Data Assignment 1 - `t54zheng` (20939203)

Task 3 - Indexing

In [1]:
```
# imports

import pandas as pd
import scipy.stats as stats
from math import sqrt
import warnings
import matplotlib.pyplot as plt
from datetime import timedelta
import numpy as np
from scipy.optimize import minimize

warnings.filterwarnings('ignore')
```

In [2]:
```
# Import raw data
data_file = "djreturns.xlsx"

dj27 = pd.read_excel(data_file, sheet_name="dj27")
individual_dj27_returns = pd.read_excel(data_file, sheet_name="returns")
sp500_returns = pd.read_excel(data_file, sheet_name="sp500")
```

In [3]:
```
# Also we carry forward the returns df from Task 2

returns_dict = {} # permno -> dataframe(permno_returns)
permnos = dj27["PERMNO"]
for permno in permnos:
    returns_df = individual_dj27_returns[individual_dj27_returns["PERMNO"] == permno]
    returns_dict[permno] = returns_df
```

Task 3 - Equal-weighted Portfolio

In [4]:
```
individual_dj27_returns
```

Out[4]:

	PERMNO	DATE	COMNAM	TICKER	PRC	RET	SHROUT
0	10107	2000-01-31	MICROSOFT CORP	MSFT	97.875000	-0.161670	5160025
1	10107	2000-02-29	MICROSOFT CORP	MSFT	89.375000	-0.086845	5160025
2	10107	2000-03-31	MICROSOFT CORP	MSFT	106.250000	0.188811	5242000
3	10107	2000-04-28	MICROSOFT CORP	MSFT	69.750000	-0.343529	5262405
4	10107	2000-05-31	MICROSOFT CORP	MSFT	62.562500	-0.103047	5262405
...	...	...	...	...	...	...	...
7123	92655	2021-08-31	UNITEDHEALTH GROUP INC	UNH	416.269989	0.009825	942917
7124	92655	2021-09-30	UNITEDHEALTH GROUP INC	UNH	390.739990	-0.057847	942917
7125	92655	2021-10-29	UNITEDHEALTH GROUP INC	UNH	460.470001	0.178456	942917
7126	92655	2021-11-30	UNITEDHEALTH GROUP INC	UNH	444.220001	-0.035290	941851
7127	92655	2021-12-31	UNITEDHEALTH GROUP INC	UNH	502.140015	0.133650	941851

7128 rows × 7 columns

To make our equally-weighted index we will allocate each ticker an equal weight of $\frac{1}{n}$, and since we have 27 stocks, we allocate each stock a weight of $\frac{1}{27}$.

In [5]:
```
# We only need to use monthly returns (already calculated) to calculate the index. So let's align the data.
# This df will hold our (unindexed [to 1000]) portfolio

# We'll just pull the dates from the sp500 returns since that, and the dj data all have aligned dates
portfolio_df = pd.DataFrame(sp500_returns["DATE"])

for permno, df in returns_dict.items():
    portfolio_df.loc[:, permno] = list(df["RET"])

# Just to validate, none of our cells are null so we can safely continue
portfolio_df.isnull().sum().sum() # returns number of null cells
```

Out[5]:
```
0
```

- Note that the reason why we can just multiply all of the returns by $\frac{1}{27}$ is because we are creating an equally weighted portfolio. Therefore we are not concerned with lookahead bias since the weights at all times are the same for each stock.

In [6]:
```
num_stocks = 27
weight = 1 / num_stocks
starting_level = 1000

portfolio_df.iloc[:, 1:] *= weight # Weighted average of portfolio returns
portfolio_df.loc[:, "Weighted Return"] = portfolio_df.iloc[:, 1:].sum(axis=1)
portfolio_df
```

Out[6]:

	DATE	10107	10145	11308	12490	14008	14541	14593	18163	18542	...	57665	59176	59328	59459	65875	66181	76076	8
0	2000-01-31	-0.005988	-0.006220	-0.000517	0.001502	0.002235	-0.001283	0.000338	-0.002765	-0.003384	...	-0.003036	-0.000284	0.007481	-0.003848	0.000457	-0.006532	0.000821	-0.00
1	2000-02-29	-0.003216	0.000241	-0.005683	-0.003095	0.002617	-0.003670	0.003882	-0.004833	-0.006436	...	-0.013889	-0.006871	0.005275	-0.009585	-0.007774	0.000777	0.007674	0.00
2	2000-03-31	0.006993	0.003511	-0.001156	0.005497	-0.003700	0.008802	0.006846	-0.013224	0.004621	...	0.014727	0.004071	0.006207	0.019897	0.009224	0.004310	0.006287	0.0(
3	2000-04-28	-0.012723	0.002329	0.000247	-0.002040	-0.003244	-0.002930	-0.003204	0.002340	0.000305	...	0.003564	0.000200	-0.001439	0.001628	-0.000903	-0.004594	-0.003825	-0.0(
4	2000-05-31	-0.003817	-0.000744	0.004801	-0.001327	0.005043	0.003464	-0.011960	0.004184	-0.001115	...	-0.000480	0.003097	-0.000612	0.001949	-0.003985	-0.005039	-0.006619	-0.0(
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
259	2021-08-31	0.002279	-0.000150	-0.000468	0.000268	-0.002185	-0.001346	0.001572	0.000042	0.000738	...	-0.000552	-0.000993	0.000474	0.002684	-0.000518	-0.000227	0.002441	0.0(
260	2021-09-30	-0.002449	-0.003135	-0.002249	-0.000372	-0.002115	0.001791	-0.002520	-0.000674	-0.003320	...	-0.004386	0.000350	-0.000534	-0.001582	-0.000667	0.000424	-0.002880	-0.0(
261	2021-10-29	0.006529	0.001106	0.002753	-0.003687	-0.000989	0.004761	0.002172	0.001076	0.002537	...	0.005626	0.001477	-0.002975	0.002161	-0.000261	0.004906	0.001300	0.00
262	2021-11-30	-0.000046	-0.002609	-0.002300	-0.000348	-0.001133	-0.000091	0.003887	0.000412	-0.001935	...	0.000432	-0.004578	0.000414	-0.003207	-0.001901	0.002876	-0.000748	-0.0(
263	2021-12-31	0.000642	0.001148	0.004774	0.005238	0.004859	0.001470	0.002749	0.004867	0.002565	...	-0.000496	0.002748	0.001731	0.002611	0.001245	0.001484	0.005761	0.00

264 rows × 29 columns

To avoid look-ahead bias, we calculate the index level L_t as $L_{t-1} \times r_{p,t}$

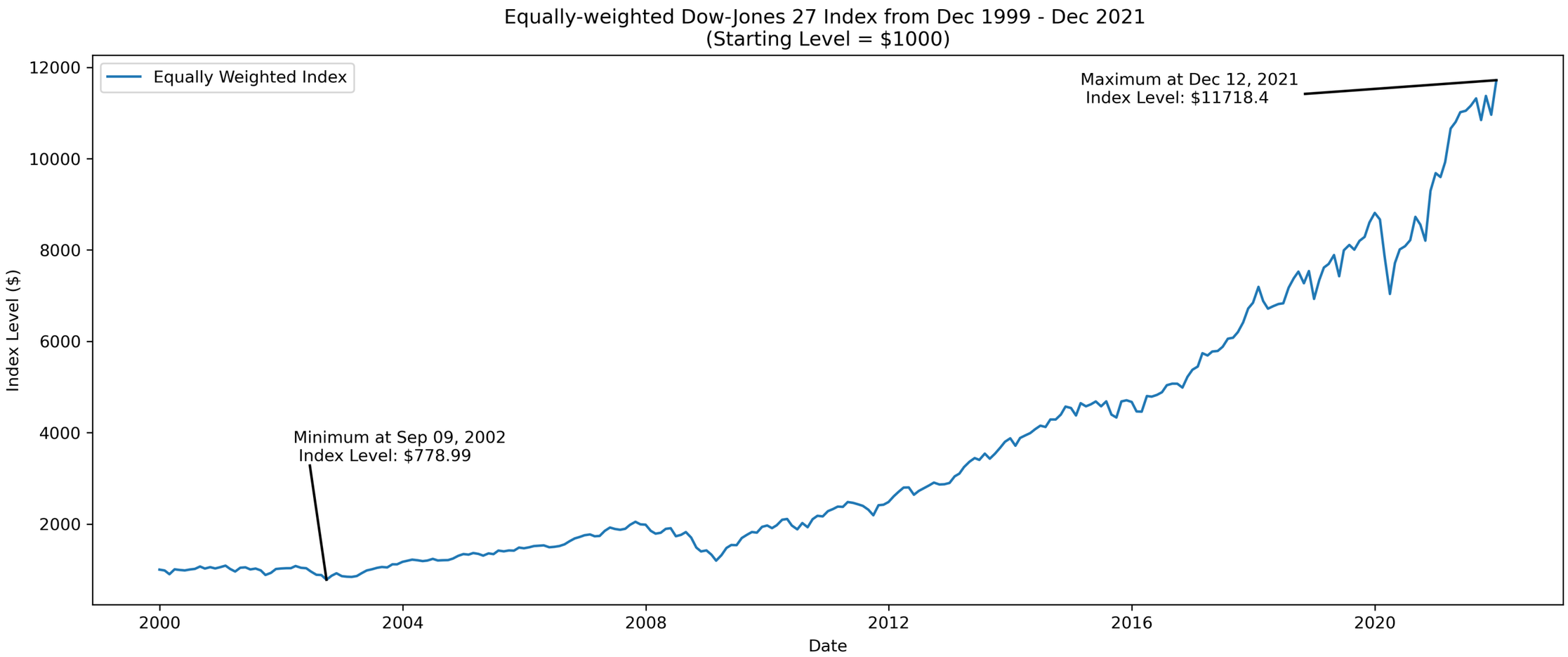
In [7]:
```
# Now we'll use this data to populate our index_df
index_returns_df = portfolio_df[["DATE", "Weighted Return"]]

index_df = pd.DataFrame(columns = ["Date", "Index Level"])
index_df.loc[0] = ["1999-12-31", 1000.00]

for index, row in index_returns_df.iterrows():
    index_df.loc[index + 1, "Date"] = str(index_returns_df.loc[index, "DATE"])
    index_df.loc[index + 1, "Index Level"] = (1+ index_returns_df.loc[index, "Weighted Return"]) * index_df.loc[index, "Index Level"]
index_df["Date"] = pd.to_datetime(index_df["Date"], format='mixed') # Fix datetime

index_df["Index Level"] = index_df["Index Level"].round(2)
index_df
```

Out[7]:

	Date	Index Level
0	1999-12-31	1000.00
1	2000-01-31	981.12
2	2000-02-29	899.21
3	2000-03-31	1006.58
4	2000-04-28	993.31
...	...	...
260	2021-08-31	11319.80
261	2021-09-30	10845.42
262	2021-10-29	11373.66
263	2021-11-30	10961.18
264	2021-12-31	11718.40

265 rows × 2 columns

In [12]:
```
index_df.set_index(["Date"])

plt.figure(figsize=(16, 6), dpi=300)
plt.plot(index_df["Date"], index_df["Index Level"], label="Equally Weighted Index")

# We need to find (and annotate the min and max)

# Min
min_y = min(index_df["Index Level"])
min_x = index_df[index_df["Index Level"] == min_y]["Date"].iloc[0]

# Plot minimum
plt.plot([min_x, min_x - timedelta(100)], [min_y, min_y + 2500], linestyle="-", color="black")
plt.text(min_x - timedelta(200), min_y + 2600, f"Minimum at {min_x.strftime('%b %m, %Y')}\n Index Level: ${min_y}")

# Max
max_y = max(index_df["Index Level"])
max_x = index_df[index_df["Index Level"] == max_y]["Date"].iloc[0]

# Plot maximum
plt.plot([max_x, max_x - timedelta(1150)], [max_y, max_y - 300], linestyle="-", color="black")
plt.text(max_x - timedelta(2500), max_y - 500, f"Maximum at {max_x.strftime('%b %m, %Y')}\n Index Level: ${max_y}")
plt.legend()

plt.title("Equally-weighted Dow-Jones 27 Index from Dec 1999 - Dec 2021 \n" +
          "(Starting Level = $1000)")
plt.ylabel("Index Level ($)")
plt.xlabel("Date")
plt.show()
```


Equally-weighted Dow-Jones 27 Index from Dec 1999 - Dec 2021
(Starting Level = $1000)
Equally Weighted Index
Maximum at Dec 12, 2021
Index Level: $11718.4
Minimum at Sep 09, 2002
Index Level: $778.99
Index Level ($)
12000
10000
8000
6000
4000
2000
2000
2004
2008
2012
2016
2020
Date