

Chapter 1

Project and Goal

1.1 Abstract

This paper adapts the non-parametric dynamic time warping (DTW) technique to analyze the temporal alignment and similarity of the SP 500 index with various economic indicators. DTW offers notable advantages over traditional financial analysis methods by addressing the limitations associated with fixed temporal alignments in time series data. Unlike conventional approaches, DTW can effectively capture the shifting dynamics of leading and lagging relationships, enabling more nuanced insights into correlations between the SP 500 and economic variables. Using cluster analysis, this study identifies distinct recovery patterns in the index under varying economic conditions, underscoring the importance of these insights for optimizing investment strategies.

1.2 Executive Summary

The primary objective of this paper is to explore the application of dynamic time warping (DTW) in analyzing and visualizing seasonal patterns in financial markets, while providing educational insights to enhance understanding of the findings.

It is important to note that this paper does not aim to offer investment or trading advice. Consequently, it will not provide tools for technical analysis or trend prediction.

1.3 Output

The primary output of this research will be a comprehensive analysis that utilizes DTW to examine and illustrate patterns across various financial assets. The study will detail the methodology employed to implement DTW, including its advantages in capturing temporal alignments of trends. We will present graphical representations of behavior over specified time frames and highlight cases where assets demonstrate weak performance due to historical volatility or irregularities.

Additionally, the paper will include an educational section that outlines the principles of dynamic time warping, its significance in financial analysis, and guidance on interpreting the data presented. This section will also provide links to additional resources for further exploration of the topic.

1.4 Motivations

This research originated from a recognized need to better understand and analyze patterns within financial markets, alongside an interest in leveraging dynamic time warping as a novel analytical approach. Given the scarcity of comparable studies employing DTW to investigate financial assets, we were motivated to develop this paper.

Furthermore, this study offers an opportunity to gain deeper insights into the methodologies for retrieving, manipulating, and visualizing financial data using DTW. It also serves as a platform for academic exploration, emphasizing the significance of rigorous analysis in understanding financial phenomena and the dynamic relationships between various assets over time.

Chapter 2

Tasks e Resources

2.1 Method identification

Initially, we invested time in studying Dynamic Time Warping (DTW) to discern patterns in financial time series data. DTW is a technique that measures similarity between two temporal sequences which may vary in speed. This method is particularly useful in financial applications where the timing of price movements may not align perfectly.

The project's key stages can be delineated into three main phases: downloading and manipulating the data, applying DTW to analyze the time series data, and analysing the results.

For detailed steps, please refer to the roadmap section.

2.2 Prerequisites

A fundamental understanding of financial markets, including the distinct characteristics among asset classes, their varying levels of volatility, and their responses to economic cycles, is crucial for this project.

From a mathematical perspective, a basic understanding of time series analysis and similarity measures is required. The project involves manipulating returns over different periods and calculating metrics to evaluate the strength of similarity between time series.

Proficiency in Python, particularly in manipulating dataframes using libraries such as NumPy and Pandas, is essential. Additionally, familiarity with time series libraries, such as 'tslearn' for DTW, is necessary.

2.3 Dynamic Time Warping Overview

Dynamic Time Warping (DTW) is a robust algorithm for measuring the distance between two sequences that may vary in time or speed. This technique finds applications in various domains, including finance, where it can identify similarities in price movements even when they occur at different rates.

The DTW algorithm aligns two sequences by warping the time axis, allowing for a non-linear mapping of one sequence onto another. This is particularly useful for analyzing historical price data, enabling the identification of trends and patterns that may not be apparent through traditional analysis methods.

The steps in applying DTW generally involve:

- Calculating the cost matrix for the two time series.
- Identifying the optimal path through this matrix that minimizes the cumulative distance.
- Extracting the distance measure and the warping path for further analysis.

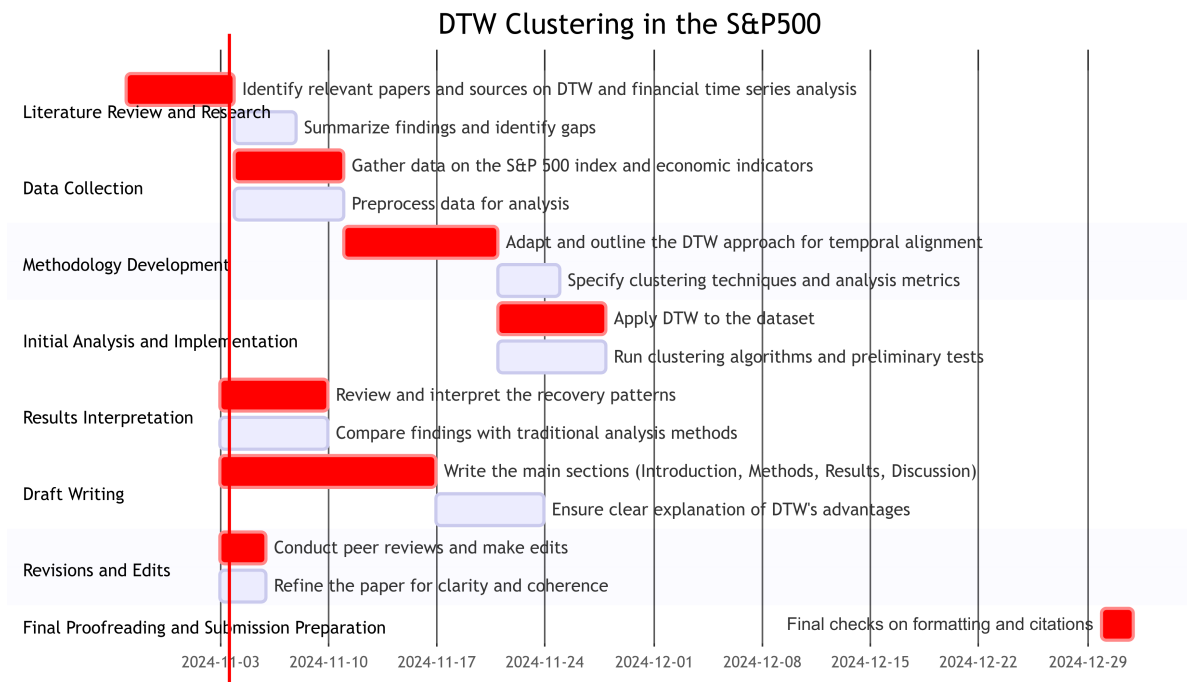
2.4 Frameworks, APIs and languages

- Programming Languages: Python.
- Source code editor: [Vscode](#).
- Libraries: Pandas, Numpy, Matplotlib, FastAPI, tslearn.
- Paper writing platform: Overleaf & Zotero.
- Financial API: Twelvedata.

Chapter 3

Timeline

We created a Gantt Chart to provide details on each step of the project. This tool will assist us in planning and monitoring activities over time. Every team member can refer to the chart to understand project phases in detail. Additionally, we will discuss resource and personnel allocation in each phase, identifying dependencies between activities and potential risk areas.



The project aims to finish the paper before the conclusion of the academic semester at Politecnico di Milano and prior to the beginning of the exam session. Weekly meetings will be conducted to monitor project progress and task allocation.

3.1 Roadmap

This project roadmap is structured to ensure that all tasks are completed by January 1, 2025, with the collaboration of five team members working in parallel. The timeline is divided into distinct phases, each with clear objectives and deliverables. Weekly meetings will be held at the end of each week to assess progress and address any challenges encountered.

3.1.1 Phase 1: Literature Review and Research

The project begins with a comprehensive literature review, focusing on relevant papers related to Dynamic Time Warping (DTW) and financial time series analysis. This phase will last for a week, during which the team will identify significant sources and summarize findings to identify gaps in the existing literature.

3.1.2 Phase 2: Data Collection

Following the literature review, the team will gather historical data on the S&P 500 using the Twelvedata API. This will include daily closing prices over a selected period, which are crucial for the subsequent analysis. Data collection will be followed by an additional task dedicated to preprocessing the data. This preprocessing will involve cleaning the dataset, normalizing values, and aligning the time series to ensure accurate comparisons.

3.1.3 Phase 3: Methodology Development

Concurrent with the data collection phase, the team will develop the methodology for implementing DTW in clustering. This includes defining the distance measure for DTW and setting the parameters for the clustering algorithms, such as the number of clusters.

3.1.4 Phase 4: Initial Analysis and Implementation

Once the methodology is established and the data is preprocessed, the team will apply DTW to the dataset to identify patterns and trends. During this phase clustering algorithms will be tested and initial results obtained.

3.1.5 Phase 5: Results Interpretation

After the initial analysis, the team will review and interpret the recovery patterns identified through clustering. This will include comparing the results with traditional analysis methods to provide deeper insights into the data.

3.1.6 Phase 6: Draft Writing

In the final stages of the project, the team will write the research paper, which will encompass several sections: introduction, literature review, research methodology, results and discussion, and references. This writing phase will take more weeks, ensuring a thorough presentation of the research findings and a clear explanation of the advantages of using DTW.

3.1.7 Phase 7: Revisions and Final Submission Preparation

Once the draft is completed, the team will conduct peer reviews and make necessary edits over a two-week period to refine the paper's clarity and coherence. The final checks on formatting and citations will occur in the last days of December, leading up to the submission of the paper by January 1, 2025.

3.2 Report: Example of prototype

Available in the repository of the project as a pdf file.j