Advanced Pandas

Bitcoin as a Hedge for Inflation – Is It Still a Good Option?

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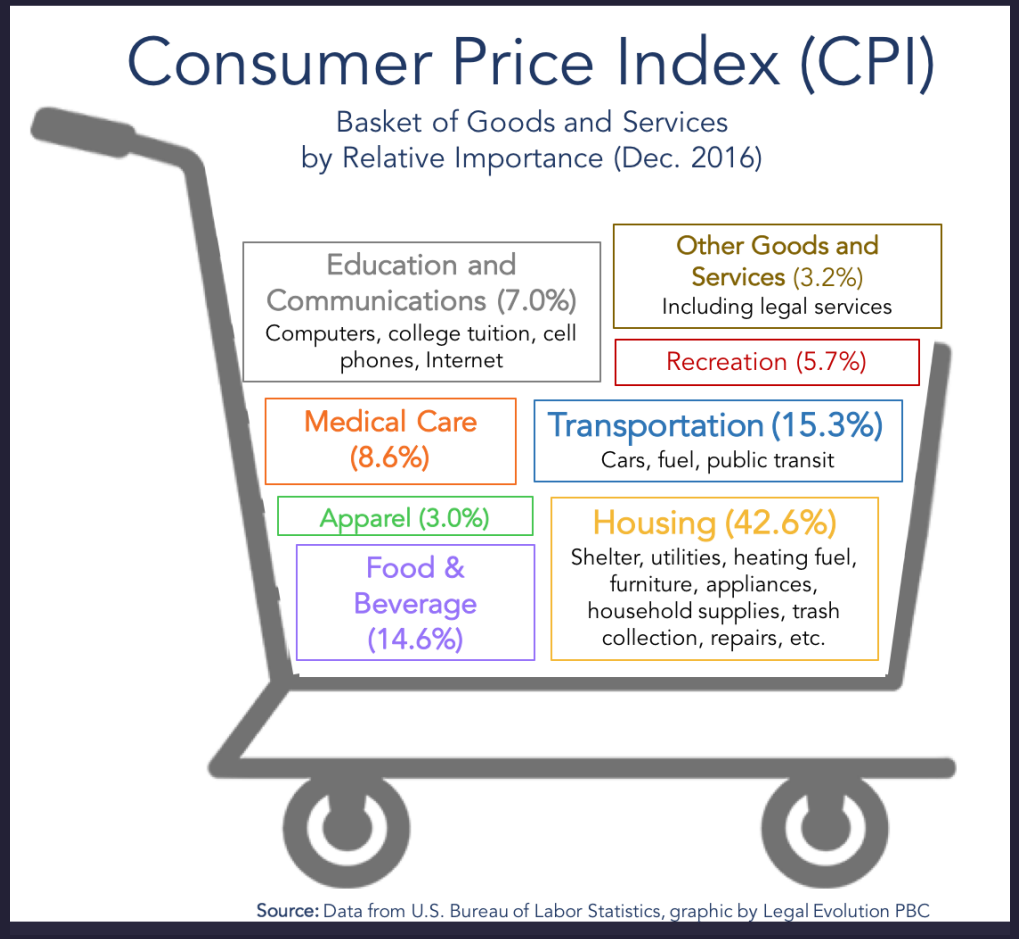
Bitcoin as a hedge for inflation?

- Bitcoin price data in the `coins` table
- Get economic indicators for inflation
  - Consumer Price Index (CPI)
  - Global Price Index of all commodities (GPI)
- **Compare** bitcoin price with economic indicators

Price Index


Consumer Price Index (CPI)
Basket of Goods and Services
by Relative Importance (Dec. 2016)
Education and Communications (7.0%)
Computers, college tuition, cell phones, Internet
Other Goods and Services (3.2%)
Including legal services
Recreation (5.7%)
Medical Care (8.6%)
Transportation (15.3%)
Cars, fuel, public transit
Apparel (3.0%)
Housing (42.6%)
Shelter, utilities, heating fuel, furniture, appliances, household supplies, trash collection, repairs, etc.
Food & Beverage (14.6%)
Source: Data from U.S. Bureau of Labor Statistics, graphic by Legal Evolution PBC

0. **Design database schema**
1. **Extract data from a source**
    i. identify endpoint, path, and query parameters from API documentation
    ii. request and get response from API
2. **Transform data**
    i. select relevant values from response
    ii. transform data into a format that can be loaded into a database
3. **Load data into database**
    i. create table
    ii. insert data into table

New tables

Table: `cpi`

Column	Type
date	VARCHAR(10)
cpi	FLOAT

Table: `gpi`

Column	Type
date	VARCHAR(10)
gpi	FLOAT

Extract CPI and GPI from Alpha Vantage

https://www.alphavantage.co/documentation/

- Endpoint
- Path
- Query parameters

Psuedocode

```
def indicators_etl(indicator: str)->None:
    """Extract, transform, and load economic indicators from Alpha Vantage API."""

    response = extract_indicators(indicator)
    data = transform_indicators(response)
    load_indicators(data)

indicators_etl("CPI")
```

Extract

```
def extract_indicators(indicator):
    url = "https://www.alphavantage.co/query"
    params = {
        "function": indicator,
        "apikey": yourkey
    }
    response = requests.get(url, params=params)

    return response.json()
```

Accessing items in a list/tuple/dict

- list/tuple: `[index]`
- dict: `[key]`

```
cities = [
    {"name": "Montreal", "state": "QC", "country": "CA"},
    {"name": "Toronto", "state": "ON", "country": "CA"},
    {"name": "Vancouver", "state": "BC", "country": "CA"},
    {"name": "Detroit", "state": "MI", "country": "US"}
]
```

- `{"name": "Vancouver", "state": "BC", "country": "CA"}`
- `"Vancouver"`
- `"Montreal"`

dict of list

```
cities = {
    "name": ["Montreal", "Toronto", "Vancouver", "Detroit"],
    "state": ["QC", "ON", "BC", "MI"],
    "country": ["CA", "CA", "CA", "US"]
}
```

- `["Montreal", "Toronto", "Vancouver", "Detroit"]`
- `"Montreal"`

dict of dict

```
cities = {
    "Montreal": {"state": "QC", "country": "CA"},
    "Toronto": {"state": "ON", "country": "CA"},
    "Vancouver": {"state": "BC", "country": "CA"},
    "Detroit": {"state": "MI", "country": "US"}
}
```

- `{"state": "QC", "country": "CA"}`
- `"QC"`

```
cities = {
    "location": {
        "Montreal": {"state": "QC", "country": "CA"},
        "Toronto": {"state": "ON", "country": "CA"},
        ...
    },
    "stats": {
        "Montreal": [
            {"year": 2013, "population": 2000000, "area": 431.5},
            {"year": 2014, "population": 1980000, "area": 431.5}
            ],
        "Toronto": [
            {"year": 2013, "population": 2800000, "area": 630.2},
            ],
        ...
    }
}
```

- `{"year": 2013, "population": 2000000, "area": 431.5}`
- `"QC"`
- `2000000`

Select values from JSON response

```
{
    "Meta Data": {
        "1. Information": "Daily Prices and Volumes for Digital Currency",
        "2. Digital Currency Code": "BTC",
        ...
    },
    "Time Series (Digital Currency Daily)": {
        "2023-10-30": {
            ...
            "4a. close (CNY)": "252122.24151800",
            "4b. close (USD)": "34456.58000000",
            ...
        },
        "2023-10-30": {...},
    }
}
```

- `"BTC"`
- `"34456.58000000"`

Select CPI from response


```
{
    "name": "Consumer Price Index for all Urban Consumers",
    "interval": "monthly",
    "unit": "index 1982-1984=100",
    "data": [
        {
            "date": "2023-09-01",
            "value": "307.789"
        },
        {
            "date": "2023-08-01",
            "value": "307.026"
        },
        ...
    ]
}
```

Transform

```
def transform_indicators(response):
    data = []
    for values in response["data"]:
        record = (values["date"], values["value"])
        data.append(record)
    return data
```

Load

```
def load_data(conn, table, data):
    for record in data:
        query = f"INSERT INTO {table} VALUES {record}"
        conn.execute(query)
    conn.commit()
```

Read Bitcoin price, CPI, and GPI from database

```
coins_df = pd.read_sql("select * from coins order by date", conn)
cpi_df = pd.read_sql("select * from cpi order by date", conn)
gpi_df = pd.read_sql("select * from gpi order by date", conn)
```

Aggregate Bitcoin price by month

```
# First seven characters of the date is year-month (YYYY-MM-dd)
coins_df["month"] = coins_df["date"].str[:7]

# Group by month and get the last closing price of each month
coins_monthly_df = coins_df.groupby("month").agg({"close": "last"})
```

More aggregate functions

- `last` (`first`): last (first) value in a group
- `nth`: nth value in a group
- `diff`: difference from the previous value
- `pct_change`: percentage change from the previous value
- `nunique`: number of unique values in a group

...

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https://pandas.pydata.org/pandas-docs/stable/reference/groupby.html#aggregation

Calculate Bitcoin monthly return

```
coins_monthly_df["return"] = coins_monthly_df.agg({"close": "pct_change"})
```

Calculate monthly inflation rate (CPI)

```
# Month from date (YYYY-MM-dd)
cpi_df["month"] = cpi_df["date"].str[:7]

# get inflation rate
cpi_df["cpi_change"] = cpi_df.agg({"cpi": "pct_change"})
```

GPI data

	date	gpi
0	1992-01-01	.
1	1992-02-01	.
2	1992-03-01	.
3	1992-04-01	.
4	1992-05-01	.
…	…	…
376	2023-05-01	157.134002

Replace `.` with missing value

If the value of a row is `.` (dot), replace it with missing value

- `None`: Python's built-in missing value
- `pd.NA`: Pandas' missing value
- `np.nan`: Numpy's missing value

Conditional column creation using `apply`

`apply`

- method that applies **a function** along **an axis** of the DataFrame.
- `axis=0` applies function to each column (default)
- `axis=1` applies function to each row

```
def replace_dot(value):
    if value == ".":
        return None
    else:
        return value

gpi_df["gpi"] = gpi_df["gpi"].apply(replace_dot)
```

Filtering

- `query()` : SQL-like syntax
- `loc[]` : **label-based**
- `iloc[]` : position-based`

...

`query` for filtering

```
df.query('age > 25')
df.query('age > 25 and house == "Gryffindor"')
df.query('age > 25') = df['age'] * 2              # error
```

`loc` for filtering and updating

```
df.loc[df['age'] > 25]
df.loc[(df['age'] > 25) & (df['house'] == 'Gryffindor')]
df.loc[df['age'] > 25, 'age'] = df['age'] * 2   # ok
```

More on `loc[index, column]`

```
# select row 0
df.loc[0]

# error: no row named 'age'
df.loc['age']

# select column 'age' (all rows)
df.loc[:, 'age']

# select rows 0 to 3, columns 'age' and 'name'
df.loc[0:3, ['age', 'name']]

# select rows where age > 25, columns 'age' and 'name'
df.loc[df['age'] > 25, ['age', 'name']]
```

Conditional column creation using `loc`

```
gpi_df.loc[gpi_df["gpi"] == ".", "gpi"] = None
```

💻 Conditional column creation

Create a new column `positive` that is `True` if the monthly return is positive, and False otherwise

- **Q1.** `apply`
  - Write a function `is_positive` that takes a value and returns `True` if the value is positive, and `False` otherwise
  - Use `apply` to apply the function to the `return` column
  - Assign the result to a new column `positive`
- **Q2.** `loc`
  - Use `loc` to select rows where `return` is positive
  - Assign `True` to the `positive` column in the selected rows

💻 `apply` (solution)

```
def is_positive(value):
    return True if value > 0 else False

coins_monthly_df["positive"] = coins_monthly_df["return"].apply(is_positive)
```

`loc` (solution)

```
coins_monthly_df.loc[coins_monthly_df["return"] > 0, "positive"] = True
coins_monthly_df.loc[coins_monthly_df["return"] <= 0, "positive"] = False
```

GPI data

	date	gpi
0	1992-01-01	None
1	1992-02-01	None
2	1992-03-01	None
3	1992-04-01	None
4	1992-05-01	None
...	...	...
376	2023-05-01	157.134002

Handling missing data

- `isna()`: returns `True` if the value is missing, `False` otherwise
- `notna()`: returns `True` if the value is not missing, `False` otherwise
- `dropna()`: drop rows with missing data

```
# Count missing data in each column
gpi_df.isna().agg('sum')

# Count non-missing data in each column
gpi_df.notna().agg('sum')

# Drop rows with missing data and assign to gpi_df
gpi_df = gpi_df.dropna()

# Drop rows with missing data and assign to gpi_df
gpi_df = gpi_df.dropna(subset=["gpi"])
```

Missing data imputation

Year	Firm ID	Stock Price	Revenue	Earnings	Total Assets
2015	XYZ	85.50	1000	120	5000
2016	XYZ	90.00	1050	None	5200
2017	XYZ	None	1075	125	None
2018	XYZ	None	1100	130	5400
2019	XYZ	80.25	1150	None	5600
2020	XYZ	100.00	None	140	5800

Missing data imputation

```
# Fill missing data with 0 and assign to gpi_df
gpi_df = gpi_df.fillna(0)

# Fill missing data with the previous value and assign to gpi_df
gpi_df = gpi_df.fillna(method="ffill")

# Fill missing data with the next value and assign to gpi_df
gpi_df = gpi_df.fillna(method="bfill")

# Interpolate missing data with a linear method and assign to gpi_df
gpi_df = gpi_df.interpolate(method="linear")
```

Calculate inflation rate (GPI)

```
# Month from date (YYYY-MM-dd)
gpi_df["month"] = gpi_df["date"].str[:7]

# get inflation rate
gpi_df["cpi_change"] = gpi_df.agg({"gpi": "pct_change"})
```

Merge bitcoin price and economic indicators

```
df = coins_monthly_df.merge(cpi_df, on="month").merge(gpi_df, on="month")

cols = ['month', 'return', 'cpi_change', 'gpi_change']
df = df[cols].dropna()

df.head()
```

Chaining methods

```
cols = ['month', 'return', 'cpi_change', 'gpi_change']

df = coins_monthly_df.merge(cpi_df, on="month").merge(gpi_df, on="month").dropna()[cols]
```

```
cols = ['month', 'return', 'cpi_change', 'gpi_change']

df = (
    coins_monthly_df                # coins_monthly_df
    .merge(cpi_df, on="month")      # merge with cpi_df
    .merge(gpi_df, on="month")      # merge with gpi_df
    .dropna()                       # drop rows with missing data
    [cols]                          # select columns
)
```

Data Visualization

- Matplotlib
- Seaborn
- Bokeh
- Altair
- **Plotly**

Plotly Express Syntax

```
import plotly.express as px

fig = px.scatter(df, x="age", y="height")
fig.show()
```

---

https://plotly.com/python/plotly-express/
https://plotly.com/python/px-arguments/

Line plot

```
# line plot for monthly return
fig = px.line(df, x="month", y="return")
fig.show()
```

```
# line plot for monthly return and inflation rate
fig = px.line(df, x="month", y=["return", "cpi_change"])
fig.show()
```

Moving average (`rolling`)

```
# calculate 3-month moving average
df["return_ma"] = df["return"].rolling(3).mean()

# line plot for monthly return and 3-month moving average
fig = px.line(df, x="month", y=["return", "return_ma"])
fig.show()
```

Heatmap for correlation

```
# correlation matrix
corr = df.corr()

# heatmap
fig = px.imshow(corr, color_continuous_scale="Redor")
fig.show()
```

color scale: https://plotly.com/python/builtin-colorscales/

Scatter plot with regression line

```
fig = px.scatter(df, x="inflation", y="return", trendline="ols")
fig.show()
```

Regression using `statsmodels`

```
import statsmodels.api as sm

X = df["cpi_change"]
y = df["return"]
X = sm.add_constant(X)
model = sm.OLS(y, X).fit()
model.summary()
```

https://www.statsmodels.org/stable/index.html