0. -10.  17. -15.  -4.  14. -12.   3.   8. -13.   7.  -7.] [ 2
.  2.  0. -4.  7. -8.  2.]
[  2.  -5.   4.   3.  -7.   3.  -5.  -3.   6.   5.   1.  -9.  11.   6.
  -8.   0. -10.  17. -15.  -4.  14. -12.   3.   8. -13.   7.  -7.   2.] [ 2
.  0. -4.  7. -8.  2. 19.]
[ -5.   4.   3.  -7.   3.  -5.  -3.   6.   5.   1.  -9.  11.   6.  -8.
   0. -10.  17. -15.  -4.  14. -12.   3.   8. -13.   7.  -7.   2.   2.] [ 0
. -4.  7. -8.  2. 19.  0.]
[  4.   3.  -7.   3.  -5.  -3.   6.   5.   1.  -9.  11.   6.  -8.   0.
 -10.  17. -15.  -4.  14. -12.   3.   8. -13.   7.  -7.   2.   2.   0.] [ -
4.   7.  -8.   2.  19.   0. -13.]
[  3.  -7.   3.  -5.  -3.   6.   5.   1.  -9.  11.   6.  -8.   0. -10.
  17. -15.  -4.  14. -12.   3.   8. -13.   7.  -7.   2.   2.   0.  -4.] [
7.  -8.   2.  19.   0. -13.  -8.]
[ -7.   3.  -5.  -3.   6.   5.   1.  -9.  11.   6.  -8.   0. -10.  17.
 -15.  -4.  14. -12.   3.   8. -13.   7.  -7.   2.   2.   0.  -4.   7.] [ -
8.   2.  19.   0. -13.  -8.   9.]
[  3.  -5.  -3.   6.   5.   1.  -9.  11.   6.  -8.   0. -10.  17. -15.
  -4.  14. -12.   3.   8. -13.   7.  -7.   2.   2.   0.  -4.   7.  -8.] [
2.  19.   0. -13.  -8.   9.   3.]
[ -5.  -3.   6.   5.   1.  -9.  11.   6.  -8.   0. -10.  17. -15.  -4.
  14. -12.   3.   8. -13.   7.  -7.   2.   2.   0.  -4.   7.  -8.   2.] [ 1
9.   0. -13.  -8.   9.   3. -12.]
[ -3.   6.   5.   1.  -9.  11.   6.  -8.   0. -10.  17. -15.  -4.  14.
```

```
 -12.   3.   8. -13.   7.  -7.   2.   2.   0.  -4.   7.  -8.   2.  19.] [
0. -13.  -8.   9.   3. -12.  27.]
[  6.   5.   1.  -9.  11.   6.  -8.   0. -10.  17. -15.  -4.  14. -12.
   3.   8. -13.   7.  -7.   2.   2.   0.  -4.   7.  -8.   2.  19.   0.] [-1
3.  -8.   9.   3. -12.  27. -22.]
[  5.   1.  -9.  11.   6.  -8.   0. -10.  17. -15.  -4.  14. -12.   3.
   8. -13.   7.  -7.   2.   2.   0.  -4.   7.  -8.   2.  19.   0. -13.] [ -
8.   9.   3. -12.  27. -22.  12.]
[  1.  -9.  11.   6.  -8.   0. -10.  17. -15.  -4.  14. -12.   3.   8.
 -13.   7.  -7.   2.   2.   0.  -4.   7.  -8.   2.  19.   0. -13.  -8.] [
9.   3. -12.  27. -22.  12. -18.]
[ -9.  11.   6.  -8.   0. -10.  17. -15.  -4.  14. -12.   3.   8. -13.
   7.  -7.   2.   2.   0.  -4.   7.  -8.   2.  19.   0. -13.  -8.   9.] [
3. -12.  27. -22.  12. -18.  23.]
[ 11.   6.  -8.   0. -10.  17. -15.  -4.  14. -12.   3.   8. -13.   7.
  -7.   2.   2.   0.  -4.   7.  -8.   2.  19.   0. -13.  -8.   9.   3.] [-1
2.  27. -22.  12. -18.  23. -15.]
[  6.  -8.   0. -10.  17. -15.  -4.  14. -12.   3.   8. -13.   7.  -7.
   2.   2.   0.  -4.   7.  -8.   2.  19.   0. -13.  -8.   9.   3. -12.] [ 2
7. -22.  12. -18.  23. -15.   6.]
[ -8.   0. -10.  17. -15.  -4.  14. -12.   3.   8. -13.   7.  -7.   2.
   2.   0.  -4.   7.  -8.   2.  19.   0. -13.  -8.   9.   3. -12.  27.] [-2
2.  12. -18.  23. -15.   6.  -3.]
[  0. -10.  17. -15.  -4.  14. -12.   3.   8. -13.   7.  -7.   2.   2.
   0.  -4.   7.  -8.   2.  19.   0. -13.  -8.   9.   3. -12.  27. -22.] [ 1
2. -18.  23. -15.   6.  -3.   8.]
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  -4.   7.  -8.   2.  19.   0. -13.  -8.   9.   3. -12.  27. -22.  12.] [-1
8.  23. -15.   6.  -3.   8.   1.]
[ 17. -15.  -4.  14. -12.   3.   8. -13.   7.  -7.   2.   2.   0.  -4.
   7.  -8.   2.  19.   0. -13.  -8.   9.   3. -12.  27. -22.  12. -18.] [ 2
3. -15.   6.  -3.   8.   1. -10.]
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  -8.   2.  19.   0. -13.  -8.   9.   3. -12.  27. -22.  12. -18.  23.] [-1
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[ -4.  14. -12.   3.   8. -13.   7.  -7.   2.   2.   0.  -4.   7.  -8.
   2.  19.   0. -13.  -8.   9.   3. -12.  27. -22.  12. -18.  23. -15.] [
6.  -3.   8.   1. -10.   1.  -5.]
[ 14. -12.   3.   8. -13.   7.  -7.   2.   2.   0.  -4.   7.  -8.   2.
  19.   0. -13.  -8.   9.   3. -12.  27. -22.  12. -18.  23. -15.   6.] [ -
3.   8.   1. -10.   1.  -5.  11.]
[-12.   3.   8. -13.   7.  -7.   2.   2.   0.  -4.   7.  -8.   2.  19.
   0. -13.  -8.   9.   3. -12.  27. -22.  12. -18.  23. -15.   6.  -3.] [
8.   1. -10.   1.  -5.  11.  -2.]
[  3.   8. -13.   7.  -7.   2.   2.   0.  -4.   7.  -8.   2.  19.   0.
 -13.  -8.   9.   3. -12.  27. -22.  12. -18.  23. -15.   6.  -3.   8.] [
1. -10.   1.  -5.  11.  -2.  -6.]
[  8. -13.   7.  -7.   2.   2.   0.  -4.   7.  -8.   2.  19.   0. -13.
  -8.   9.   3. -12.  27. -22.  12. -18.  23. -15.   6.  -3.   8.   1.] [-1
0.   1.  -5.  11.  -2.  -6.  -2.]
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. -5. 11. -2. -6. -2. -6.]
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   3. -12.  27. -22.  12. -18.  23. -15.   6.  -3.   8.   1. -10.   1.] [-5
. 11. -2. -6. -2. -6. 18.]
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 -12.  27. -22.  12. -18.  23. -15.   6.  -3.   8.   1. -10.   1.  -5.] [11
. -2. -6. -2. -6. 18. -6.]
[  2.   2.   0.  -4.   7.  -8.   2.  19.   0. -13.  -8.   9.   3. -12.
  27. -22.  12. -18.  23. -15.   6.  -3.   8.   1. -10.   1.  -5.  11.] [-2
```

```
. -6. -2. -6. 18. -6.  4.]
[  2.   0.  -4.   7.  -8.   2.  19.   0. -13.  -8.   9.   3. -12.  27.
 -22.  12. -18.  23. -15.   6.  -3.   8.   1. -10.   1.  -5.  11.  -2.] [-6
. -2. -6. 18. -6.  4.  3.]
[  0.  -4.   7.  -8.   2.  19.   0. -13.  -8.   9.   3. -12.  27. -22.
  12. -18.  23. -15.   6.  -3.   8.   1. -10.   1.  -5.  11.  -2.  -6.] [-2
. -6. 18. -6.  4.  3. -4.]
[ -4.   7.  -8.   2.  19.   0. -13.  -8.   9.   3. -12.  27. -22.  12.
 -18.  23. -15.   6.  -3.   8.   1. -10.   1.  -5.  11.  -2.  -6.  -2.] [-6
. 18. -6.  4.  3. -4. -7.]
[  7.  -8.   2.  19.   0. -13.  -8.   9.   3. -12.  27. -22.  12. -18.
  23. -15.   6.  -3.   8.   1. -10.   1.  -5.  11.  -2.  -6.  -2.  -6.] [18
. -6.  4.  3. -4. -7. -8.]
[ -8.   2.  19.   0. -13.  -8.   9.   3. -12.  27. -22.  12. -18.  23.
 -15.   6.  -3.   8.   1. -10.   1.  -5.  11.  -2.  -6.  -2.  -6.  18.] [-6
.  4.  3. -4. -7. -8. 13.]
[  2.  19.   0. -13.  -8.   9.   3. -12.  27. -22.  12. -18.  23. -15.
   6.  -3.   8.   1. -10.   1.  -5.  11.  -2.  -6.  -2.  -6.  18.  -6.] [ 4
.  3. -4. -7. -8. 13. 16.]
[ 19.   0. -13.  -8.   9.   3. -12.  27. -22.  12. -18.  23. -15.   6.
  -3.   8.   1. -10.   1.  -5.  11.  -2.  -6.  -2.  -6.  18.  -6.   4.] [
3.  -4.  -7.  -8.  13.  16. -19.]
[  0. -13.  -8.   9.   3. -12.  27. -22.  12. -18.  23. -15.   6.  -3.
   8.   1. -10.   1.  -5.  11.  -2.  -6.  -2.  -6.  18.  -6.   4.   3.] [ -
4.  -7.  -8.  13.  16. -19.   2.]
[-13.  -8.   9.   3. -12.  27. -22.  12. -18.  23. -15.   6.  -3.   8.
   1. -10.   1.  -5.  11.  -2.  -6.  -2.  -6.  18.  -6.   4.   3.  -4.] [ -
7.  -8.  13.  16. -19.   2.  14.]
[ -8.   9.   3. -12.  27. -22.  12. -18.  23. -15.   6.  -3.   8.   1.
 -10.   1.  -5.  11.  -2.  -6.  -2.  -6.  18.  -6.   4.   3.  -4.  -7.] [ -
8.  13.  16. -19.   2.  14. -23.]
[  9.   3. -12.  27. -22.  12. -18.  23. -15.   6.  -3.   8.   1. -10.
   1.  -5.  11.  -2.  -6.  -2.  -6.  18.  -6.   4.   3.  -4.  -7.  -8.] [ 1
3.  16. -19.   2.  14. -23.  21.]
[  3. -12.  27. -22.  12. -18.  23. -15.   6.  -3.   8.   1. -10.   1.
  -5.  11.  -2.  -6.  -2.  -6.  18.  -6.   4.   3.  -4.  -7.  -8.  13.] [ 1
6. -19.   2.  14. -23.  21.   1.]
[-12.  27. -22.  12. -18.  23. -15.   6.  -3.   8.   1. -10.   1.  -5.
  11.  -2.  -6.  -2.  -6.  18.  -6.   4.   3.  -4.  -7.  -8.  13.  16.] [-1
9.   2.  14. -23.  21.   1.  -8.]
[ 27. -22.  12. -18.  23. -15.   6.  -3.   8.   1. -10.   1.  -5.  11.
  -2.  -6.  -2.  -6.  18.  -6.   4.   3.  -4.  -7.  -8.  13.  16. -19.] [
2.  14. -23.  21.   1.  -8. -16.]
[-22.  12. -18.  23. -15.   6.  -3.   8.   1. -10.   1.  -5.  11.  -2.
  -6.  -2.  -6.  18.  -6.   4.   3.  -4.  -7.  -8.  13.  16. -19.   2.] [ 1
4. -23.  21.   1.  -8. -16.  18.]
[ 12. -18.  23. -15.   6.  -3.   8.   1. -10.   1.  -5.  11.  -2.  -6.
  -2.  -6.  18.  -6.   4.   3.  -4.  -7.  -8.  13.  16. -19.   2.  14.] [-2
3.  21.   1.  -8. -16.  18.  -4.]
[-18.  23. -15.   6.  -3.   8.   1. -10.   1.  -5.  11.  -2.  -6.  -2.
  -6.  18.  -6.   4.   3.  -4.  -7.  -8.  13.  16. -19.   2.  14. -23.] [ 2
1.   1.  -8. -16.  18.  -4.  -1.]
[ 23. -15.   6.  -3.   8.   1. -10.   1.  -5.  11.  -2.  -6.  -2.  -6.
  18.  -6.   4.   3.  -4.  -7.  -8.  13.  16. -19.   2.  14. -23.  21.] [
1.  -8. -16.  18.  -4.  -1.   8.]
[-15.   6.  -3.   8.   1. -10.   1.  -5.  11.  -2.  -6.  -2.  -6.  18.
  -6.   4.   3.  -4.  -7.  -8.  13.  16. -19.   2.  14. -23.  21.   1.] [ -
8. -16.  18.  -4.  -1.   8.  -6.]
[  6.  -3.   8.   1. -10.   1.  -5.  11.  -2.  -6.  -2.  -6.  18.  -6.
   4.   3.  -4.  -7.  -8.  13.  16. -19.   2.  14. -23.  21.   1.  -8.] [-1
6.  18.  -4.  -1.   8.  -6.   4.]
```

```
[ -3.   8.   1. -10.   1.  -5.  11.  -2.  -6.  -2.  -6.  18.  -6.   4.
   3.  -4.  -7.  -8.  13.  16. -19.   2.  14. -23.  21.   1.  -8. -16.] [18
. -4. -1.  8. -6.  4. -9.]
[  8.   1. -10.   1.  -5.  11.  -2.  -6.  -2.  -6.  18.  -6.   4.   3.
  -4.  -7.  -8.  13.  16. -19.   2.  14. -23.  21.   1.  -8. -16.  18.] [ -
4.  -1.   8.  -6.   4.  -9. -10.]
[  1. -10.   1.  -5.  11.  -2.  -6.  -2.  -6.  18.  -6.   4.   3.  -4.
  -7.  -8.  13.  16. -19.   2.  14. -23.  21.   1.  -8. -16.  18.  -4.] [ -
1.   8.  -6.   4.  -9. -10.   1.]
[-10.   1.  -5.  11.  -2.  -6.  -2.  -6.  18.  -6.   4.   3.  -4.  -7.
  -8.  13.  16. -19.   2.  14. -23.  21.   1.  -8. -16.  18.  -4.  -1.] [
8.  -6.   4.  -9. -10.   1.  19.]
[  1.  -5.  11.  -2.  -6.  -2.  -6.  18.  -6.   4.   3.  -4.  -7.  -8.
  13.  16. -19.   2.  14. -23.  21.   1.  -8. -16.  18.  -4.  -1.   8.] [ -
6.   4.  -9. -10.   1.  19. -14.]
[ -5.  11.  -2.  -6.  -2.  -6.  18.  -6.   4.   3.  -4.  -7.  -8.  13.
  16. -19.   2.  14. -23.  21.   1.  -8. -16.  18.  -4.  -1.   8.  -6.] [
4.  -9. -10.   1.  19. -14.  -7.]
[ 11.  -2.  -6.  -2.  -6.  18.  -6.   4.   3.  -4.  -7.  -8.  13.  16.
 -19.   2.  14. -23.  21.   1.  -8. -16.  18.  -4.  -1.   8.  -6.   4.] [ -
9. -10.   1.  19. -14.  -7.  -2.]
[ -2.  -6.  -2.  -6.  18.  -6.   4.   3.  -4.  -7.  -8.  13.  16. -19.
   2.  14. -23.  21.   1.  -8. -16.  18.  -4.  -1.   8.  -6.   4.  -9.] [-1
0.   1.  19. -14.  -7.  -2.   1.]
[ -6.  -2.  -6.  18.  -6.   4.   3.  -4.  -7.  -8.  13.  16. -19.   2.
  14. -23.  21.   1.  -8. -16.  18.  -4.  -1.   8.  -6.   4.  -9. -10.] [
1.  19. -14.  -7.  -2.   1.   3.]
[ -2.  -6.  18.  -6.   4.   3.  -4.  -7.  -8.  13.  16. -19.   2.  14.
 -23.  21.   1.  -8. -16.  18.  -4.  -1.   8.  -6.   4.  -9. -10.   1.] [ 1
9. -14.  -7.  -2.   1.   3.   4.]
[ -6.  18.  -6.   4.   3.  -4.  -7.  -8.  13.  16. -19.   2.  14. -23.
  21.   1.  -8. -16.  18.  -4.  -1.   8.  -6.   4.  -9. -10.   1.  19.] [-1
4.  -7.  -2.   1.   3.   4.   1.]
[ 18.  -6.   4.   3.  -4.  -7.  -8.  13.  16. -19.   2.  14. -23.  21.
   1.  -8. -16.  18.  -4.  -1.   8.  -6.   4.  -9. -10.   1.  19. -14.] [-7
. -2.  1.  3.  4.  1. -3.]
[ -6.   4.   3.  -4.  -7.  -8.  13.  16. -19.   2.  14. -23.  21.   1.
  -8. -16.  18.  -4.  -1.   8.  -6.   4.  -9. -10.   1.  19. -14.  -7.] [-2
.  1.  3.  4.  1. -3.  0.]
[  4.   3.  -4.  -7.  -8.  13.  16. -19.   2.  14. -23.  21.   1.  -8.
 -16.  18.  -4.  -1.   8.  -6.   4.  -9. -10.   1.  19. -14.  -7.  -2.] [ 1
.  3.  4.  1. -3.  0. 15.]
[  3.  -4.  -7.  -8.  13.  16. -19.   2.  14. -23.  21.   1.  -8. -16.
  18.  -4.  -1.   8.  -6.   4.  -9. -10.   1.  19. -14.  -7.  -2.   1.] [
3.   4.   1.  -3.   0.  15. -15.]
[ -4.  -7.  -8.  13.  16. -19.   2.  14. -23.  21.   1.  -8. -16.  18.
  -4.  -1.   8.  -6.   4.  -9. -10.   1.  19. -14.  -7.  -2.   1.   3.] [
4.   1.  -3.   0.  15. -15.  -2.]
[ -7.  -8.  13.  16. -19.   2.  14. -23.  21.   1.  -8. -16.  18.  -4.
  -1.   8.  -6.   4.  -9. -10.   1.  19. -14.  -7.  -2.   1.   3.   4.] [
1.  -3.   0.  15. -15.  -2.   8.]
[ -8.  13.  16. -19.   2.  14. -23.  21.   1.  -8. -16.  18.  -4.  -1.
   8.  -6.   4.  -9. -10.   1.  19. -14.  -7.  -2.   1.   3.   4.   1.] [ -
3.   0.  15. -15.  -2.   8.   1.]
```

Приведем входные данные к нужному формату.

In [225…

```
n_features = 1
features = features.reshape(features.shape[0], features.shape[1], n_feature
```

Определим и обучим модель с одним скрытым слоем.

In [226…

```
# определяем модель
model_vector_LSTM1 = Sequential()
model_vector_LSTM1.add(LSTM(50, activation='relu', input_shape=(n_steps_in,
model_vector_LSTM1.add(Dense(n_steps_out))
model_vector_LSTM1.compile(optimizer='adam', loss='mse')
# обучаем модель
model_vector_LSTM1.fit(features, target, epochs=120, verbose=1)
```

```
Epoch 1/120
10/10 [==============================] - 1s 12ms/step - loss: 118.6456
Epoch 2/120
10/10 [==============================] - 0s 12ms/step - loss: 117.4109
Epoch 3/120
10/10 [==============================] - 0s 13ms/step - loss: 116.6102
Epoch 4/120
10/10 [==============================] - 0s 12ms/step - loss: 115.7155
Epoch 5/120
10/10 [==============================] - 0s 14ms/step - loss: 114.8789
Epoch 6/120
10/10 [==============================] - 0s 12ms/step - loss: 114.0004
Epoch 7/120
10/10 [==============================] - 0s 12ms/step - loss: 113.1877
Epoch 8/120
10/10 [==============================] - 0s 14ms/step - loss: 112.8801
Epoch 9/120
10/10 [==============================] - 0s 13ms/step - loss: 113.3787
Epoch 10/120
10/10 [==============================] - 0s 12ms/step - loss: 113.2663
Epoch 11/120
10/10 [==============================] - 0s 12ms/step - loss: 112.2629
Epoch 12/120
10/10 [==============================] - 0s 13ms/step - loss: 110.9653
Epoch 13/120
10/10 [==============================] - 0s 13ms/step - loss: 110.3367
Epoch 14/120
10/10 [==============================] - 0s 13ms/step - loss: 110.0408
Epoch 15/120
10/10 [==============================] - 0s 12ms/step - loss: 108.4926
Epoch 16/120
10/10 [==============================] - 0s 13ms/step - loss: 107.6548
Epoch 17/120
10/10 [==============================] - 0s 13ms/step - loss: 106.1314
Epoch 18/120
10/10 [==============================] - 0s 13ms/step - loss: 105.7525
Epoch 19/120
10/10 [==============================] - 0s 13ms/step - loss: 104.2012
Epoch 20/120
10/10 [==============================] - 0s 12ms/step - loss: 102.4968
Epoch 21/120
10/10 [==============================] - 0s 13ms/step - loss: 101.3353
Epoch 22/120
10/10 [==============================] - 0s 12ms/step - loss: 99.3692
Epoch 23/120
10/10 [==============================] - 0s 14ms/step - loss: 97.7048
Epoch 24/120
10/10 [==============================] - 0s 12ms/step - loss: 95.8973
Epoch 25/120
```

```
10/10 [==============================] - 0s 13ms/step - loss: 94.8025
Epoch 26/120
10/10 [==============================] - 0s 12ms/step - loss: 93.8019
Epoch 27/120
10/10 [==============================] - 0s 14ms/step - loss: 95.2712
Epoch 28/120
10/10 [==============================] - 0s 12ms/step - loss: 94.1161
Epoch 29/120
10/10 [==============================] - 0s 12ms/step - loss: 90.3212
Epoch 30/120
10/10 [==============================] - 0s 13ms/step - loss: 86.8479
Epoch 31/120
10/10 [==============================] - 0s 14ms/step - loss: 83.6665
Epoch 32/120
10/10 [==============================] - 0s 13ms/step - loss: 81.7194
Epoch 33/120
10/10 [==============================] - 0s 12ms/step - loss: 78.0225
Epoch 34/120
10/10 [==============================] - 0s 13ms/step - loss: 76.7096
Epoch 35/120
10/10 [==============================] - 0s 13ms/step - loss: 76.9466
Epoch 36/120
10/10 [==============================] - 0s 13ms/step - loss: 72.7344
Epoch 37/120
10/10 [==============================] - 0s 12ms/step - loss: 69.6232
Epoch 38/120
10/10 [==============================] - 0s 12ms/step - loss: 69.1753
Epoch 39/120
10/10 [==============================] - 0s 14ms/step - loss: 68.7112
Epoch 40/120
10/10 [==============================] - 0s 14ms/step - loss: 64.6706
Epoch 41/120
10/10 [==============================] - 0s 13ms/step - loss: 59.7933
Epoch 42/120
10/10 [==============================] - 0s 13ms/step - loss: 56.3593
Epoch 43/120
10/10 [==============================] - 0s 12ms/step - loss: 56.9381
Epoch 44/120
10/10 [==============================] - 0s 12ms/step - loss: 58.0235
Epoch 45/120
10/10 [==============================] - 0s 13ms/step - loss: 55.0641
Epoch 46/120
10/10 [==============================] - 0s 14ms/step - loss: 53.0265
Epoch 47/120
10/10 [==============================] - 0s 14ms/step - loss: 50.9025
Epoch 48/120
10/10 [==============================] - 0s 13ms/step - loss: 49.2141
Epoch 49/120
10/10 [==============================] - 0s 13ms/step - loss: 46.0360
Epoch 50/120
10/10 [==============================] - 0s 13ms/step - loss: 42.7039
Epoch 51/120
10/10 [==============================] - 0s 13ms/step - loss: 40.7957
Epoch 52/120
10/10 [==============================] - 0s 12ms/step - loss: 38.9471
Epoch 53/120
10/10 [==============================] - 0s 13ms/step - loss: 43.1451
Epoch 54/120
10/10 [==============================] - 0s 14ms/step - loss: 40.4229
Epoch 55/120
10/10 [==============================] - 0s 13ms/step - loss: 38.0583
```

```
Epoch 56/120
10/10 [==============================] - 0s 13ms/step - loss: 37.9670
Epoch 57/120
10/10 [==============================] - 0s 13ms/step - loss: 34.6148
Epoch 58/120
10/10 [==============================] - 0s 12ms/step - loss: 32.0994
Epoch 59/120
10/10 [==============================] - 0s 13ms/step - loss: 30.3251
Epoch 60/120
10/10 [==============================] - 0s 13ms/step - loss: 28.7787
Epoch 61/120
10/10 [==============================] - 0s 14ms/step - loss: 28.3161
Epoch 62/120
10/10 [==============================] - 0s 13ms/step - loss: 29.9391
Epoch 63/120
10/10 [==============================] - 0s 13ms/step - loss: 28.9542
Epoch 64/120
10/10 [==============================] - 0s 12ms/step - loss: 27.6028
Epoch 65/120
10/10 [==============================] - 0s 13ms/step - loss: 25.6188
Epoch 66/120
10/10 [==============================] - 0s 12ms/step - loss: 24.1315
Epoch 67/120
10/10 [==============================] - 0s 13ms/step - loss: 24.0952
Epoch 68/120
10/10 [==============================] - 0s 12ms/step - loss: 23.3710
Epoch 69/120
10/10 [==============================] - 0s 15ms/step - loss: 23.1104
Epoch 70/120
10/10 [==============================] - 0s 12ms/step - loss: 22.2520
Epoch 71/120
10/10 [==============================] - 0s 13ms/step - loss: 21.4159
Epoch 72/120
10/10 [==============================] - 0s 13ms/step - loss: 20.9838
Epoch 73/120
10/10 [==============================] - 0s 14ms/step - loss: 20.0904
Epoch 74/120
10/10 [==============================] - 0s 12ms/step - loss: 19.5873
Epoch 75/120
10/10 [==============================] - 0s 15ms/step - loss: 19.8729
Epoch 76/120
10/10 [==============================] - 0s 14ms/step - loss: 18.4388
Epoch 77/120
10/10 [==============================] - 0s 13ms/step - loss: 18.4648
Epoch 78/120
10/10 [==============================] - 0s 14ms/step - loss: 17.9766
Epoch 79/120
10/10 [==============================] - 0s 13ms/step - loss: 17.0441
Epoch 80/120
10/10 [==============================] - 0s 12ms/step - loss: 20.6201
Epoch 81/120
10/10 [==============================] - 0s 13ms/step - loss: 20.1444
Epoch 82/120
10/10 [==============================] - 0s 12ms/step - loss: 18.6531
Epoch 83/120
10/10 [==============================] - 0s 13ms/step - loss: 19.3739
Epoch 84/120
10/10 [==============================] - 0s 14ms/step - loss: 19.9813
Epoch 85/120
10/10 [==============================] - 0s 12ms/step - loss: 17.0337
Epoch 86/120
```

```
10/10 [==============================] - 0s 12ms/step - loss: 15.8854
Epoch 87/120
10/10 [==============================] - 0s 13ms/step - loss: 14.3310
Epoch 88/120
10/10 [==============================] - 0s 13ms/step - loss: 14.2942
Epoch 89/120
10/10 [==============================] - 0s 13ms/step - loss: 14.4388
Epoch 90/120
10/10 [==============================] - 0s 13ms/step - loss: 13.0520
Epoch 91/120
10/10 [==============================] - 0s 12ms/step - loss: 12.3095
Epoch 92/120
10/10 [==============================] - 0s 15ms/step - loss: 11.6519
Epoch 93/120
10/10 [==============================] - 0s 12ms/step - loss: 12.1931
Epoch 94/120
10/10 [==============================] - 0s 13ms/step - loss: 11.5654
Epoch 95/120
10/10 [==============================] - 0s 12ms/step - loss: 11.0613
Epoch 96/120
10/10 [==============================] - 0s 13ms/step - loss: 10.3394
Epoch 97/120
10/10 [==============================] - 0s 12ms/step - loss: 9.6797
Epoch 98/120
10/10 [==============================] - 0s 13ms/step - loss: 9.3684
Epoch 99/120
10/10 [==============================] - 0s 14ms/step - loss: 8.7787
Epoch 100/120
10/10 [==============================] - 0s 13ms/step - loss: 9.1871
Epoch 101/120
10/10 [==============================] - 0s 12ms/step - loss: 9.4543
Epoch 102/120
10/10 [==============================] - 0s 13ms/step - loss: 9.4551
Epoch 103/120
10/10 [==============================] - 0s 12ms/step - loss: 8.8518
Epoch 104/120
10/10 [==============================] - 0s 13ms/step - loss: 7.7081
Epoch 105/120
10/10 [==============================] - 0s 12ms/step - loss: 7.9024
Epoch 106/120
10/10 [==============================] - 0s 13ms/step - loss: 7.6983
Epoch 107/120
10/10 [==============================] - 0s 14ms/step - loss: 7.5121
Epoch 108/120
10/10 [==============================] - 0s 13ms/step - loss: 6.9830
Epoch 109/120
10/10 [==============================] - 0s 13ms/step - loss: 6.4092
Epoch 110/120
10/10 [==============================] - 0s 13ms/step - loss: 6.0585
Epoch 111/120
10/10 [==============================] - 0s 13ms/step - loss: 6.1850
Epoch 112/120
10/10 [==============================] - 0s 14ms/step - loss: 6.0639
Epoch 113/120
10/10 [==============================] - 0s 13ms/step - loss: 6.1845
Epoch 114/120
10/10 [==============================] - 0s 14ms/step - loss: 6.3522
Epoch 115/120
10/10 [==============================] - 0s 13ms/step - loss: 6.1804
Epoch 116/120
10/10 [==============================] - 0s 12ms/step - loss: 6.6266
```

```
Epoch 117/120
10/10 [==============================] - 0s 14ms/step - loss: 6.2010
Epoch 118/120
10/10 [==============================] - 0s 12ms/step - loss: 5.5982
Epoch 119/120
10/10 [==============================] - 0s 12ms/step - loss: 5.4637
Epoch 120/120
10/10 [==============================] - 0s 13ms/step - loss: 5.6233
```

Out[226…

```
<keras.callbacks.History at 0x7ff4008327d0>
```

Определим признаки на входе.

In [216…

```
features_input = np.array(sales_diff[:'2021-12-23'].tail(28))
features_input = features_input.reshape(1, n_steps_in, n_features)
```

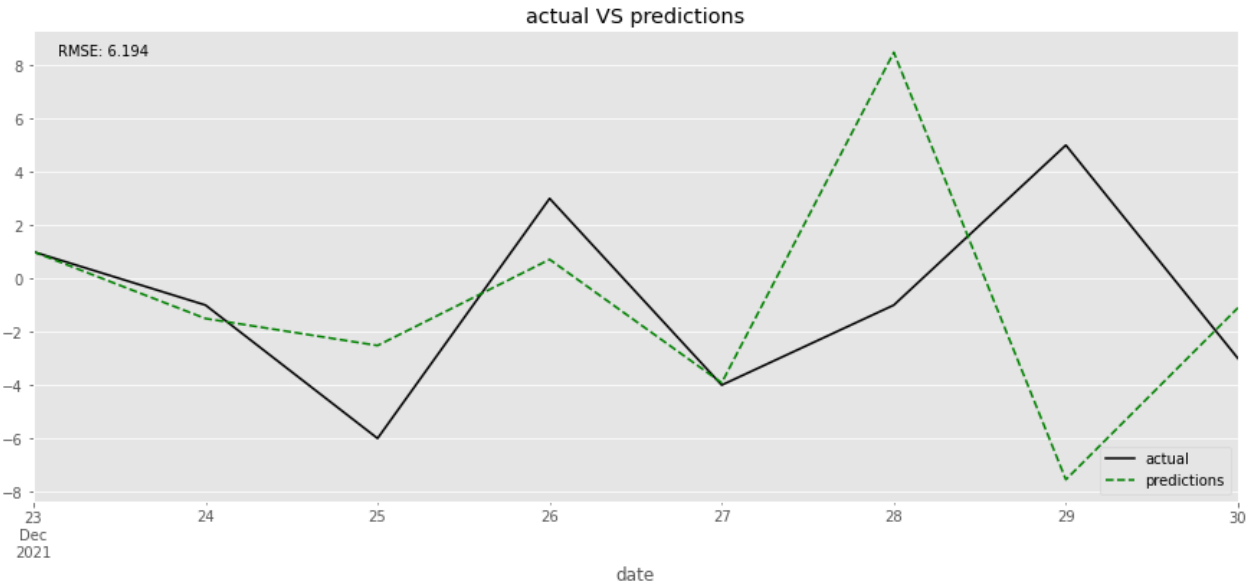
Теперь вычислим RMSE на последней неделе и построим график.

In [134…

```
prediction = model_vector_LSTM1.predict(features_input, verbose=0)
error = rmse(sales_diff['2021-12-24':], prediction[0])
```

In [135…

```
plot_result(8, error,
            sales_diff['2021-12-23':],
            np.concatenate(([sales_diff['2021-12-23']], prediction[0])))
```



Попробуем добавить ещё один слой.

In [136…

```
# определяем модель
model_vector_LSTM2 = Sequential()
model_vector_LSTM2.add(LSTM(30, activation='relu', return_sequences=True, i
model_vector_LSTM2.add(LSTM(110, activation='relu'))
model_vector_LSTM2.add(Dense(n_steps_out))
model_vector_LSTM2.compile(optimizer='adam', loss='mse')
# обучаем модель
model_vector_LSTM2.fit(features, target, epochs=120, verbose=1)
```

```
Epoch 1/120
10/10 [==============================] - 4s 51ms/step - loss: 118.0332
Epoch 2/120
10/10 [==============================] - 1s 50ms/step - loss: 117.8657
Epoch 3/120
10/10 [==============================] - 1s 51ms/step - loss: 117.8432
Epoch 4/120
10/10 [==============================] - 0s 50ms/step - loss: 117.8312
Epoch 5/120
10/10 [==============================] - 1s 52ms/step - loss: 117.7976
Epoch 6/120
10/10 [==============================] - 1s 54ms/step - loss: 117.7444
Epoch 7/120
10/10 [==============================] - 1s 113ms/step - loss: 117.7008
Epoch 8/120
10/10 [==============================] - 0s 50ms/step - loss: 117.4331
Epoch 9/120
10/10 [==============================] - 1s 52ms/step - loss: 116.1831
Epoch 10/120
10/10 [==============================] - 1s 50ms/step - loss: 115.1513
Epoch 11/120
10/10 [==============================] - 1s 53ms/step - loss: 112.6232
Epoch 12/120
10/10 [==============================] - 1s 50ms/step - loss: 111.5622
Epoch 13/120
10/10 [==============================] - 1s 52ms/step - loss: 110.2635
Epoch 14/120
10/10 [==============================] - 0s 49ms/step - loss: 110.2715
Epoch 15/120
10/10 [==============================] - 1s 53ms/step - loss: 106.6753
Epoch 16/120
10/10 [==============================] - 1s 51ms/step - loss: 104.7881
Epoch 17/120
10/10 [==============================] - 1s 52ms/step - loss: 102.9620
Epoch 18/120
10/10 [==============================] - 1s 50ms/step - loss: 101.0126
Epoch 19/120
10/10 [==============================] - 1s 56ms/step - loss: 100.1906
Epoch 20/120
10/10 [==============================] - 0s 50ms/step - loss: 98.0456
Epoch 21/120
10/10 [==============================] - 1s 51ms/step - loss: 91.2796
Epoch 22/120
10/10 [==============================] - 1s 51ms/step - loss: 86.5435
Epoch 23/120
10/10 [==============================] - 1s 50ms/step - loss: 83.6029
Epoch 24/120
10/10 [==============================] - 0s 47ms/step - loss: 76.8034
Epoch 25/120
10/10 [==============================] - 1s 52ms/step - loss: 69.9700
Epoch 26/120
10/10 [==============================] - 0s 49ms/step - loss: 63.0773
Epoch 27/120
10/10 [==============================] - 1s 51ms/step - loss: 58.1042
Epoch 28/120
10/10 [==============================] - 1s 82ms/step - loss: 53.8062
Epoch 29/120
10/10 [==============================] - 1s 113ms/step - loss: 49.7875
Epoch 30/120
10/10 [==============================] - 0s 49ms/step - loss: 44.7782
Epoch 31/120
```

```
10/10 [==============================] - 1s 51ms/step - loss: 41.6951
Epoch 32/120
10/10 [==============================] - 0s 50ms/step - loss: 37.3055
Epoch 33/120
10/10 [==============================] - 1s 52ms/step - loss: 30.2170
Epoch 34/120
10/10 [==============================] - 1s 52ms/step - loss: 25.6502
Epoch 35/120
10/10 [==============================] - 1s 54ms/step - loss: 22.2377
Epoch 36/120
10/10 [==============================] - 0s 49ms/step - loss: 19.1808
Epoch 37/120
10/10 [==============================] - 1s 53ms/step - loss: 17.1238
Epoch 38/120
10/10 [==============================] - 1s 51ms/step - loss: 14.3474
Epoch 39/120
10/10 [==============================] - 1s 52ms/step - loss: 12.4668
Epoch 40/120
10/10 [==============================] - 1s 50ms/step - loss: 10.1876
Epoch 41/120
10/10 [==============================] - 1s 51ms/step - loss: 8.5656
Epoch 42/120
10/10 [==============================] - 1s 51ms/step - loss: 6.8177
Epoch 43/120
10/10 [==============================] - 1s 53ms/step - loss: 5.5558
Epoch 44/120
10/10 [==============================] - 0s 49ms/step - loss: 4.9421
Epoch 45/120
10/10 [==============================] - 1s 52ms/step - loss: 4.2996
Epoch 46/120
10/10 [==============================] - 0s 48ms/step - loss: 3.7847
Epoch 47/120
10/10 [==============================] - 1s 54ms/step - loss: 3.3046
Epoch 48/120
10/10 [==============================] - 0s 49ms/step - loss: 3.1634
Epoch 49/120
10/10 [==============================] - 1s 52ms/step - loss: 2.7158
Epoch 50/120
10/10 [==============================] - 1s 50ms/step - loss: 2.3788
Epoch 51/120
10/10 [==============================] - 1s 53ms/step - loss: 2.0389
Epoch 52/120
10/10 [==============================] - 1s 51ms/step - loss: 1.7991
Epoch 53/120
10/10 [==============================] - 1s 53ms/step - loss: 1.8753
Epoch 54/120
10/10 [==============================] - 1s 52ms/step - loss: 1.8356
Epoch 55/120
10/10 [==============================] - 1s 51ms/step - loss: 1.7039
Epoch 56/120
10/10 [==============================] - 1s 51ms/step - loss: 1.4942
Epoch 57/120
10/10 [==============================] - 1s 53ms/step - loss: 1.4525
Epoch 58/120
10/10 [==============================] - 1s 51ms/step - loss: 1.3990
Epoch 59/120
10/10 [==============================] - 1s 51ms/step - loss: 1.2613
Epoch 60/120
10/10 [==============================] - 1s 51ms/step - loss: 1.2423
Epoch 61/120
10/10 [==============================] - 1s 51ms/step - loss: 1.1350
```

```
Epoch 62/120
10/10 [==============================] - 1s 51ms/step - loss: 1.0684
Epoch 63/120
10/10 [==============================] - 1s 53ms/step - loss: 0.9999
Epoch 64/120
10/10 [==============================] - 0s 49ms/step - loss: 0.9946
Epoch 65/120
10/10 [==============================] - 1s 52ms/step - loss: 0.8667
Epoch 66/120
10/10 [==============================] - 1s 50ms/step - loss: 0.7448
Epoch 67/120
10/10 [==============================] - 1s 50ms/step - loss: 0.6033
Epoch 68/120
10/10 [==============================] - 1s 52ms/step - loss: 0.6108
Epoch 69/120
10/10 [==============================] - 1s 51ms/step - loss: 0.5393
Epoch 70/120
10/10 [==============================] - 1s 53ms/step - loss: 0.4921
Epoch 71/120
10/10 [==============================] - 1s 51ms/step - loss: 0.4550
Epoch 72/120
10/10 [==============================] - 1s 52ms/step - loss: 0.4125
Epoch 73/120
10/10 [==============================] - 1s 53ms/step - loss: 0.4298
Epoch 74/120
10/10 [==============================] - 1s 51ms/step - loss: 0.4253
Epoch 75/120
10/10 [==============================] - 1s 51ms/step - loss: 0.4598
Epoch 76/120
10/10 [==============================] - 0s 50ms/step - loss: 0.4914
Epoch 77/120
10/10 [==============================] - 1s 53ms/step - loss: 0.4482
Epoch 78/120
10/10 [==============================] - 1s 52ms/step - loss: 0.4280
Epoch 79/120
10/10 [==============================] - 1s 52ms/step - loss: 0.4135
Epoch 80/120
10/10 [==============================] - 1s 51ms/step - loss: 0.3873
Epoch 81/120
10/10 [==============================] - 1s 51ms/step - loss: 0.4077
Epoch 82/120
10/10 [==============================] - 1s 52ms/step - loss: 0.3717
Epoch 83/120
10/10 [==============================] - 1s 53ms/step - loss: 0.3150
Epoch 84/120
10/10 [==============================] - 1s 50ms/step - loss: 0.2834
Epoch 85/120
10/10 [==============================] - 1s 54ms/step - loss: 0.2932
Epoch 86/120
10/10 [==============================] - 1s 51ms/step - loss: 0.3171
Epoch 87/120
10/10 [==============================] - 1s 53ms/step - loss: 0.3566
Epoch 88/120
10/10 [==============================] - 1s 53ms/step - loss: 0.3116
Epoch 89/120
10/10 [==============================] - 1s 52ms/step - loss: 0.3140
Epoch 90/120
10/10 [==============================] - 1s 51ms/step - loss: 0.3212
Epoch 91/120
10/10 [==============================] - 1s 52ms/step - loss: 0.2650
Epoch 92/120
```

```
10/10 [==============================] - 1s 51ms/step - loss: 0.2458
Epoch 93/120
10/10 [==============================] - 1s 52ms/step - loss: 0.2369
Epoch 94/120
10/10 [==============================] - 1s 50ms/step - loss: 0.2092
Epoch 95/120
10/10 [==============================] - 1s 51ms/step - loss: 0.1898
Epoch 96/120
10/10 [==============================] - 1s 52ms/step - loss: 0.1716
Epoch 97/120
10/10 [==============================] - 1s 54ms/step - loss: 0.1723
Epoch 98/120
10/10 [==============================] - 1s 52ms/step - loss: 0.1421
Epoch 99/120
10/10 [==============================] - 1s 52ms/step - loss: 0.1535
Epoch 100/120
10/10 [==============================] - 1s 51ms/step - loss: 0.1648
Epoch 101/120
10/10 [==============================] - 1s 51ms/step - loss: 0.1786
Epoch 102/120
10/10 [==============================] - 1s 52ms/step - loss: 0.1811
Epoch 103/120
10/10 [==============================] - 1s 52ms/step - loss: 0.1427
Epoch 104/120
10/10 [==============================] - 1s 52ms/step - loss: 0.1341
Epoch 105/120
10/10 [==============================] - 1s 52ms/step - loss: 0.1325
Epoch 106/120
10/10 [==============================] - 1s 53ms/step - loss: 0.1394
Epoch 107/120
10/10 [==============================] - 1s 52ms/step - loss: 0.1416
Epoch 108/120
10/10 [==============================] - 1s 54ms/step - loss: 0.1498
Epoch 109/120
10/10 [==============================] - 1s 52ms/step - loss: 0.1404
Epoch 110/120
10/10 [==============================] - 1s 52ms/step - loss: 0.1163
Epoch 111/120
10/10 [==============================] - 1s 52ms/step - loss: 0.1241
Epoch 112/120
10/10 [==============================] - 1s 52ms/step - loss: 0.1172
Epoch 113/120
10/10 [==============================] - 1s 51ms/step - loss: 0.1238
Epoch 114/120
10/10 [==============================] - 1s 54ms/step - loss: 0.1387
Epoch 115/120
10/10 [==============================] - 1s 52ms/step - loss: 0.1731
Epoch 116/120
10/10 [==============================] - 1s 53ms/step - loss: 0.1896
Epoch 117/120
10/10 [==============================] - 1s 52ms/step - loss: 0.1867
Epoch 118/120
10/10 [==============================] - 1s 54ms/step - loss: 0.1747
Epoch 119/120
10/10 [==============================] - 1s 54ms/step - loss: 0.1642
Epoch 120/120
10/10 [==============================] - 1s 54ms/step - loss: 0.1537
```

Out[136…
```
<keras.callbacks.History at 0x7ff4207c4750>
```

Вычислим RMSE и построим график.

In [137…

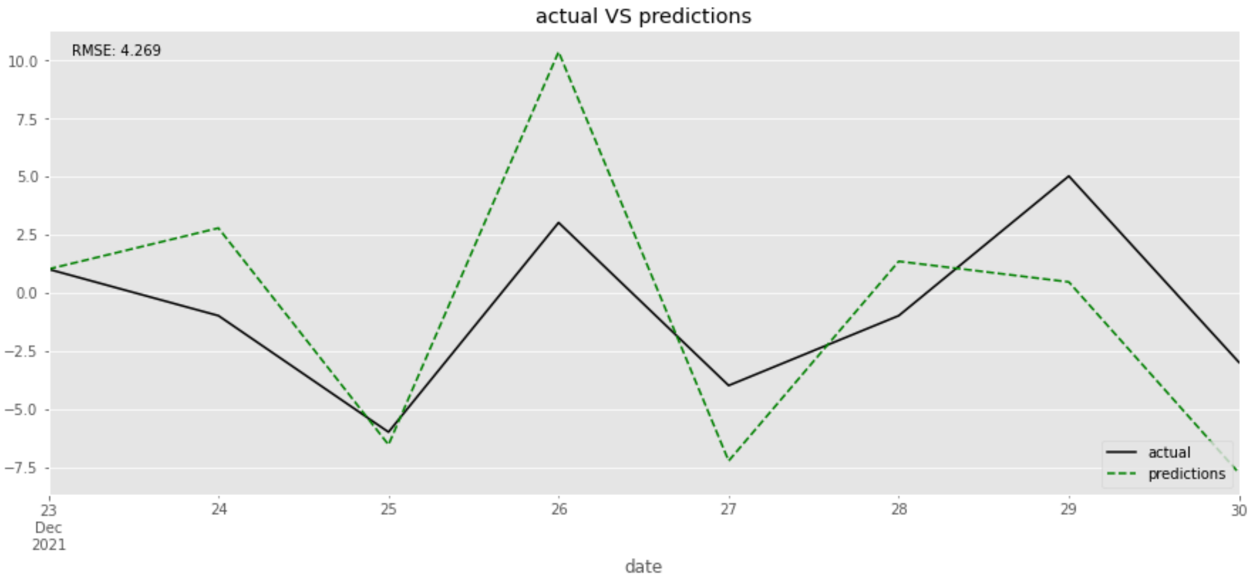
```
prediction = model_vector_LSTM2.predict(features_input, verbose=0)
error = rmse(sales_diff['2021-12-24':], prediction[0])
error
```

Out[137…

```
4.269215704174214
```

In [138…

```
plot_result(8, error,
            sales_diff['2021-12-23':],
            np.concatenate(([sales_diff['2021-12-23']], prediction[0])))
```



Сделаем сеть сложнее.

In [227…

```
# определяем модель
model_vector_LSTM3 = Sequential()
model_vector_LSTM3.add(LSTM(30, activation='relu', return_sequences=True,
model_vector_LSTM3.add(LSTM(40, activation='relu', return_sequences=True))
model_vector_LSTM3.add(LSTM(70, activation='relu'))
model_vector_LSTM3.add(Dense(n_steps_out))
model_vector_LSTM3.compile(optimizer='adam', loss='mse')
# обучаем модель
model_vector_LSTM3.fit(features, target, epochs=120, verbose=1)
```

```
Epoch 1/120
10/10 [==============================] - 60s 39ms/step - loss: 117.9580
Epoch 2/120
10/10 [==============================] - 1s 61ms/step - loss: 117.8687
Epoch 3/120
10/10 [==============================] - 1s 64ms/step - loss: 117.8294
Epoch 4/120
10/10 [==============================] - 1s 66ms/step - loss: 117.7844
Epoch 5/120
10/10 [==============================] - 1s 68ms/step - loss: 117.7048
Epoch 6/120
10/10 [==============================] - 0s 49ms/step - loss: 117.5560
```

```
Epoch 7/120
10/10 [==============================] - 0s 40ms/step - loss: 117.1133
Epoch 8/120
10/10 [==============================] - 0s 39ms/step - loss: 115.5281
Epoch 9/120
10/10 [==============================] - 0s 39ms/step - loss: 113.7559
Epoch 10/120
10/10 [==============================] - 0s 38ms/step - loss: 112.5152
Epoch 11/120
10/10 [==============================] - 0s 39ms/step - loss: 111.6843
Epoch 12/120
10/10 [==============================] - 0s 37ms/step - loss: 109.8621
Epoch 13/120
10/10 [==============================] - 0s 40ms/step - loss: 109.6690
Epoch 14/120
10/10 [==============================] - 0s 38ms/step - loss: 106.8428
Epoch 15/120
10/10 [==============================] - 0s 38ms/step - loss: 105.2809
Epoch 16/120
10/10 [==============================] - 0s 40ms/step - loss: 105.1628
Epoch 17/120
10/10 [==============================] - 0s 39ms/step - loss: 104.0506
Epoch 18/120
10/10 [==============================] - 0s 38ms/step - loss: 102.0928
Epoch 19/120
10/10 [==============================] - 0s 40ms/step - loss: 98.0574
Epoch 20/120
10/10 [==============================] - 0s 37ms/step - loss: 93.5953
Epoch 21/120
10/10 [==============================] - 0s 39ms/step - loss: 89.6289
Epoch 22/120
10/10 [==============================] - 0s 38ms/step - loss: 85.2284
Epoch 23/120
10/10 [==============================] - 0s 39ms/step - loss: 80.2330
Epoch 24/120
10/10 [==============================] - 0s 38ms/step - loss: 72.9749
Epoch 25/120
10/10 [==============================] - 0s 38ms/step - loss: 70.0935
Epoch 26/120
10/10 [==============================] - 0s 39ms/step - loss: 63.0037
Epoch 27/120
10/10 [==============================] - 0s 38ms/step - loss: 66.0530
Epoch 28/120
10/10 [==============================] - 0s 38ms/step - loss: 58.3524
Epoch 29/120
10/10 [==============================] - 0s 39ms/step - loss: 52.4716
Epoch 30/120
10/10 [==============================] - 0s 38ms/step - loss: 49.1505
Epoch 31/120
10/10 [==============================] - 0s 39ms/step - loss: 45.0525
Epoch 32/120
10/10 [==============================] - 0s 39ms/step - loss: 42.1776
Epoch 33/120
10/10 [==============================] - 0s 38ms/step - loss: 40.4676
Epoch 34/120
10/10 [==============================] - 0s 39ms/step - loss: 39.3530
Epoch 35/120
10/10 [==============================] - 0s 41ms/step - loss: 35.9011
Epoch 36/120
10/10 [==============================] - 0s 39ms/step - loss: 31.3137
Epoch 37/120
```

```
10/10 [==============================] - 0s 40ms/step - loss: 30.2402
Epoch 38/120
10/10 [==============================] - 0s 38ms/step - loss: 26.0537
Epoch 39/120
10/10 [==============================] - 0s 39ms/step - loss: 23.2370
Epoch 40/120
10/10 [==============================] - 0s 38ms/step - loss: 21.0588
Epoch 41/120
10/10 [==============================] - 0s 38ms/step - loss: 19.4086
Epoch 42/120
10/10 [==============================] - 0s 40ms/step - loss: 18.6250
Epoch 43/120
10/10 [==============================] - 0s 38ms/step - loss: 17.4421
Epoch 44/120
10/10 [==============================] - 0s 39ms/step - loss: 14.6263
Epoch 45/120
10/10 [==============================] - 0s 40ms/step - loss: 13.4950
Epoch 46/120
10/10 [==============================] - 0s 39ms/step - loss: 12.8061
Epoch 47/120
10/10 [==============================] - 0s 39ms/step - loss: 12.4124
Epoch 48/120
10/10 [==============================] - 0s 38ms/step - loss: 10.3351
Epoch 49/120
10/10 [==============================] - 0s 38ms/step - loss: 10.3395
Epoch 50/120
10/10 [==============================] - 0s 39ms/step - loss: 10.0022
Epoch 51/120
10/10 [==============================] - 0s 39ms/step - loss: 9.6548
Epoch 52/120
10/10 [==============================] - 0s 39ms/step - loss: 9.2312
Epoch 53/120
10/10 [==============================] - 0s 38ms/step - loss: 9.4780
Epoch 54/120
10/10 [==============================] - 0s 38ms/step - loss: 7.6084
Epoch 55/120
10/10 [==============================] - 0s 39ms/step - loss: 6.4162
Epoch 56/120
10/10 [==============================] - 0s 38ms/step - loss: 5.9601
Epoch 57/120
10/10 [==============================] - 0s 40ms/step - loss: 5.3177
Epoch 58/120
10/10 [==============================] - 0s 43ms/step - loss: 4.9244
Epoch 59/120
10/10 [==============================] - 0s 37ms/step - loss: 4.6874
Epoch 60/120
10/10 [==============================] - 0s 39ms/step - loss: 4.9824
Epoch 61/120
10/10 [==============================] - 0s 40ms/step - loss: 4.3149
Epoch 62/120
10/10 [==============================] - 0s 39ms/step - loss: 3.9703
Epoch 63/120
10/10 [==============================] - 0s 40ms/step - loss: 3.3336
Epoch 64/120
10/10 [==============================] - 0s 39ms/step - loss: 3.0376
Epoch 65/120
10/10 [==============================] - 0s 40ms/step - loss: 2.9737
Epoch 66/120
10/10 [==============================] - 0s 38ms/step - loss: 2.6372
Epoch 67/120
10/10 [==============================] - 0s 38ms/step - loss: 2.7282
```

```
Epoch 68/120
10/10 [==============================] - 0s 40ms/step - loss: 2.6772
Epoch 69/120
10/10 [==============================] - 0s 39ms/step - loss: 2.5122
Epoch 70/120
10/10 [==============================] - 1s 60ms/step - loss: 2.5026
Epoch 71/120
10/10 [==============================] - 1s 63ms/step - loss: 2.2837
Epoch 72/120
10/10 [==============================] - 1s 59ms/step - loss: 2.1749
Epoch 73/120
10/10 [==============================] - 1s 63ms/step - loss: 2.1316
Epoch 74/120
10/10 [==============================] - 1s 63ms/step - loss: 2.0725
Epoch 75/120
10/10 [==============================] - 1s 99ms/step - loss: 1.9799
Epoch 76/120
10/10 [==============================] - 1s 90ms/step - loss: 1.8143
Epoch 77/120
10/10 [==============================] - 1s 70ms/step - loss: 1.5793
Epoch 78/120
10/10 [==============================] - 1s 64ms/step - loss: 1.4845
Epoch 79/120
10/10 [==============================] - 1s 68ms/step - loss: 1.3677
Epoch 80/120
10/10 [==============================] - 1s 63ms/step - loss: 1.4213
Epoch 81/120
10/10 [==============================] - 0s 47ms/step - loss: 1.4175
Epoch 82/120
10/10 [==============================] - 0s 39ms/step - loss: 1.2052
Epoch 83/120
10/10 [==============================] - 0s 39ms/step - loss: 1.2091
Epoch 84/120
10/10 [==============================] - 0s 39ms/step - loss: 1.1364
Epoch 85/120
10/10 [==============================] - 0s 38ms/step - loss: 1.1239
Epoch 86/120
10/10 [==============================] - 0s 38ms/step - loss: 1.1518
Epoch 87/120
10/10 [==============================] - 0s 39ms/step - loss: 1.1191
Epoch 88/120
10/10 [==============================] - 0s 39ms/step - loss: 1.1746
Epoch 89/120
10/10 [==============================] - 0s 39ms/step - loss: 1.1518
Epoch 90/120
10/10 [==============================] - 0s 40ms/step - loss: 1.0860
Epoch 91/120
10/10 [==============================] - 0s 39ms/step - loss: 1.0046
Epoch 92/120
10/10 [==============================] - 0s 39ms/step - loss: 0.8022
Epoch 93/120
10/10 [==============================] - 0s 43ms/step - loss: 0.7020
Epoch 94/120
10/10 [==============================] - 0s 40ms/step - loss: 0.6478
Epoch 95/120
10/10 [==============================] - 0s 38ms/step - loss: 0.6337
Epoch 96/120
10/10 [==============================] - 0s 40ms/step - loss: 0.7384
Epoch 97/120
10/10 [==============================] - 0s 39ms/step - loss: 0.8081
Epoch 98/120
```

```
10/10 [==============================] - 0s 40ms/step - loss: 0.8320
Epoch 99/120
10/10 [==============================] - 1s 60ms/step - loss: 0.7686
Epoch 100/120
10/10 [==============================] - 1s 66ms/step - loss: 0.6534
Epoch 101/120
10/10 [==============================] - 1s 66ms/step - loss: 0.5922
Epoch 102/120
10/10 [==============================] - 1s 67ms/step - loss: 0.5435
Epoch 103/120
10/10 [==============================] - 1s 63ms/step - loss: 0.4656
Epoch 104/120
10/10 [==============================] - 1s 63ms/step - loss: 0.4644
Epoch 105/120
10/10 [==============================] - 1s 69ms/step - loss: 0.4825
Epoch 106/120
10/10 [==============================] - 1s 67ms/step - loss: 0.5356
Epoch 107/120
10/10 [==============================] - 1s 60ms/step - loss: 0.5071
Epoch 108/120
10/10 [==============================] - 0s 39ms/step - loss: 0.5431
Epoch 109/120
10/10 [==============================] - 0s 40ms/step - loss: 0.5967
Epoch 110/120
10/10 [==============================] - 0s 39ms/step - loss: 0.6930
Epoch 111/120
10/10 [==============================] - 0s 40ms/step - loss: 0.7942
Epoch 112/120
10/10 [==============================] - 0s 39ms/step - loss: 0.9179
Epoch 113/120
10/10 [==============================] - 0s 40ms/step - loss: 1.0511
Epoch 114/120
10/10 [==============================] - 0s 38ms/step - loss: 0.8958
Epoch 115/120
10/10 [==============================] - 0s 38ms/step - loss: 0.6970
Epoch 116/120
10/10 [==============================] - 0s 40ms/step - loss: 0.6439
Epoch 117/120
10/10 [==============================] - 0s 40ms/step - loss: 0.4888
Epoch 118/120
10/10 [==============================] - 1s 64ms/step - loss: 0.4715
Epoch 119/120
10/10 [==============================] - 1s 64ms/step - loss: 0.3911
Epoch 120/120
10/10 [==============================] - 1s 63ms/step - loss: 0.3344
```

Out[227…

```
<keras.callbacks.History at 0x7ff3fe3c7850>
```

In [228…

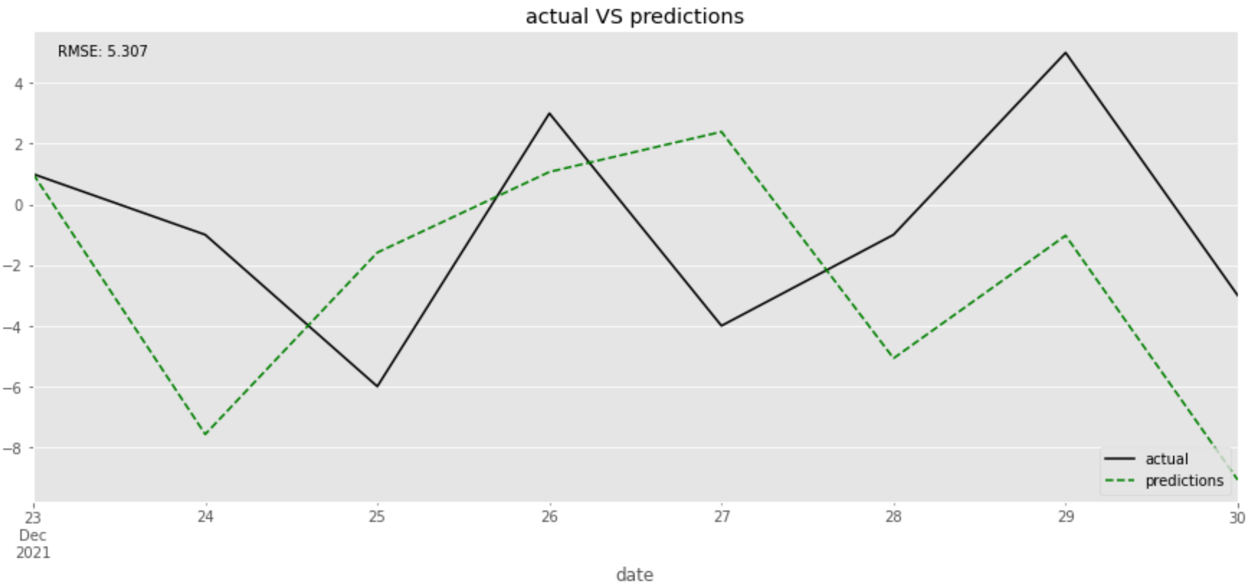
```
prediction = model_vector_LSTM3.predict(features_input, verbose=0)
error = rmse(sales_diff['2021-12-24':], prediction[0])
error
```

Out[228…

```
5.306878018027217
```

In [229…

```
plot_result(8, error,
            sales_diff['2021-12-23':],
            np.concatenate(([sales_diff['2021-12-23']], prediction[0])))
```



Попробуем другое количество нейронов в скрытых слоях.

In [171…

```
# определяем модель
model_vector_LSTM4 = Sequential()
model_vector_LSTM4.add(LSTM(28, activation='relu', return_sequences=True, i
model_vector_LSTM4.add(LSTM(35, activation='relu', return_sequences=True))
model_vector_LSTM4.add(LSTM(77, activation='relu'))
model_vector_LSTM4.add(Dense(n_steps_out))
model_vector_LSTM4.compile(optimizer='adam', loss='mse')
# обучаем модель
model_vector_LSTM4.fit(features, target, epochs=120, verbose=1)
```

```
Epoch 1/120
10/10 [==============================] - 5s 40ms/step - loss: 116.2020
Epoch 2/120
10/10 [==============================] - 0s 40ms/step - loss: 116.1203
Epoch 3/120
10/10 [==============================] - 0s 38ms/step - loss: 116.1011
Epoch 4/120
10/10 [==============================] - 0s 39ms/step - loss: 116.0937
Epoch 5/120
10/10 [==============================] - 0s 38ms/step - loss: 116.0711
Epoch 6/120
10/10 [==============================] - 0s 38ms/step - loss: 116.0382
Epoch 7/120
10/10 [==============================] - 0s 39ms/step - loss: 115.9756
Epoch 8/120
10/10 [==============================] - 0s 38ms/step - loss: 115.9996
Epoch 9/120
10/10 [==============================] - 0s 40ms/step - loss: 115.7449
Epoch 10/120
10/10 [==============================] - 0s 38ms/step - loss: 115.4903
Epoch 11/120
10/10 [==============================] - 0s 40ms/step - loss: 114.5592
Epoch 12/120
10/10 [==============================] - 0s 38ms/step - loss: 113.2185
Epoch 13/120
10/10 [==============================] - 0s 39ms/step - loss: 111.8360
Epoch 14/120
```

```
10/10 [==============================] - 0s 40ms/step - loss: 109.5695
Epoch 15/120
10/10 [==============================] - 0s 39ms/step - loss: 108.5019
Epoch 16/120
10/10 [==============================] - 0s 39ms/step - loss: 107.0675
Epoch 17/120
10/10 [==============================] - 0s 39ms/step - loss: 104.4746
Epoch 18/120
10/10 [==============================] - 0s 38ms/step - loss: 102.5650
Epoch 19/120
10/10 [==============================] - 0s 39ms/step - loss: 104.1136
Epoch 20/120
10/10 [==============================] - 0s 37ms/step - loss: 99.9670
Epoch 21/120
10/10 [==============================] - 0s 38ms/step - loss: 97.5387
Epoch 22/120
10/10 [==============================] - 0s 39ms/step - loss: 95.4739
Epoch 23/120
10/10 [==============================] - 0s 38ms/step - loss: 95.3993
Epoch 24/120
10/10 [==============================] - 0s 39ms/step - loss: 91.4840
Epoch 25/120
10/10 [==============================] - 0s 38ms/step - loss: 88.3904
Epoch 26/120
10/10 [==============================] - 0s 40ms/step - loss: 83.7082
Epoch 27/120
10/10 [==============================] - 0s 38ms/step - loss: 79.0795
Epoch 28/120
10/10 [==============================] - 0s 39ms/step - loss: 73.8353
Epoch 29/120
10/10 [==============================] - 0s 40ms/step - loss: 70.5298
Epoch 30/120
10/10 [==============================] - 0s 38ms/step - loss: 65.6685
Epoch 31/120
10/10 [==============================] - 0s 37ms/step - loss: 58.8875
Epoch 32/120
10/10 [==============================] - 0s 39ms/step - loss: 52.8185
Epoch 33/120
10/10 [==============================] - 0s 38ms/step - loss: 52.8601
Epoch 34/120
10/10 [==============================] - 0s 37ms/step - loss: 46.5802
Epoch 35/120
10/10 [==============================] - 0s 39ms/step - loss: 43.1144
Epoch 36/120
10/10 [==============================] - 0s 37ms/step - loss: 36.5833
Epoch 37/120
10/10 [==============================] - 0s 37ms/step - loss: 34.8358
Epoch 38/120
10/10 [==============================] - 0s 39ms/step - loss: 30.5373
Epoch 39/120
10/10 [==============================] - 0s 38ms/step - loss: 26.6086
Epoch 40/120
10/10 [==============================] - 0s 39ms/step - loss: 28.0625
Epoch 41/120
10/10 [==============================] - 0s 38ms/step - loss: 28.7818
Epoch 42/120
10/10 [==============================] - 0s 38ms/step - loss: 23.0315
Epoch 43/120
10/10 [==============================] - 0s 41ms/step - loss: 19.8876
Epoch 44/120
10/10 [==============================] - 0s 38ms/step - loss: 17.5934
```

```
Epoch 45/120
10/10 [==============================] - 0s 39ms/step - loss: 17.0312
Epoch 46/120
10/10 [==============================] - 0s 37ms/step - loss: 16.4450
Epoch 47/120
10/10 [==============================] - 0s 37ms/step - loss: 13.9766
Epoch 48/120
10/10 [==============================] - 0s 39ms/step - loss: 12.7773
Epoch 49/120
10/10 [==============================] - 0s 37ms/step - loss: 10.3710
Epoch 50/120
10/10 [==============================] - 0s 37ms/step - loss: 9.1595
Epoch 51/120
10/10 [==============================] - 0s 39ms/step - loss: 8.6687
Epoch 52/120
10/10 [==============================] - 0s 39ms/step - loss: 8.3953
Epoch 53/120
10/10 [==============================] - 0s 39ms/step - loss: 7.3290
Epoch 54/120
10/10 [==============================] - 0s 38ms/step - loss: 6.1109
Epoch 55/120
10/10 [==============================] - 0s 38ms/step - loss: 5.6149
Epoch 56/120
10/10 [==============================] - 0s 38ms/step - loss: 5.0183
Epoch 57/120
10/10 [==============================] - 0s 38ms/step - loss: 4.6588
Epoch 58/120
10/10 [==============================] - 0s 38ms/step - loss: 4.5579
Epoch 59/120
10/10 [==============================] - 1s 93ms/step - loss: 4.2784
Epoch 60/120
10/10 [==============================] - 1s 80ms/step - loss: 3.8518
Epoch 61/120
10/10 [==============================] - 0s 37ms/step - loss: 3.6143
Epoch 62/120
10/10 [==============================] - 0s 38ms/step - loss: 3.6312
Epoch 63/120
10/10 [==============================] - 0s 37ms/step - loss: 3.4870
Epoch 64/120
10/10 [==============================] - 0s 38ms/step - loss: 3.2324
Epoch 65/120
10/10 [==============================] - 0s 37ms/step - loss: 2.9877
Epoch 66/120
10/10 [==============================] - 0s 38ms/step - loss: 2.5778
Epoch 67/120
10/10 [==============================] - 0s 38ms/step - loss: 2.3615
Epoch 68/120
10/10 [==============================] - 0s 37ms/step - loss: 2.3218
Epoch 69/120
10/10 [==============================] - 0s 37ms/step - loss: 2.2965
Epoch 70/120
10/10 [==============================] - 0s 38ms/step - loss: 2.3647
Epoch 71/120
10/10 [==============================] - 0s 38ms/step - loss: 2.2927
Epoch 72/120
10/10 [==============================] - 0s 39ms/step - loss: 2.2613
Epoch 73/120
10/10 [==============================] - 0s 37ms/step - loss: 2.0193
Epoch 74/120
10/10 [==============================] - 0s 37ms/step - loss: 1.8698
Epoch 75/120
```

```
10/10 [==============================] - 0s 38ms/step - loss: 1.7363
Epoch 76/120
10/10 [==============================] - 0s 38ms/step - loss: 1.6746
Epoch 77/120
10/10 [==============================] - 0s 38ms/step - loss: 1.5223
Epoch 78/120
10/10 [==============================] - 0s 39ms/step - loss: 1.5388
Epoch 79/120
10/10 [==============================] - 0s 39ms/step - loss: 1.5899
Epoch 80/120
10/10 [==============================] - 0s 40ms/step - loss: 1.5360
Epoch 81/120
10/10 [==============================] - 0s 38ms/step - loss: 1.4189
Epoch 82/120
10/10 [==============================] - 0s 37ms/step - loss: 1.2384
Epoch 83/120
10/10 [==============================] - 0s 39ms/step - loss: 1.1527
Epoch 84/120
10/10 [==============================] - 0s 38ms/step - loss: 1.0600
Epoch 85/120
10/10 [==============================] - 0s 37ms/step - loss: 1.0120
Epoch 86/120
10/10 [==============================] - 0s 38ms/step - loss: 1.0523
Epoch 87/120
10/10 [==============================] - 0s 38ms/step - loss: 0.9767
Epoch 88/120
10/10 [==============================] - 0s 39ms/step - loss: 1.0218
Epoch 89/120
10/10 [==============================] - 0s 38ms/step - loss: 1.0077
Epoch 90/120
10/10 [==============================] - 0s 37ms/step - loss: 1.0024
Epoch 91/120
10/10 [==============================] - 0s 38ms/step - loss: 0.9058
Epoch 92/120
10/10 [==============================] - 0s 38ms/step - loss: 0.8355
Epoch 93/120
10/10 [==============================] - 0s 38ms/step - loss: 0.8614
Epoch 94/120
10/10 [==============================] - 0s 37ms/step - loss: 1.0171
Epoch 95/120
10/10 [==============================] - 0s 37ms/step - loss: 0.9408
Epoch 96/120
10/10 [==============================] - 0s 38ms/step - loss: 0.8914
Epoch 97/120
10/10 [==============================] - 0s 38ms/step - loss: 0.9055
Epoch 98/120
10/10 [==============================] - 0s 38ms/step - loss: 0.8216
Epoch 99/120
10/10 [==============================] - 0s 39ms/step - loss: 0.8212
Epoch 100/120
10/10 [==============================] - 0s 38ms/step - loss: 0.8751
Epoch 101/120
10/10 [==============================] - 0s 39ms/step - loss: 0.8363
Epoch 102/120
10/10 [==============================] - 0s 38ms/step - loss: 0.8568
Epoch 103/120
10/10 [==============================] - 0s 37ms/step - loss: 0.8664
Epoch 104/120
10/10 [==============================] - 0s 39ms/step - loss: 0.9883
Epoch 105/120
10/10 [==============================] - 0s 37ms/step - loss: 0.9107
```

```
Epoch 106/120
10/10 [==============================] - 0s 37ms/step - loss: 0.8228
Epoch 107/120
10/10 [==============================] - 0s 39ms/step - loss: 0.7476
Epoch 108/120
10/10 [==============================] - 0s 38ms/step - loss: 0.6698
Epoch 109/120
10/10 [==============================] - 0s 38ms/step - loss: 0.6457
Epoch 110/120
10/10 [==============================] - 0s 38ms/step - loss: 0.6228
Epoch 111/120
10/10 [==============================] - 0s 38ms/step - loss: 0.6141
Epoch 112/120
10/10 [==============================] - 0s 39ms/step - loss: 0.6094
Epoch 113/120
10/10 [==============================] - 0s 38ms/step - loss: 0.6325
Epoch 114/120
10/10 [==============================] - 0s 38ms/step - loss: 0.5997
Epoch 115/120
10/10 [==============================] - 0s 38ms/step - loss: 0.5521
Epoch 116/120
10/10 [==============================] - 0s 38ms/step - loss: 0.5013
Epoch 117/120
10/10 [==============================] - 0s 40ms/step - loss: 0.5102
Epoch 118/120
10/10 [==============================] - 0s 38ms/step - loss: 0.5192
Epoch 119/120
10/10 [==============================] - 0s 37ms/step - loss: 0.5940
Epoch 120/120
10/10 [==============================] - 0s 38ms/step - loss: 0.6495
```

Out[171…

```
<keras.callbacks.History at 0x7ff413056d10>
```

In [172…

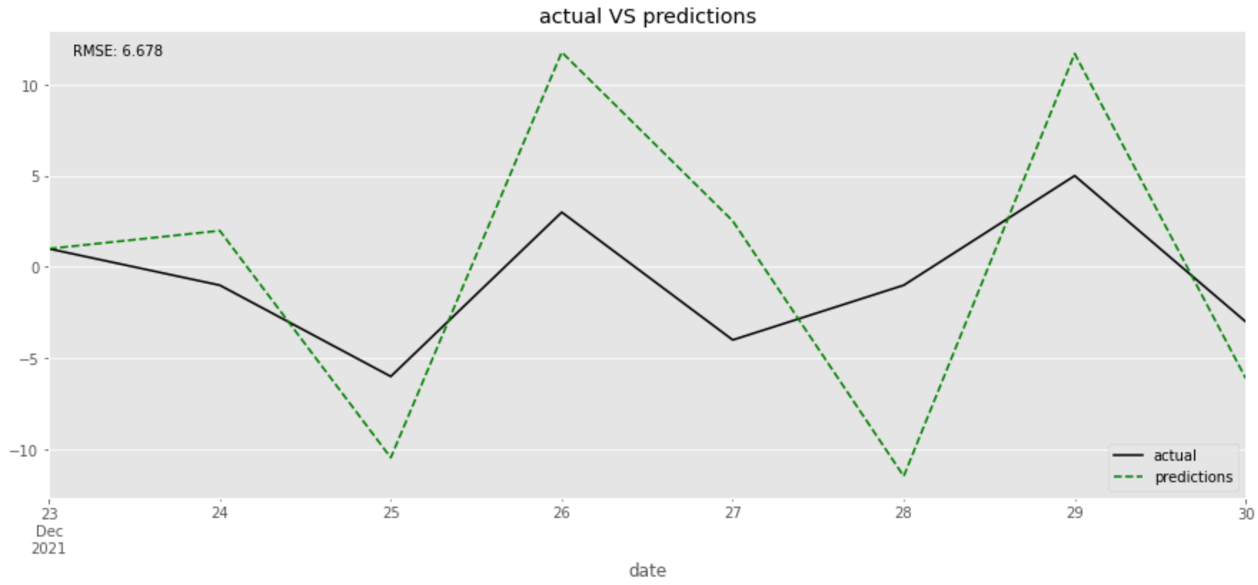
```
prediction = model_vector_LSTM4.predict(features_input, verbose=0)
error = rmse(sales_diff['2021-12-24':], prediction[0])
error
```

Out[172…

```
6.677857061958654
```

In [173…

```
plot_result(8, error,
            sales_diff['2021-12-23':],
            np.concatenate(([sales_diff['2021-12-23']], prediction[0])))
```



In [189…

```
# определяем модель
model_vector_LSTM5 = Sequential()
model_vector_LSTM5.add(LSTM(14, activation='relu', return_sequences=True, i
model_vector_LSTM5.add(LSTM(28, activation='relu', return_sequences=True))
model_vector_LSTM5.add(LSTM(70, activation='relu'))
model_vector_LSTM5.add(Dense(n_steps_out))
model_vector_LSTM5.compile(optimizer='adam', loss='mse')
# обучаем модель
model_vector_LSTM5.fit(features, target, epochs=120, verbose=1)
```

```
Epoch 1/120
10/10 [==============================] - 4s 101ms/step - loss: 116.3946
Epoch 2/120
10/10 [==============================] - 0s 47ms/step - loss: 116.1132
Epoch 3/120
10/10 [==============================] - 0s 35ms/step - loss: 116.0882
Epoch 4/120
10/10 [==============================] - 0s 37ms/step - loss: 116.0689
Epoch 5/120
10/10 [==============================] - 0s 37ms/step - loss: 116.0506
Epoch 6/120
10/10 [==============================] - 0s 36ms/step - loss: 116.0309
Epoch 7/120
10/10 [==============================] - 0s 37ms/step - loss: 116.0159
Epoch 8/120
10/10 [==============================] - 0s 36ms/step - loss: 116.0042
Epoch 9/120
10/10 [==============================] - 0s 37ms/step - loss: 116.0049
Epoch 10/120
10/10 [==============================] - 0s 36ms/step - loss: 115.9041
Epoch 11/120
10/10 [==============================] - 0s 36ms/step - loss: 115.8479
Epoch 12/120
10/10 [==============================] - 0s 37ms/step - loss: 115.7030
Epoch 13/120
10/10 [==============================] - 0s 36ms/step - loss: 114.4861
Epoch 14/120
10/10 [==============================] - 0s 34ms/step - loss: 113.8613
Epoch 15/120
```

```
10/10 [==============================] - 0s 37ms/step - loss: 112.8295
Epoch 16/120
10/10 [==============================] - 0s 35ms/step - loss: 111.5599
Epoch 17/120
10/10 [==============================] - 0s 36ms/step - loss: 109.8232
Epoch 18/120
10/10 [==============================] - 0s 35ms/step - loss: 108.1963
Epoch 19/120
10/10 [==============================] - 0s 35ms/step - loss: 107.2187
Epoch 20/120
10/10 [==============================] - 0s 36ms/step - loss: 105.1500
Epoch 21/120
10/10 [==============================] - 0s 35ms/step - loss: 102.3773
Epoch 22/120
10/10 [==============================] - 0s 35ms/step - loss: 101.0084
Epoch 23/120
10/10 [==============================] - 0s 51ms/step - loss: 100.4267
Epoch 24/120
10/10 [==============================] - 0s 35ms/step - loss: 102.3352
Epoch 25/120
10/10 [==============================] - 0s 35ms/step - loss: 98.2563
Epoch 26/120
10/10 [==============================] - 0s 37ms/step - loss: 94.9799
Epoch 27/120
10/10 [==============================] - 0s 35ms/step - loss: 91.5185
Epoch 28/120
10/10 [==============================] - 0s 36ms/step - loss: 88.6491
Epoch 29/120
10/10 [==============================] - 0s 36ms/step - loss: 86.6212
Epoch 30/120
10/10 [==============================] - 0s 36ms/step - loss: 83.0975
Epoch 31/120
10/10 [==============================] - 0s 35ms/step - loss: 79.7388
Epoch 32/120
10/10 [==============================] - 0s 35ms/step - loss: 77.1635
Epoch 33/120
10/10 [==============================] - 0s 35ms/step - loss: 74.0826
Epoch 34/120
10/10 [==============================] - 0s 37ms/step - loss: 69.9199
Epoch 35/120
10/10 [==============================] - 0s 35ms/step - loss: 70.6365
Epoch 36/120
10/10 [==============================] - 0s 35ms/step - loss: 67.1286
Epoch 37/120
10/10 [==============================] - 0s 36ms/step - loss: 61.1817
Epoch 38/120
10/10 [==============================] - 0s 36ms/step - loss: 58.5991
Epoch 39/120
10/10 [==============================] - 0s 35ms/step - loss: 56.5448
Epoch 40/120
10/10 [==============================] - 0s 36ms/step - loss: 51.2740
Epoch 41/120
10/10 [==============================] - 0s 36ms/step - loss: 47.3602
Epoch 42/120
10/10 [==============================] - 0s 35ms/step - loss: 47.4027
Epoch 43/120
10/10 [==============================] - 0s 36ms/step - loss: 43.0608
Epoch 44/120
10/10 [==============================] - 0s 35ms/step - loss: 39.9905
Epoch 45/120
10/10 [==============================] - 0s 37ms/step - loss: 36.8810
```

```
Epoch 46/120
10/10 [==============================] - 0s 37ms/step - loss: 32.4780
Epoch 47/120
10/10 [==============================] - 0s 36ms/step - loss: 29.2614
Epoch 48/120
10/10 [==============================] - 0s 37ms/step - loss: 26.0020
Epoch 49/120
10/10 [==============================] - 0s 36ms/step - loss: 27.1807
Epoch 50/120
10/10 [==============================] - 0s 35ms/step - loss: 27.2109
Epoch 51/120
10/10 [==============================] - 0s 36ms/step - loss: 24.7144
Epoch 52/120
10/10 [==============================] - 0s 35ms/step - loss: 20.6574
Epoch 53/120
10/10 [==============================] - 0s 36ms/step - loss: 18.4942
Epoch 54/120
10/10 [==============================] - 0s 37ms/step - loss: 16.6474
Epoch 55/120
10/10 [==============================] - 0s 36ms/step - loss: 14.8268
Epoch 56/120
10/10 [==============================] - 0s 35ms/step - loss: 14.6530
Epoch 57/120
10/10 [==============================] - 0s 36ms/step - loss: 13.2235
Epoch 58/120
10/10 [==============================] - 0s 36ms/step - loss: 13.7518
Epoch 59/120
10/10 [==============================] - 0s 37ms/step - loss: 11.8690
Epoch 60/120
10/10 [==============================] - 0s 36ms/step - loss: 10.1525
Epoch 61/120
10/10 [==============================] - 0s 35ms/step - loss: 9.3647
Epoch 62/120
10/10 [==============================] - 0s 36ms/step - loss: 8.0508
Epoch 63/120
10/10 [==============================] - 0s 35ms/step - loss: 7.2170
Epoch 64/120
10/10 [==============================] - 0s 35ms/step - loss: 6.6113
Epoch 65/120
10/10 [==============================] - 0s 35ms/step - loss: 5.9548
Epoch 66/120
10/10 [==============================] - 0s 35ms/step - loss: 5.4985
Epoch 67/120
10/10 [==============================] - 0s 35ms/step - loss: 4.9136
Epoch 68/120
10/10 [==============================] - 0s 36ms/step - loss: 4.5837
Epoch 69/120
10/10 [==============================] - 0s 36ms/step - loss: 4.2499
Epoch 70/120
10/10 [==============================] - 0s 36ms/step - loss: 3.9722
Epoch 71/120
10/10 [==============================] - 0s 36ms/step - loss: 3.9844
Epoch 72/120
10/10 [==============================] - 0s 34ms/step - loss: 3.5006
Epoch 73/120
10/10 [==============================] - 0s 35ms/step - loss: 3.4418
Epoch 74/120
10/10 [==============================] - 0s 37ms/step - loss: 3.3214
Epoch 75/120
10/10 [==============================] - 0s 36ms/step - loss: 2.9459
Epoch 76/120
```

```
10/10 [==============================] - 0s 35ms/step - loss: 2.7613
Epoch 77/120
10/10 [==============================] - 0s 36ms/step - loss: 2.5754
Epoch 78/120
10/10 [==============================] - 0s 36ms/step - loss: 2.4391
Epoch 79/120
10/10 [==============================] - 0s 36ms/step - loss: 2.2936
Epoch 80/120
10/10 [==============================] - 0s 35ms/step - loss: 2.1209
Epoch 81/120
10/10 [==============================] - 0s 36ms/step - loss: 2.2930
Epoch 82/120
10/10 [==============================] - 0s 37ms/step - loss: 2.4388
Epoch 83/120
10/10 [==============================] - 0s 36ms/step - loss: 2.1180
Epoch 84/120
10/10 [==============================] - 0s 36ms/step - loss: 2.0554
Epoch 85/120
10/10 [==============================] - 0s 36ms/step - loss: 1.9726
Epoch 86/120
10/10 [==============================] - 0s 35ms/step - loss: 1.9965
Epoch 87/120
10/10 [==============================] - 0s 35ms/step - loss: 1.8103
Epoch 88/120
10/10 [==============================] - 0s 35ms/step - loss: 1.6044
Epoch 89/120
10/10 [==============================] - 0s 35ms/step - loss: 1.5601
Epoch 90/120
10/10 [==============================] - 0s 36ms/step - loss: 1.4807
Epoch 91/120
10/10 [==============================] - 0s 36ms/step - loss: 1.4167
Epoch 92/120
10/10 [==============================] - 0s 36ms/step - loss: 1.4708
Epoch 93/120
10/10 [==============================] - 0s 35ms/step - loss: 1.4335
Epoch 94/120
10/10 [==============================] - 0s 35ms/step - loss: 1.3258
Epoch 95/120
10/10 [==============================] - 0s 36ms/step - loss: 1.3767
Epoch 96/120
10/10 [==============================] - 0s 37ms/step - loss: 1.2770
Epoch 97/120
10/10 [==============================] - 0s 37ms/step - loss: 1.1334
Epoch 98/120
10/10 [==============================] - 0s 35ms/step - loss: 1.1592
Epoch 99/120
10/10 [==============================] - 0s 37ms/step - loss: 1.1860
Epoch 100/120
10/10 [==============================] - 0s 36ms/step - loss: 1.0935
Epoch 101/120
10/10 [==============================] - 0s 37ms/step - loss: 1.0751
Epoch 102/120
10/10 [==============================] - 0s 38ms/step - loss: 1.0087
Epoch 103/120
10/10 [==============================] - 0s 36ms/step - loss: 0.9048
Epoch 104/120
10/10 [==============================] - 0s 35ms/step - loss: 0.8924
Epoch 105/120
10/10 [==============================] - 0s 37ms/step - loss: 0.9001
Epoch 106/120
10/10 [==============================] - 0s 36ms/step - loss: 0.8590
```

```
Epoch 107/120
10/10 [==============================] - 0s 36ms/step - loss: 0.7446
Epoch 108/120
10/10 [==============================] - 0s 36ms/step - loss: 0.7274
Epoch 109/120
10/10 [==============================] - 0s 36ms/step - loss: 0.7247
Epoch 110/120
10/10 [==============================] - 0s 36ms/step - loss: 0.7253
Epoch 111/120
10/10 [==============================] - 0s 36ms/step - loss: 0.7059
Epoch 112/120
10/10 [==============================] - 0s 35ms/step - loss: 0.7210
Epoch 113/120
10/10 [==============================] - 0s 35ms/step - loss: 0.6432
Epoch 114/120
10/10 [==============================] - 0s 35ms/step - loss: 0.5857
Epoch 115/120
10/10 [==============================] - 0s 35ms/step - loss: 0.5776
Epoch 116/120
10/10 [==============================] - 0s 36ms/step - loss: 0.5974
Epoch 117/120
10/10 [==============================] - 0s 35ms/step - loss: 0.6211
Epoch 118/120
10/10 [==============================] - 0s 35ms/step - loss: 0.6477
Epoch 119/120
10/10 [==============================] - 0s 36ms/step - loss: 0.6953
Epoch 120/120
10/10 [==============================] - 0s 35ms/step - loss: 0.7071
```

Out[189…

```
<keras.callbacks.History at 0x7ff410141950>
```

In [190…

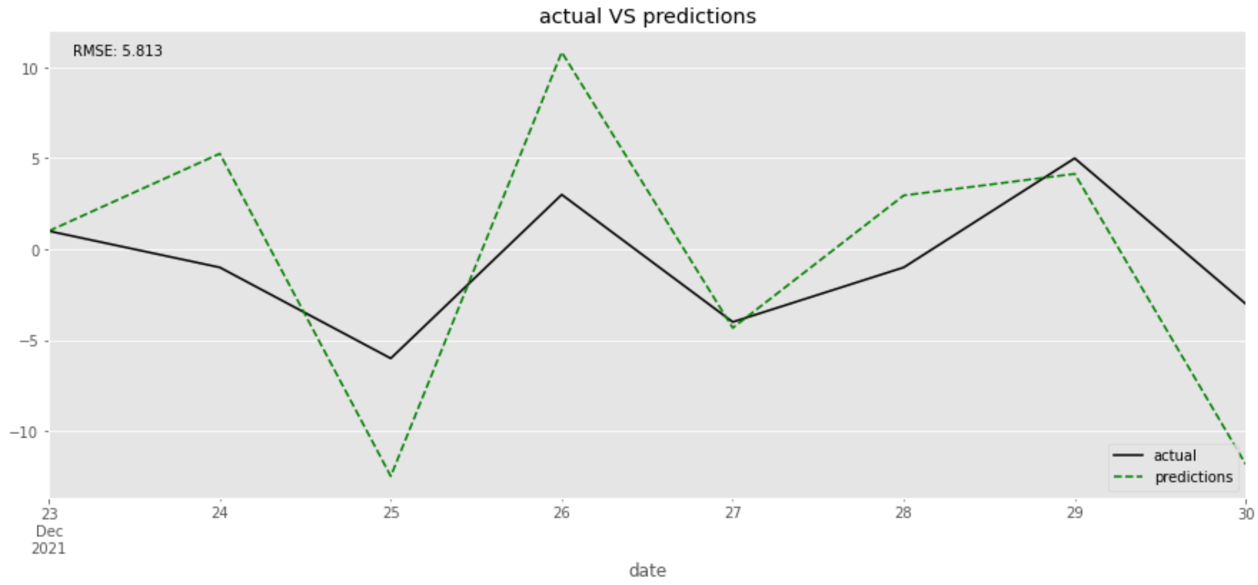
```
prediction = model_vector_LSTM5.predict(features_input, verbose=0)
error = rmse(sales_diff['2021-12-24':], prediction[0])
error
```

Out[190…

```
5.81318634524251
```

In [191…

```
plot_result(8, error,
            sales_diff['2021-12-23':],
            np.concatenate(([sales_diff['2021-12-23']], prediction[0])))
```



Лучшей из опробованных конфигураций оказалась конфигурация модели `model_vector_LSTM2` .

ИТОГ

Мы построили несколько моделей, однако последний тип модели многошаговой LSTM отличается от предыдущих тем, что она возвращает прогноз на ближайшие 7 дней вперед. В предыдущих моделях чтобы повысить качество предсказаний, мы делали одношаговые прогнозы и обучали модель на каждом шаге с учётом последнего реального значения. Таким образом предсказание не далеко отклонялось от реальных данных. Поэтому модель SARIMA имеет лучшее качество в сравнении с остальными моделями.

Однако если мы проведем симуляцию, подставляя последние предсказанные значения на вход модели, то за несколько шагов SARIMA сведётся к предсказанию последним значением.

Поэтому более интересным является многошаговый прогноз LSTM. К тому же RMSE при валидации не слишком сильно уступает модели SARIMA, и выше, чем у градиентного бустинга и одношаговых LSTM-моделей.

Конечно, мы перебрали лишь некоторые модели LSTM. И если бы мы многократно запускали симуляцию одной и тоже конфигурации модели без фиксации random state, то можно было бы с большей уверенностью судить о качестве той или иной нейросети.

Обучим лучшую модель заново с учётом последней недели и сделаем прогноз.

In [230…

```
n_steps_in, n_steps_out = 28, 7
features_, target_ = split_sequence(sales_diff, n_steps_in, n_steps_out)
```

In [231…

```
# определяем модель
model_vector_LSTM = Sequential()
model_vector_LSTM.add(LSTM(30, activation='relu', return_sequences=True, i
model_vector_LSTM.add(LSTM(110, activation='relu'))
model_vector_LSTM.add(Dense(n_steps_out))
model_vector_LSTM.compile(optimizer='adam', loss='mse')
# обучаем модель
model_vector_LSTM.fit(features_, target_, epochs=120, verbose=1)
```

```
Epoch 1/120
10/10 [==============================] - 3s 34ms/step - loss: 116.3928
Epoch 2/120
10/10 [==============================] - 0s 33ms/step - loss: 115.7341
Epoch 3/120
10/10 [==============================] - 0s 34ms/step - loss: 114.6666
Epoch 4/120
10/10 [==============================] - 0s 33ms/step - loss: 113.2666
Epoch 5/120
10/10 [==============================] - 0s 34ms/step - loss: 112.5899
Epoch 6/120
10/10 [==============================] - 0s 35ms/step - loss: 111.6240
Epoch 7/120
10/10 [==============================] - 0s 34ms/step - loss: 109.9180
Epoch 8/120
10/10 [==============================] - 0s 33ms/step - loss: 109.1073
Epoch 9/120
10/10 [==============================] - 0s 34ms/step - loss: 108.8127
Epoch 10/120
10/10 [==============================] - 0s 35ms/step - loss: 107.4500
Epoch 11/120
10/10 [==============================] - 0s 33ms/step - loss: 106.3293
Epoch 12/120
10/10 [==============================] - 0s 34ms/step - loss: 104.5637
Epoch 13/120
10/10 [==============================] - 0s 33ms/step - loss: 102.1454
Epoch 14/120
10/10 [==============================] - 0s 32ms/step - loss: 99.7241
Epoch 15/120
10/10 [==============================] - 0s 34ms/step - loss: 95.2891
Epoch 16/120
10/10 [==============================] - 0s 33ms/step - loss: 91.2400
Epoch 17/120
10/10 [==============================] - 0s 33ms/step - loss: 90.3020
Epoch 18/120
10/10 [==============================] - 0s 35ms/step - loss: 84.2525
Epoch 19/120
10/10 [==============================] - 0s 33ms/step - loss: 77.0389
Epoch 20/120
10/10 [==============================] - 0s 33ms/step - loss: 71.5628
Epoch 21/120
10/10 [==============================] - 0s 35ms/step - loss: 75.4126
Epoch 22/120
10/10 [==============================] - 0s 33ms/step - loss: 69.1651
Epoch 23/120
10/10 [==============================] - 0s 33ms/step - loss: 59.8477
Epoch 24/120
10/10 [==============================] - 0s 33ms/step - loss: 54.4521
Epoch 25/120
10/10 [==============================] - 0s 33ms/step - loss: 49.0447
```

```
Epoch 26/120
10/10 [==============================] - 0s 33ms/step - loss: 43.3999
Epoch 27/120
10/10 [==============================] - 0s 34ms/step - loss: 38.0629
Epoch 28/120
10/10 [==============================] - 0s 33ms/step - loss: 34.5020
Epoch 29/120
10/10 [==============================] - 0s 33ms/step - loss: 31.2430
Epoch 30/120
10/10 [==============================] - 0s 34ms/step - loss: 27.2206
Epoch 31/120
10/10 [==============================] - 0s 33ms/step - loss: 23.9380
Epoch 32/120
10/10 [==============================] - 0s 34ms/step - loss: 20.0926
Epoch 33/120
10/10 [==============================] - 0s 33ms/step - loss: 18.8329
Epoch 34/120
10/10 [==============================] - 0s 33ms/step - loss: 16.6011
Epoch 35/120
10/10 [==============================] - 0s 33ms/step - loss: 14.7176
Epoch 36/120
10/10 [==============================] - 0s 33ms/step - loss: 12.5057
Epoch 37/120
10/10 [==============================] - 0s 33ms/step - loss: 10.8718
Epoch 38/120
10/10 [==============================] - 0s 33ms/step - loss: 9.4655
Epoch 39/120
10/10 [==============================] - 0s 32ms/step - loss: 8.5725
Epoch 40/120
10/10 [==============================] - 0s 32ms/step - loss: 7.1191
Epoch 41/120
10/10 [==============================] - 0s 33ms/step - loss: 6.8250
Epoch 42/120
10/10 [==============================] - 0s 33ms/step - loss: 5.7720
Epoch 43/120
10/10 [==============================] - 0s 32ms/step - loss: 5.3002
Epoch 44/120
10/10 [==============================] - 0s 33ms/step - loss: 4.8149
Epoch 45/120
10/10 [==============================] - 0s 34ms/step - loss: 4.1789
Epoch 46/120
10/10 [==============================] - 0s 33ms/step - loss: 3.5410
Epoch 47/120
10/10 [==============================] - 0s 33ms/step - loss: 3.0443
Epoch 48/120
10/10 [==============================] - 0s 33ms/step - loss: 3.1475
Epoch 49/120
10/10 [==============================] - 0s 33ms/step - loss: 2.6628
Epoch 50/120
10/10 [==============================] - 0s 33ms/step - loss: 2.5954
Epoch 51/120
10/10 [==============================] - 0s 35ms/step - loss: 2.4342
Epoch 52/120
10/10 [==============================] - 0s 34ms/step - loss: 2.3043
Epoch 53/120
10/10 [==============================] - 0s 33ms/step - loss: 2.1700
Epoch 54/120
10/10 [==============================] - 0s 33ms/step - loss: 2.1247
Epoch 55/120
10/10 [==============================] - 0s 34ms/step - loss: 1.9256
Epoch 56/120
```

```
10/10 [==============================] - 0s 33ms/step - loss: 2.0398
Epoch 57/120
10/10 [==============================] - 0s 34ms/step - loss: 1.6561
Epoch 58/120
10/10 [==============================] - 0s 34ms/step - loss: 1.5426
Epoch 59/120
10/10 [==============================] - 0s 34ms/step - loss: 1.3707
Epoch 60/120
10/10 [==============================] - 0s 34ms/step - loss: 1.3892
Epoch 61/120
10/10 [==============================] - 0s 34ms/step - loss: 1.2964
Epoch 62/120
10/10 [==============================] - 0s 34ms/step - loss: 1.3447
Epoch 63/120
10/10 [==============================] - 0s 34ms/step - loss: 1.2816
Epoch 64/120
10/10 [==============================] - 0s 34ms/step - loss: 1.0559
Epoch 65/120
10/10 [==============================] - 0s 34ms/step - loss: 0.9683
Epoch 66/120
10/10 [==============================] - 0s 33ms/step - loss: 0.7891
Epoch 67/120
10/10 [==============================] - 0s 33ms/step - loss: 0.8444
Epoch 68/120
10/10 [==============================] - 0s 33ms/step - loss: 0.8079
Epoch 69/120
10/10 [==============================] - 0s 33ms/step - loss: 0.7483
Epoch 70/120
10/10 [==============================] - 0s 33ms/step - loss: 0.6787
Epoch 71/120
10/10 [==============================] - 0s 34ms/step - loss: 0.5790
Epoch 72/120
10/10 [==============================] - 0s 33ms/step - loss: 0.5723
Epoch 73/120
10/10 [==============================] - 0s 33ms/step - loss: 0.5698
Epoch 74/120
10/10 [==============================] - 0s 34ms/step - loss: 0.4906
Epoch 75/120
10/10 [==============================] - 0s 34ms/step - loss: 0.4595
Epoch 76/120
10/10 [==============================] - 0s 34ms/step - loss: 0.4376
Epoch 77/120
10/10 [==============================] - 0s 33ms/step - loss: 0.4249
Epoch 78/120
10/10 [==============================] - 0s 33ms/step - loss: 0.4420
Epoch 79/120
10/10 [==============================] - 0s 35ms/step - loss: 0.3854
Epoch 80/120
10/10 [==============================] - 0s 33ms/step - loss: 0.4110
Epoch 81/120
10/10 [==============================] - 0s 34ms/step - loss: 0.4146
Epoch 82/120
10/10 [==============================] - 0s 33ms/step - loss: 0.4272
Epoch 83/120
10/10 [==============================] - 0s 33ms/step - loss: 0.4452
Epoch 84/120
10/10 [==============================] - 0s 34ms/step - loss: 0.4749
Epoch 85/120
10/10 [==============================] - 0s 34ms/step - loss: 0.4550
Epoch 86/120
10/10 [==============================] - 0s 34ms/step - loss: 0.5445
```

```
Epoch 87/120
10/10 [==============================] - 0s 33ms/step - loss: 0.5144
Epoch 88/120
10/10 [==============================] - 0s 34ms/step - loss: 0.4569
Epoch 89/120
10/10 [==============================] - 0s 33ms/step - loss: 0.4183
Epoch 90/120
10/10 [==============================] - 0s 33ms/step - loss: 0.3752
Epoch 91/120
10/10 [==============================] - 0s 35ms/step - loss: 0.3488
Epoch 92/120
10/10 [==============================] - 0s 33ms/step - loss: 0.3552
Epoch 93/120
10/10 [==============================] - 0s 33ms/step - loss: 0.4297
Epoch 94/120
10/10 [==============================] - 0s 34ms/step - loss: 0.4803
Epoch 95/120
10/10 [==============================] - 0s 34ms/step - loss: 0.4622
Epoch 96/120
10/10 [==============================] - 0s 33ms/step - loss: 0.4457
Epoch 97/120
10/10 [==============================] - 0s 33ms/step - loss: 0.4226
Epoch 98/120
10/10 [==============================] - 0s 33ms/step - loss: 0.4261
Epoch 99/120
10/10 [==============================] - 0s 32ms/step - loss: 0.5144
Epoch 100/120
10/10 [==============================] - 0s 34ms/step - loss: 0.4760
Epoch 101/120
10/10 [==============================] - 0s 33ms/step - loss: 0.4262
Epoch 102/120
10/10 [==============================] - 0s 32ms/step - loss: 0.5867
Epoch 103/120
10/10 [==============================] - 0s 34ms/step - loss: 0.4936
Epoch 104/120
10/10 [==============================] - 0s 33ms/step - loss: 0.4272
Epoch 105/120
10/10 [==============================] - 0s 34ms/step - loss: 0.4115
Epoch 106/120
10/10 [==============================] - 0s 34ms/step - loss: 0.3365
Epoch 107/120
10/10 [==============================] - 0s 34ms/step - loss: 0.2841
Epoch 108/120
10/10 [==============================] - 0s 33ms/step - loss: 0.2822
Epoch 109/120
10/10 [==============================] - 0s 34ms/step - loss: 0.2684
Epoch 110/120
10/10 [==============================] - 0s 33ms/step - loss: 0.2501
Epoch 111/120
10/10 [==============================] - 0s 34ms/step - loss: 0.2178
Epoch 112/120
10/10 [==============================] - 0s 35ms/step - loss: 0.1791
Epoch 113/120
10/10 [==============================] - 0s 33ms/step - loss: 0.1508
Epoch 114/120
10/10 [==============================] - 0s 33ms/step - loss: 0.1424
Epoch 115/120
10/10 [==============================] - 0s 34ms/step - loss: 0.1268
Epoch 116/120
10/10 [==============================] - 0s 34ms/step - loss: 0.1360
Epoch 117/120
```

```
10/10 [==============================] - 0s 33ms/step - loss: 0.1305
Epoch 118/120
10/10 [==============================] - 0s 35ms/step - loss: 0.1401
Epoch 119/120
10/10 [==============================] - 0s 34ms/step - loss: 0.1449
Epoch 120/120
10/10 [==============================] - 0s 33ms/step - loss: 0.1384
```

Out[231…

```
<keras.callbacks.History at 0x7ff406763f50>
```

In [232…

```
features_input_ = np.array(sales_diff.tail(28))
features_input_ = features_input_.reshape(1, n_steps_in, n_features)
```

In [233…

```
forecast = model_vector_LSTM.predict(features_input_, verbose=0)
```

Итак, прогноз разностей продаж на неделю вперёд исходя из данных о разностях за последние 4 недели.

In [234…

```
forecast[0]
```

Out[234…

```
array([-2.7339063,  1.3911389, -1.0647684,  3.6626263, -5.723689 ,
        4.9648724, -3.0692432], dtype=float32)
```

Данные о суммарном количестве продаж за день хранятся в сирии `sales_q` .

In [235…

```
sales_q.tail()
```

Out[235…

```
date
2021-12-26    11
2021-12-27     7
2021-12-28     6
2021-12-29    11
2021-12-30     8
Name: actual sales quantity, dtype: int64
```

Отталкиваясь от последнего значения, дополним этот временной ряд прогнозируемыми значениями.

In [236…

```
sales_forecast = []
sales_forecast_idx = []
last_value = sales_q.tail(1)[0]
last_idx = sales_q.tail(1).index[0]
sales_forecast.append(last_value) # для красоты графика
sales_forecast_idx.append(last_idx) # для красоты графика
for predicted_diff in range(len(forecast[0])):
  predicted_value = last_value + forecast[0][predicted_diff]
  predicted_value_idx = last_idx + timedelta(days=1)
  sales_forecast.append(round(predicted_value))
  sales_forecast_idx.append(predicted_value_idx)
  last_value = predicted_value
  last_idx = predicted_value_idx
sales_forecast = pd.DataFrame(data=sales_forecast, index=sales_forecast_id
```

In [237…

```
sales_forecast
```

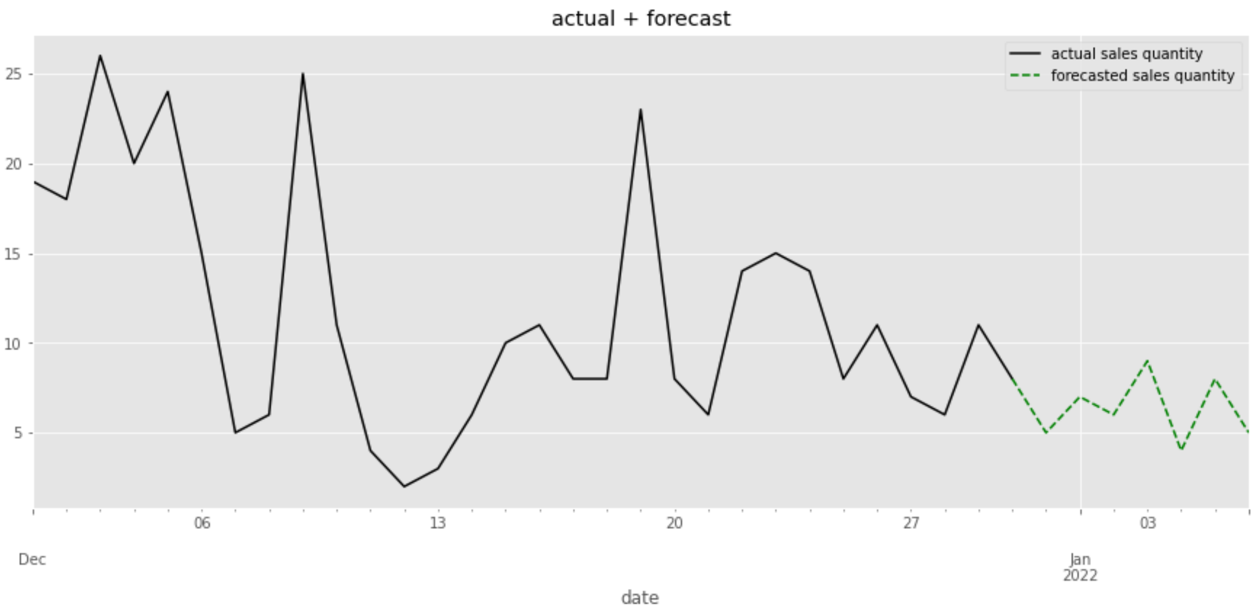
Out[237…

	forecasted sales quantity
2021-12-30	8
2021-12-31	5
2022-01-01	7
2022-01-02	6
2022-01-03	9
2022-01-04	4
2022-01-05	8
2022-01-06	5

Построим итоговый график продаж, продолжаемый прогнозируемыми значениями.

In [238…

```
sales_q.name = 'actual sales quantity'
ax = sales_q['12-01-2021':].plot(figsize=(15,6), color='black', title='actu
sales_forecast.plot(ax=ax, style='--', color='green')
ax.legend(loc='upper right')
plt.show();
```



Сохраним результат на диске.

In [239…

```
sales_forecast.columns = ['quantities']
sales_forecast.to_csv(PATH+'sales_forecast.csv')
```