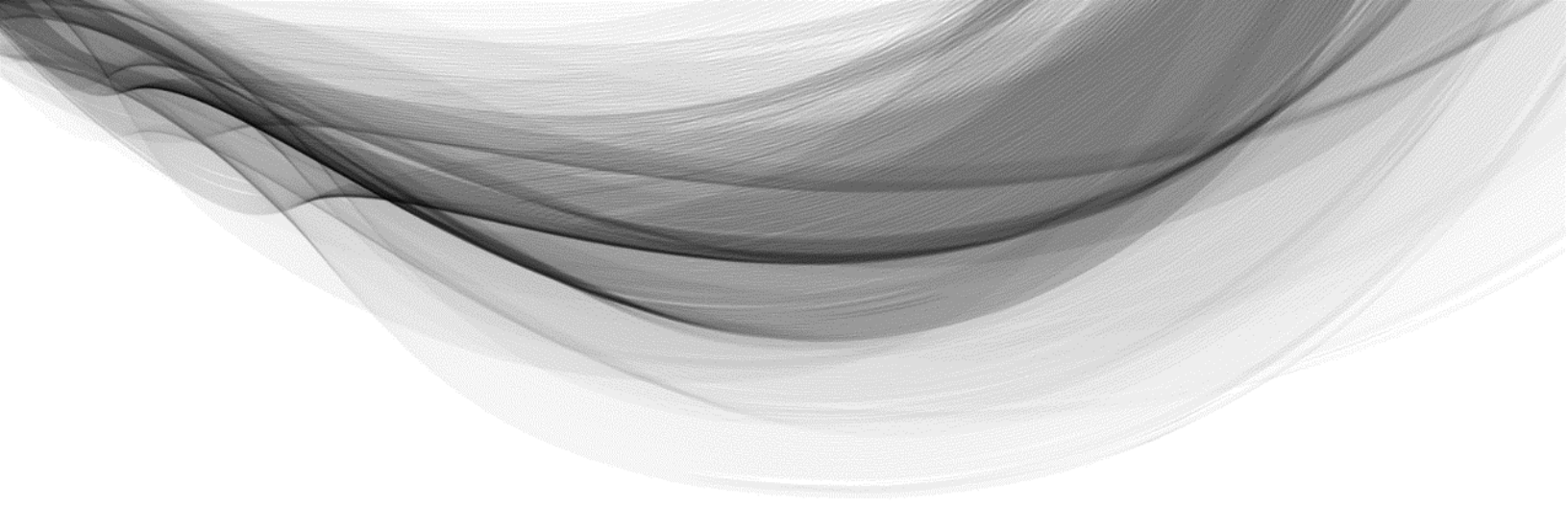




Research Proposal

L6 – Independent Project

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BSc Computing (Software Engineering)

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1. Introduction

Working Title: Detecting price and volume anomalies consistent with pump-and-dump activity within the Counter Strike 2 skins market using public market data.

Counter Strike 2 (CS2) is a popular video game, widely known for its real-money economy where in-game items such as weapon skins can be traded and sold via Steam and third-party marketplaces. With estimated valuation of close to \$5.9 billion [1], the CS2 market is largely unregulated, making it susceptible to market manipulation, specifically pump-and-dump schemes (P&Ds).

Within CS2, a P&D is a form of price manipulation where items are purchased at a low cost before being artificially inflated and sold for a profit [2]. This practice can lead ordinary players to invest in items that aren't truly in demand, and when the price of an inflated item eventually drops, they can face significant losses. Motivated by the financial harm to ordinary players and its close relationship to mainstream finance, this project aims to investigate whether automated detection methods can be used to identify suspicious market activity, acting as a first step to mitigating the impact of P&Ds within the CS2 market.

2. Background to the Research

This section reviews existing research into the CS2 skins economy and established P&D detection methods within both cryptocurrency and classical financial markets.

2.1 Market Manipulation and Price Anomalies

Market manipulation has been widely studied within cryptocurrency markets. Kamps & Kleinberg examine P&Ds in which bad actors artificially inflate an asset's value before selling their supply [3]. Their research forms the foundation for understanding suspicious price and trading volume patterns. This foundation is strengthened further by the research of La Morgia, Mei, Sassi & Stefa whose study developed a machine learning model with the ability to detect P&Ds as they happen and with a high level of accuracy [4]. However, it is important to note that an asset's value and volume are not proof of market manipulation, and each case should be judged individually.

2.2 Machine Learning and Anomaly Detection

Approaches such as machine learning offer the potential to detect P&Ds within cryptocurrency markets. Rajaei and Mahmoud's survey reviews a variety of machine-learning approaches to P&D detection within the cryptocurrency market, providing insight into existing techniques [5]. This research is further extended by Chadalapaka, Chang, Mahajan and Vasil's inquiries into P&D detection utilising deep learning techniques [6].

Isolation Forest by Liu, Ting and Zhou illustrates an approach where anomalies are isolated, providing a potential technique for detecting suspicious price movements and trading volumes without requiring every observation within the wider dataset to be labelled [7]. However, it is important to note that legitimate movements within a market can also produce unexpected behaviours, and therefore anomalies must be reviewed carefully.

2.3 Virtual Markets and the Research Gap

Virtual items have transcended their roles within games into developed markets with real economic value. Thorhauge and Nielsen examined these items and their role within these virtual economies, supporting the value of studying these markets [8]. Research investigating digital assets as financial assets and CS2 skin prices [9] provides additional context when understanding market behaviours within said economies.

Despite this, P&D detection methods developed for both cryptocurrency and classical markets may not transfer to CS2 cosmetics. Skins within the game have different characteristics, meaning their price may fluctuate significantly for legitimate reasons. This creates additional challenges when attempting to flag irregular behaviour.

This project aims to investigate whether selected computational and machine learning anomaly detection techniques can be used to identify unusual price and volume patterns within the CS2 skins market. By applying established approaches found within formal markets within an alternate context, the research will evaluate both their usefulness and limitations. Rather than assuming detected anomalies prove intended manipulation, the goal is to investigate the effectiveness of these techniques for identifying suspicious market behaviour. This provides a focused outline for connecting an increasingly relevant virtual economy with established detection methods.

3. Research Problem Statement

Within CS2, P&D schemes can lead to ordinary players losing a considerable amount of money when artificially inflated prices eventually collapse. Despite such risks, there is no established, validated method for detecting such activity using publicly available market data. One of the leading causes of this is a lack of regulation and formal oversight that is typically found within traditional markets.

This has led to a gap at the intersection of an unregulated market and established P&D detection methods, providing a new context to study. As illustrated in Section 2, existing research has already investigated P&D detection methods within cryptocurrency and classical financial markets [3, 4, 5, 6, 10]. However, the effectiveness of these techniques within the CS2 skins market is unknown, and applying proven methods in this new context may provide insight into the nature of suspicious market activity.

The project's aim is also feasible; all market pricing and volume data is public, allowing it to be collected and analysed using existing approaches and technologies. However, as outlined within Section 2, it is important to remember that unusual market behaviour is not necessarily proof of deliberate malpractice. As a result, this project will aim to investigate whether anomaly detection techniques can identify patterns consistent with P&D activity within the CS2 market. These findings will then be used to evaluate their effectiveness and limitations within this alternative context and conclude whether they can provide sufficient support when detecting suspicious market behaviour.

4. Aim and Objectives

The aim of the proposed project is to evaluate the effectiveness of P&D detection methods within the CS2 skins market. This will be achieved following four objectives:

1. **To collect** historical and current public CS2 market data, producing a structured dataset containing historical price and trading volume suitable for anomaly detection.
2. **To build** three anomaly detection methods, including a machine learning model to identify price and volume behaviour consistent with P&D activity within the CS2 skins market.
3. **To evaluate and compare** a range of implemented anomaly detection techniques using appropriate performance metrics. This includes the rate of false positives as well as general strengths, limitations and suitability within the context of CS2 skins.
4. **To design, develop and test** software that visualises market data, presents and flags detected anomalies and their respective contributing indicators. This software will demonstrate the practical application of previously evaluated methods within the CS2 skins market.

Deliverables at the conclusion of the project include:

- A structured dataset of historic CS2 market data.
- Multiple computational and machine learning approaches to P&D detection.
- A comparative evaluation of differing approaches.
- Prototyped software that presents detected anomalies and their indicators.

5. Research Methodology

This section covers the research methodology for the proposed project.

5.1 Research Design

The proposed project is an evaluation of P&D detectors within the CS2 skins market. This will involve developing a piece of software capable of ingesting historic market data while utilising established detection methods to flag behaviour consistent with P&D activity. Steam Market data is accessible via the **pricehistory** endpoint [11], providing both daily price and volume metrics. This will provide the signals required to detect suspicious behaviour within the market. Due to varying granularity, the dataset will first need to be cleaned.

Three methods will be used to detect behaviour consistent with P&D activity. In one approach a statistical baseline will be established before using z-scores to detect anomalies. Change-point detection will also be utilised in order to detect sudden changes in variance. Finally, the Isolation Forest unsupervised machine learning algorithm will also be used to detect suspicious activity as it removes the need for labelled datasets [7].

Risks to the proposed project include Valve policy and data access. In the event Valve were to close required endpoints or make significant changes to item trading, the project may no longer be viable. To mitigate this risk, snapshots of historical trading data are to be captured at the earliest possible date across both the Steam Community Market and third-party marketplaces. All data collected will be non-personal and public. Individual participants will not be required in order for the project to proceed. This helps to negate any ethical risk.

The project's results will be reproducible using stored data. Results will also be evaluated against known patterns within P&D pricing and volume data, providing validity within the research. Furthermore, the project will be generalisable as detection methods have the ability to transfer to other virtual markets. In order to evaluate the system's effectiveness, simulated P&D schemes will be injected into the dataset. This will be strengthened further by testing historical, known P&Ds. This will be used to analyse the software's precision, recall, F1 score and false positive rate.

5.2 Resources / Materials

Required resources in order for the proposed project to go ahead include:

Computer systems / hardware:

- A laptop / personal computer for development.
- A Virtual Private Server to continually capture current market pricing and volume.

Backend technologies:

- pandas / NumPy for data.
- statsmodels / ruptures for change-point.
- scikit-learn for ML Isolation Forest approach.

Frontend technologies:

- HTML / CSS / JavaScript, with Node.js as the server.
- Chart.js for plotting price / volume behaviour with flagged anomalies.

API access:

- Access to Steam Community Market `pricehistory` endpoint [11]
- Access to third-party marketplace APIs (Skinport)

Shared technologies:

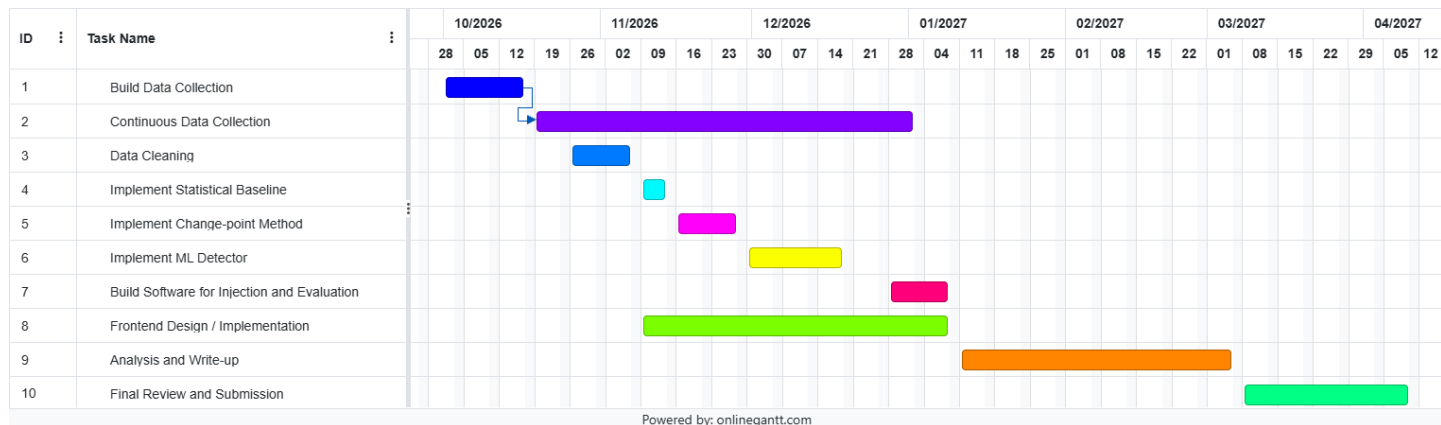
- A SQL database hosting marketplace data.

Access to journals:

- UWTSD Library access for further reading.

6. Project Planning

In order to ensure the initial implementation and final submission of the proposed project are completed effectively and in a timely manner, a Gantt Chart was designed as illustrated in Figure 1. Within the first three weeks a data collection pipeline will be developed before data collection runs into late December. During this time all key P&D detection methods are designed and implemented alongside the frontend and software injection / evaluation applications. Finally, from mid-January to early April, the project’s write-up and final review are completed before submission.



[Figure 1: Project Gantt Chart]

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