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An Empirical Analysis of Counter-Strike Weapon Cases as an Alternative Asset Class

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ABSTRACT:
Digitaalisten omaisuuserien merkitys on kasvanut nopeasti 2000-luvulla, ja virtuaalisiin ympäristöihin sidotut sijoituskohteet ovat muodostuneet uudeksi ilmiöksi sijoitusmaailmassa. Talouden epävakauden lisääntyessä kiinnostus vaihtoehtoisiin sijoituskohteisiin on kasvanut, erityisesti sellaisiin, joiden kehitys ei ole vahvasti sidoksissa perinteisiin rahoitusmarkkinoihin. Peliekosysteemeihin liittyvät digitaaliset hyödykkeet ovat yleistyneet, ja niiden markkinat ovat laajentuneet nopeasti. Counter-Strike-pelin aselaatikot edustavat tällaisia digitaalisia objekteja, joiden arvo määräytyy kysynnän, tarjonnan sekä pelaajien käyttäytymisen perusteella.

Tässä tutkielmassa tarkastellaan, miten Counter-Strike-aselaatikot käyttäytyvät sijoituskohteina ja millaisia tuotto-, riski- ja hajautusominaisuuksia niihin liittyy. Tavoitteena on arvioida, voidaanko aselaatikoita pitää vaihtoehtoisena omaisuusluokkana sekä miten niiden tuottoprofiili suhteutuu muihin keskeisiin sijoituskohteisiin. Tarkastelu perustuu modernin portfolioteorian, neoklassisen arvoteorian ja digitaalisten omaisuuserien tutkimuksen keskeisiin käsitteisiin.

Tutkielman empiirinen osuus perustuu aineistoon, joka sisältää useita aselaatikoita usean vuoden ajalta. Aineisto on kerätty aktiivisilta markkinoilta, jotta hintakehitys heijastaa todellista kaupankäyntiä. Vertailua varten on hyödynnetty aineistoa osakeindeksistä, kryptovaluuttamarkkinoilta ja kultamarkkinoilta. Aineiston pohjalta on muodostettu keskeiset tuotto- ja riskimittarit sekä markkinaa kuvaava indeksi, joka mahdollistaa koko markkinasegmentin tarkastelun.

Tulokset osoittavat, että aselaatikot muodostavat markkinan, joka poikkeaa selvästi perinteisistä omaisuusluokista. Niihin liittyy huomattavaa volatiliteettia ja yksittäisten kohteiden välillä esiintyy suurta vaihtelua. Samanaikaisesti on kuitenkin havaittu korkeita tuottoja pitkällä aikavälillä. Markkinatason tarkastelu osoittaa, että hajauttaminen tasoittaa yksittäisiin kohteisiin liittyviä riskejä ja tuottaa vakaampaa kehitystä. Hintakehityksen on lisäksi huomattu olevan pitkälti riippumatonta muista tarkastelluista markkinoista, mikä viittaa hajautushyötyihin.

Johtopäätöksenä esitetään, että Counter-Strike-aselaatikot voidaan nähdä vaihtoehtoisena digitaalisen talouden omaisuusluokkana. Vaikka yksittäisiin kohteisiin liittyy korkea riski, hajauttaminen voi parantaa tuotto-riski-suhdetta. Digitaalisiin peliesineisiin perustuvat markkinat tarjoavat siten kiinnostavan lähtökohdan jatkotutkimukselle ja laajentavat ymmärrystä vaihtoehtoisten sijoituskohteiden kentästä.

KEYWORDS: alternative assets, Digital assets, non-separable digital objects, virtual goods, portfolio management, digital consumption

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1 Introduction

Chambers, Anson, Black, and Kazemi (2020) define an investment as deferred consumption: any financial commitment made with the expectation of future benefits or yields. According to this definition, the concept of investment covers a very broad range of assets and activities; planting a tree, buying stocks, and acquiring a university degree can all be considered investments. In the modern global economic environment, corporate stocks and investment-grade bonds from anywhere in the world are considered traditional investments (Chambers, Black & Lacey, 2018). Investments that financial institutions, for example, pension funds, include in their holdings are referred to as institutional quality investments and are anticipated to deliver reasonable returns at an acceptable level of risk (Chambers, Anson, Black & Kazemi, 2020).

The definition of an alternative investment varies a great deal, and there is no universally standardized definition for what specifically counts as an alternative investment (Chambers, Black & Lacey, 2018). Skully (2007) defines alternative investments in a general sense as assets that lack immediate and liquid trading markets, while Kräussl, Lehnert & Rinne (2017) determine alternative investments as all investments that are not traditional long-only positions in publicly traded equities, fixed-income securities, or cash. Alternative investments are not generally considered institutional-quality investments. For example, institutional pension funds are often hesitant to hold assets such as collectibles instead of the publicly traded equities of a major corporation (Chambers, Anson, Black & Kazemi, 2020).

The relationship that exists between risk and reward is highly uncertain and unlikely to remain stable over time (Lo, 2004). The Adaptive Markets Hypothesis (AMH), introduced by Lo (2004), suggests that due to the ever-changing nature of the risk/reward relationship, it is necessary to adapt to changing market conditions to achieve a consistent level of expected returns. Throughout its history, the investment market has undergone significant transformations, encouraging investors to seek returns beyond the traditional assets, such as stocks and bonds (Jagirdar & Gupta, 2023). In addition to

previously mentioned factors, Kräussl, Lehnert & Rinne (2017) and Skully (2007) highlight diversification benefits, potential for higher yields, access to emerging asset classes, and illiquidity premiums among the key reasons why alternative investments have gained notable popularity over the last century.

Chambers, Black & Lacey (2018) list hedge funds, private equity, real assets, and structured products as the largest categories of alternative investments. Wilson (2007) states that these alternative investments have become mainstream and are no longer considered as special case alternatives. Kräussl, Lehnert & Rinne (2017) report significant growth in investing in real estate, hedge funds, private equities, commodities, and collectibles. Andonov, Bauer & Cremers (2017) observe that also U.S. public pension funds are increasing their investments into alternative investments when Treasury rates are decreasing.

As a result of the aforementioned alternative assets becoming more widely utilized and mainstream, there are a lot of studies and data about investing in such asset categories as hedge funds, private equity, and collectibles. Faye & Fur (2023) report a considerable growth on the exchange of digital collectibles but also acknowledge the lack of research on the topic. Therefore, this thesis will instead focus on more modern and less studied alternative investment assets: non-separable digital objects – specifically, weapon cases in video game series Counter-Strike (CS).

1.1 Objectives and research problem

The primary objective of this thesis is to analyse weapon cases in the video game series Counter-Strike (CS) as an alternative investment asset. The thesis presents investors, both individual and professional, with a modern alternative asset that they may consider including in their portfolios. This study examines the risk and returns of CS weapon cases as an investment compared to investing in the S&P 500 index, bitcoin and gold. Furthermore, the study aims to assess the potential portfolio diversification benefits of

including these assets in a portfolio, with Modern Portfolio Theory (MPT) serving as one of the key theoretical frameworks of the study. The motivation for the study derives from a personal interest in modern alternative investments.

Although alternative investments are relatively widely researched subject, the research is usually focused on already well-known assets such as real estate, private equities, commodities, and collectibles. Considerably less attention has been given to modern date investment opportunities emerging from digital collectibles markets, and even fewer studies examine the potential of investing in non-separable digital objects such as CS weapon cases.

The hypotheses of this study are outlined below. These hypotheses are established by observing literature and empirical studies that contribute to the research of alternative investments and CS weapon cases from an investing perspective. The primary hypothesis of the study is that there is a low or negative correlation between CS weapon cases and the S&P 500 index, which indicates diversification benefits. The second hypothesis assumes that CS weapon cases as an investment asset generates a positive average return over the study period. The third and fourth hypothesis are focused on the riskiness of CS weapon cases as an investment. The third hypothesis assumes that CS weapon cases have higher volatility that S&P500 index, while the fourth hypothesis assumes that the Sharpe ratio of CS weapon cases is lower than that of the S&P500 Index.

Hypothesis 1: The correlation between CS weapon cases and the S&P 500 index is low or negative, indicating diversification benefits

Hypothesis 2: CS weapon cases generate a positive average return over the study period

Hypothesis 3: The volatility of CS weapon cases is higher than that of the S&P500 index

Hypothesis 4: The Sharpe ratio of CS weapon cases is lower than that of the S&P 500 index

1.2 Structure of the study

The thesis is structured as follows. Chapter one is the introduction, which presents the research problem and the hypotheses of the study. The second chapter is a literature review on what alternative investments are and what type of risks and benefits are associated with alternative investments. The third chapter focuses more closely on CS weapon cases as an investment asset, revealing more closely what they are and how they are traded. The fourth chapter introduces the data, methodology, key concepts, and theoretical models used in this study. The results and findings of this study are revealed in chapter five, and the conclusions and suggestions for further research are presented in the sixth chapter.

2 Alternative investments

At a macro level, alternative investments consist of assets other than stocks and bonds traded on public markets (Liu, Sun, Huang, Tang & Wu, 2017). According to Knutzen (2022), alternative investment markets have evolved from a niche sector to a relevant component of the investing world, and he believes that these markets will continue to grow in importance and become even more mainstream. Alternative investment instruments demand greater operational competence and more advanced execution capabilities, particularly in the post-investment management phase (Liu, Sun, Huang, Tang & Wu, 2017). Because of the complex nature of alternative investment instruments, it is important to understand the historical evolution, diverse types, benefits and risks, and relevant critiques associated with alternative investing (Mundi & Kumar, 2023). This chapter presents the relevant information and provides a comprehensive overview of alternative investments.

2.1 History of alternative investments

Tulip Mania in 17th-century Holland is one of the first recorded cases of speculative bubbles in history (Garber, 1989; Quinn & Turner, 2020). Transactions of Tulip Mania consisted of speculation on non-traditional assets, in this case rare tulip bulbs, via futures contracts as early as 1636. While Tulip Mania was not formally categorized as a case of alternative investing at the time, it can be regarded as a precursor to modern alternative investing, as the speculative nature of Tulip Mania prefigures modern alternative investment strategies, where investors utilize non-traditional assets to realize returns independent of traditional financial markets (Garber, 2001; Quinn & Turner, 2020).

In 1949, sociologist Alfred Winslow Jones, founder of the Jones & Co. LLC fund, created the first hedge fund, the earliest alternative investment asset identified in the academic literature (Brown, 2001; Crockett, 2007; Sokołowska, 2015). Jones utilized the

method of short selling that made it possible for investors to profit despite price drops on the market, thus successfully hedging some of the market risk (Crockett, 2007; Sokołowska, 2015). The establishment of the first hedge fund is widely regarded as the beginning of the alternative investments market (Sokołowska, 2015). Nowadays hedge funds are the most recognized alternative investment institutions, and the number of hedge funds has risen gradually since the 1950s. Hedge funds gained a lot of popularity in the 70s and 80s as a result of new investment instruments such as derivatives and the limitations of traditional investment funds and pension funds (Crockett, 2007; Sokołowska, 2015). The use of leverage and active trading strategies allowed hedge funds to generate absolute returns less dependent on traditional equity and bond markets, leading to the institutionalization of hedge funds in the 1990s as pension funds, along with other large institutional investors, started to allocate larger portions of their funds to the hedge funds (Sokołowska, 2015).

The Global Financial Crisis of 2008 significantly affected and shaped both the global economy and the capital markets. Before the Global Financial Crisis, alternative investments were mostly utilized only by a minority of pioneering investors, but inadequate recoveries in developed economies post-crisis generated intensive competition for funding and pressure due to declining returns globally (Liu, Sun, Huang, Tang & Wu, 2017). Following the global financial crisis, developed economies have suffered from very low and even negative real interest rates, resulting in an environment where alternative investments like hedge funds, commodities, and real estate have prospered (Menconi, 2022). According to Cumming, Helge Haß & Schweizer (2014,) and Liu, Sun, Huang, Tang & Wu (2017), the post-financial crisis economy associated with declining interest rates and modest returns led to increasing numbers of large institutional investors also developing interest in private markets and alternative assets. Alternative investment funds and assets have become increasingly

crucial for the portfolios of institutional investors for the purpose of delivering higher returns with more stability.

The magnitude of the negative impact resulting from the financial crisis on the markets established the need for an adequate level of regulation and oversight over major financial institutions, markets, and instruments, including hedge funds and alternative investments (Ferran, 2011; George & Dymally, 2013). The pioneering EU-wide governance framework for alternative investment fund managers, the Alternative Investment Fund Managers Directive (AIFMD), came into effect in July 2011, forming substantial standards and offering regulators tools to monitor hedge funds and other alternative investments (George & Dymally, 2013). Together with the U.S. Dodd–Frank Act, the AIFMD strengthened transparency and oversight on the alternative assets market and led to wider acceptance and integration of alternative assets into institutional investors' portfolios (George & Dymally, 2013; Kokkila, 2016; Kroszner & Shiller, 2011; Yang, 2023).

The ascent of sovereign wealth funds (SWFs) into globally substantial investors can be regarded as one of the most influential changes over the past few decades (Meggins, Malik & Zhou, 2023). This development has also significantly affected the popularity of alternative investments, as the twelve biggest SWFs in the world have all allocated funds into alternative assets. Most notably, Norway's Government Pension Fund Global (NGPFG) has modified its investment preferences and in 2010 began to invest in real estate assets, targeting a portfolio allocation of 5 percent (Liu, Sun, Huang, Tang & Wu, 2017). The performance of technology companies during the global lockdown in 2020-2021 encouraged SWFs to allocate even more capital into alternative investments (Meggins, Malik & Zhou, 2023).

Another notable group of investors, the public pension funds in the United States, have also experienced similar development, strategically reallocating their risky investments away from public equities and towards alternative assets such as private equity and

hedge funds (Layne, 2025; Begenau, Liang, & Siriwardane, 2025). In 2001 alternative assets accounted for only 14% of risky investments of U.S. public pension funds, increasing to 39% by 2021. (Begenau, Liang, & Siriwardane, 2025). Begenau, Liang, and Siriwardane (2025) argue that this trend is due to U.S. public pension funds progressively believing that alternatives earn alpha relative to public equities.

Although the investment strategies of institutional investors differ depending on their source of capital, liquidity requirements, and risk appetite, three of the most prevailing trends of the last two decades have globally been the growing allocation to alternative assets, the rising confidence in long-term investing, and the increased focus on post-investment management (Liu, Sun, Huang, Tang & Wu, 2017).

2.2 Current Trends and Future Outlook

The utilization of alternative investments and continuous effort to identify profitable investment strategies have developed into key focus areas for investors striving to optimize returns while mitigating risk in the transformative sphere of modern finance (Syahputra, 2023). Significant technological advancements, especially blockchain technology, artificial intelligence, and big data analytics, are notably reshaping traditional finance by enabling new investment strategies and enhancing operational productivity (Gomber, Koch, & Siering, 2018). Improved performance of computers and processing hardware allows investors to employ modern strategies, such as algorithmic trading, that allow high-speed and high-frequency trading based on predefined rules and algorithms (Syahputra, 2023). Increasing attention on environmental sustainability and social responsibility and interest in digital assets are also notable key trends that are reshaping capital markets and revolutionizing traditional financial systems (Geczy, Stambaugh, & Levin, 2015; Biais, Bisière, & Pouget, 2020).

Alternative investments have evolved into a vital component of the standard asset allocation strategies of institutional portfolio managers (Liu, Sun, Huang, Tang & Wu,

2017). Even though alternative investing is not a new phenomenon, it is still growing in popularity and importance (Liu, Sun, Huang, Tang & Wu, 2017). Knutzen (2022) & Liu, Sun, Huang, Tang & Wu (2017) believe that this trend will continue in the future, anticipating that the private sector will proceed to grow and that alternative investments will become progressively mainstream. This growth will be enabled, for instance, by the pursuit of higher returns, the growth of the private market ecosystem, enhanced access to private markets for a larger number of investors, and the potential of alternative investing, which is projected to develop even further as a result of new technologies like blockchain (Knutzen, 2022).

2.3 Alternative Investment Assets

Alternative investment assets include a wide and constantly evolving spectrum of asset types that fall outside well-known traditional asset classes such as stocks, bonds, and cash (Balaban et al., 2021). There is no universal standard definition of what qualifies as an alternative investment due to the ever-changing nature of the field (Chambers, Black & Lacey, 2018). Generally speaking, alternative investments include hedge funds, private equity, real assets, and structured products, which often use unconventional investment methods. However, alternative investments also include less well-known assets like fine art, wine, collectible coins, cryptocurrencies, and initial public offerings (IPOs) (Wong, 2024; Mundi & Kumar, 2023; Chorkowy, 2025).

Wong (2024) highlights lower liquidity, less regulation and transparency, and more limited historical return and volatility data compared to traditional assets as key characteristics of alternative investments. According to Balaban et al. (2021), alternative investments are also associated with higher fees, relatively low correlation of returns with those of traditional investments, unique legal and tax considerations, restrictions on redemption, and concentrated portfolios. Alternative investments are typically only traded through private markets and require active management, resulting in them being less accessible and preferred for the public (Balaban et al., 2021; Wong, 2024).

The next subsections will introduce the most important alternative assets, split into traditional and modern alternatives to demonstrate how the alternative investments have evolved over time.

2.3.1 Traditional Alternative Investments

Real estate, commodities, hedge funds, and private equity are the most well-known alternative investment assets and therefore form the foundation of the alternative investments field (Gregoriou, 2008; Chambers et al., 2020). Institutional and professional investors have long utilized these alternative asset classes (Fabozzi, 2009; Scharfman, 2012), and for that reason, this thesis categorizes them as "traditional" alternative assets.

2.3.1.1 Real Estate

Real estate has been one of the most important and stable forms of wealth for thousands of years and plays an important role in many institutional portfolios (Garay, 2016; Georgiev, Gupta, & Kunkel, 2003). Real estate investing includes buying, managing, owning, and selling real property to generate income or profit from the increase in the value of the property. Real property consists of buildings, land, and improvements made to them (Liow, 2016). Real estate investing is generally identified as acquiring a property for commercial or investment purposes instead of for personal housing needs (Krulický & Horák, 2019). Investing in residential, commercial, and industrial properties, as well as undeveloped land, are also other forms of real estate investing (Liow, 2016). There are two main approaches to real estate investing: direct and indirect. Direct real estate investing means purchasing and managing actual physical properties, and indirect real estate investment refers to purchasing shares of real estate investment companies or funds that manage such properties (Georgiev et al., 2003).

According to Manganelli (2015), the main reason for investing in real estate is the preservation of the invested capital, as research shows that while the values of

properties fluctuate in line with local market cycles, they also increase in value over the long term, thus safeguarding the real value of the investment. Tyson & Griswold (2019) report that investing in real estate typically generates at least an annualized return of 8 to 10 percent per year over multi-decade periods. As noted by Liow (2016), real estate investments are excellent for managing portfolio risk due to relative stability and lower volatility compared to assets such as equities and bonds. Additional advantages of real estate as an investment include tax-deferred compounding of value, regular cash flows, the potential to offer absolute returns, and various possible income tax benefits (Tyson & Griswold, 2019; Garay, 2016).

One of the biggest limitations of real estate investing is the heterogeneity of properties, as the physical features of the individual properties, such as age, location, design, size, and intended use, as well as different lease structures, can considerably affect the income flows (Garay, 2016; Manganelli, 2015). Properties are also often regarded as a relatively illiquid asset because of high transaction costs and the absence of centralized trading, which limits the opportunities of efficient acquisition and disposition of properties at market value. The illiquidity of the real estate market can result in longer holding periods, valuation challenges, and asymmetric information within the market (Garay, 2016; Georgiev et al., 2003).

2.3.1.2 Commodities

Commodities are another important type of traditional alternative investments. These include tangible goods such as metals, energy resources, and agricultural products (Irwin & Sanders, 2012). There are multiple different strategies that investors use to invest in commodities. These include derivatives, physical markets, and equity markets (Rouwenhorst & Tang, 2012; Jensen & Mercer, 2011). Investors traditionally gain exposure to commodities through commodity futures instead of directly investing in physical commodities due to the considerable expenses arising from trading, insuring, and storing physical commodities. A notable exception is that numerous investors obtain

and hold onto precious metals as a tangible asset or in the form of currency (Jensen & Mercer, 2011).

Gold is recognized as the most significant and widely held investment commodity and is commonly received as a “safe haven” asset because of its historical ability to sustain wealth in times of financial instability (Baur & Lucey, 2010; Beckmann, Berger & Czudaj, 2015). Gold is distinct from other precious metals due to its twofold role as a commodity and a medium of exchange. As a commodity, gold's market value is driven by supply-and-demand dynamics just like any other good or service, but gold is also, in addition, acquired by investors to store wealth in times of high market volatility and economic uncertainty. Investors most frequently gain exposure to gold via purchasing bullion bars, exchange-traded funds (ETFs), and coins (Moraitis, 2018).

Investing in commodities provides direct exposure to a variety of unique factors and offers unique hedging features. Variables such as weather, geopolitics, political or economic instability, and changes in supply and demand influence the value of different commodities. Precious metals, especially gold, as an investment asset, are thought to have unique portfolio benefits, and research demonstrates that gold provides protection against economic turmoil and heightened volatility in the equity and bond markets as well as a hedge against U.S. inflation and the foreign exchange value of the U.S. dollar (Jensen & Mercer, 2011; Moraitis, 2018; Chorkowy, 2025).

There are several other essential commodities, for instance, energy commodities, that are crucial to several participants in the financial markets, playing a key role in the risk-sharing process. Energy prices significantly shape the economic development of nations, governments, and corporations, as high volatility in the energy prices affects both energy producers and consumers, thereby having an effect on the overall economy. This risk is often mitigated with energy commodity derivatives (Gatfaoui, 2019).

2.3.1.3 Hedge Funds and Mutual Funds

Hedge funds and mutual funds are the most important and popular pooled investment vehicles. Pooled investment funds gather capital from investors for collective management, which means that unrelated independent investors pool their capital for the fund manager to control and invest instead of them. The structure of pooled funds allows investors to gain access to diversified, professionally managed portfolios and bigger investment opportunities than are available through direct investments in stocks, for example (Elton & Gruber, 2013; Stulz, 2007). The purpose of hedge funds and mutual funds is to generate positive returns and protect investors' capital. The investors trust that the professional fund manager will be able to ensure the value of their initial investment and generate them some profit (Ackerman et al., 1999; Agarwal & Naik, 2000; Fung & Hsieh, 2002; Stulz, 2007). Pooled funds have become increasingly popular after the early 1990s, and the number of pooled funds has risen significantly (Benmahi, 2023).

Mutual funds are tightly regulated pooled investment funds that aim to offer investors an easy, relatively secure, and professionally controlled way to invest in the financial markets. Mutual funds provide the means for even small-scale investors to obtain access to well-diversified and professionally managed portfolios at a reasonably low cost, funneling savings into investments and supporting economic growth, thus having a significant impact on the financial markets (Arora & Gupta, 2024; Smith, 2016). Some of the mutual funds are managed passively with the objective to copy the performance of a market index such as the S&P 500, whereas actively managed mutual funds aim to outperform market benchmarks via strategic security selection and timing (Stulz, 2007). Regardless of the important role in the financial market, mutual funds have limitations and shortcomings; most importantly, Smith (2016) states that many actively managed mutual funds underperform compared to the benchmarks because of management fees and transaction costs.

Contrary to mutual funds, hedge funds are primarily unregulated and not available to the small-scale investors. Hedge funds are privately organized funds that are intended

for wealthy individuals and institutional investors (Stulz, 2007). Hedge fund managers have flexibility and can take advantage of long and short positions, leverage, and derivatives when pursuing absolute returns (Ackermann et al., 1999; Agarwal & Naik, 2000; Fung & Hsieh, 2002; Stulz, 2007). Crockett (2007) mentions shorting securities as a main characteristic of hedge funds. These funds strive to accomplish positive returns no matter the market conditions, as well as maintain low volatility and low correlation with traditional asset classes (Benmahi, 2023). As suggested by Amin & Kat (2003), the inclusion of hedge funds into a portfolio can enhance diversification and improve overall performance and risk-adjusted returns. Hedge funds play an important role in the financial markets, contributing to the overall market liquidity and flexibility. Despite the popularity and strong historical performance of hedge funds, they are associated with higher risk and lower transparency than mutual funds due to more complex investing strategies and limited regulatory oversight (Benmahi, 2023; Stulz, 2007).

2.3.2 Modern Alternative Assets

Modern alternative investments have emerged to complement the traditional alternative assets, reflecting evolving market demands and investor preferences that arise from the technological, structural, and societal evolution of finance in the 21st century. Modern alternative investment assets offer diversification benefits, new growth opportunities, and unique risk–return profiles (Hafner, 2020; Koutsouri, 2023). Key categories of modern alternative investments include infrastructure, digital assets, ESG and sustainable alternatives, and collectibles. These modern alternatives have become highly relevant recently as institutional investors increasingly allocate funds into these asset classes gaining inflation protection and most importantly, exposure to new arising fields like energy transition, digitalization, and technological innovation (Bitsch, Buchner & Kaserer, 2010; Henttonen, 2020).

2.3.2.1 Collectables

Collectibles as an asset class consist of countless different investment assets, including, for example, paintings, stamps, coins, ceramics, photography, furniture, books, wines, baseball cards, and figurines (Burton & Jacobsen, 1999; Erdős, 2015). These assets often combine financial and non-financial motivations for ownership and are thus often viewed as emotional assets for many investors. Collectible prices are mostly driven by scarcity, emotional factors, and aesthetic value (Campbell, Koedijk, & de Roon, 2008). Although collectibles have been categorized as hobbyist items in the past, there has been a notable growing interest in utilizing them as an investment asset (Snee, 2014). Even though financial gain is not habitually the main motivation for purchasing collectibles, many collectors expect the financial benefits that come with the investment (Burton & Jacobsen, 1999). Collectibles are commonly purchased for two reasons: either to accumulate immediate enjoyment through ownership or to possibly sell the item for profit at a later time (Snee, 2014).

Collectibles are generally considered an illiquid asset class. Due to the absence of organized official liquid marketplaces, collectibles are often acquired from dealers, private individuals, auctions, or other types of over-the-counter markets, which may prolong the liquidation process significantly. As an example, a wine collection can take several months to liquidate (Sanning, Shaffer, & Sharratt, 2006; Walgreen, 2010). Unlike traditional assets, collectibles do not generate any cash flows, making them very vulnerable to market turmoil, as their returns are generated solely from price appreciation. In addition, the fact that high transaction costs, storage requirements, and possible insurance expenses often reduce the net earnings, together with being subject to physical risks stemming from damage, deterioration, or theft, really adds to the complexity of managing collectibles as an investment asset (Walgreen, 2010). Despite the disadvantages and limited or nonexistent use value, collectibles provide social status and aesthetic enjoyment to the owners, which distinguishes them from many of the other alternative assets (Goetzmann, 1993).

The relevance of collectibles as an investment asset is highlighted in the market size estimates. As an example, Maxwell of the London International Vintners Exchange (Liv-ex) estimated the global wine investment market at approximately three billion dollars in 2009. Collectibles are regularly traded via specialized dealers, and high-value collectible items frequently appear in major auction houses worldwide. Even though these markets can also be seen as relatively illiquid compared to traditional financial markets, the collectors are in general willing to tolerate the illiquidity because of the non-financial motivations of ownership (Erdős, 2015).

2.3.2.2 Infrastructure Investments

Investment in infrastructure has evolved into one of the most popular and attractive alternative investments, especially among institutional investors. Infrastructure investments consist of investments in essential infrastructure like transportation systems, utilities, energy facilities, and other infrastructure that support long-term economic growth. The popularity of infrastructure investments stems from the potential for stable, inflation-linked cash flows that have low correlation with the traditional financial markets. Such investments often have quite predictable constant demand and are stable even during economic recessions, making them very popular among long-term investors like pension funds and sovereign wealth funds (Inderst, 2010).

The most common way that private investors invest in infrastructure is via collaborating with governments through public-private partnerships (PPPs). In PPP agreements, private investors and entities contribute to different infrastructure development projects by helping with the financing, constructing, and operating infrastructure, receiving a share of user-fee revenues or other cash flows in return. This procedure benefits both parties by allowing governments to mitigate risks while capitalizing on the efficiency and technological advancement of the private sector's participants and granting private investors exposure to real assets with stable cash flows and diversification benefits (Araújo & Sutherland, 2010).

Global trends and preferences such as green energy and emission reduction also offer new infrastructure investment opportunities, including renewable energy and smart-grid systems (Newell & Mulvaney, 2013). In addition, digital infrastructure like data centers, optical fiber networks, and 5G telecommunications systems has become increasingly vital for governments, offering valuable investment opportunities for investors (Henttonen, 2020). These subcategories present outstanding long-term growth potential and play important roles in modern, well-diversified alternative investment portfolios (Newell & Mulvaney, 2013; Henttonen, 2020).

Despite all the valuable advantages, infrastructure as an investment asset has its limitations. These limitations include limited liquidity, regulatory complexity, high capital requirements, and political risk. Due to these challenges, investing in infrastructure requires careful pre-investment evaluation as well as long-term commitment (Inderst, 2010).

2.3.2.3 Cryptocurrencies

Digital assets include a wide variety of items that are created and stored in digital form; among these are digital currencies and cryptocurrencies. Digitally distributed digital currencies offer faster borderless global transactions than the traditional fiat currencies (Li & Whinston, 2020). Within digital assets, cryptocurrencies, intangible digital items that can be utilized, traded, and exchanged virtually, have risen as the most influential (Binsi, 2025). Lack of confidence in the financial system after the global financial crisis of 2008 led to risen interest in cryptocurrencies among investors (Lee, Guo, & Wang, 2017; Van der Merwe, 2021). Cryptocurrencies are designed to serve as a medium of exchange utilizing cryptography to ensure secure transactions, govern the creation of units, and validate transfers (Bartos, 2015; Tredinnick, 2019; Vejačka, 2014). Companies and other institutional entities are progressively recognizing the importance of cryptocurrencies

and trying to adapt accordingly, leading to rapid development of cryptocurrency-based systems (Grujić & Vojinović, 2024).

Cryptocurrencies take advantage of blockchain technology, which operates as a decentralized, distributed ledger that is maintained by multiple independent actors. Blockchain stores the ownership and transaction data securely and reliably, obviating the need for central authorities like banks or centralized exchanges in the validation of transactions (Li & Whinston, 2020; Read, 2025). One of the major achievements of blockchain technology and cryptocurrencies is overcoming the historical double-spending problem, further enhancing the reliability and attractiveness of cryptocurrencies (Lee, Guo, & Wang, 2017). Cryptocurrencies are decentralized and offer more privacy compared to traditional currencies (Li & Whinston, 2020; Tredinnick, 2019). Due to the technical complexity of the topic, the underlying mechanisms of blockchain technology and cryptography are not discussed in further detail in this thesis.

The number of different cryptocurrencies has reached thousands, and the cryptocurrency market has evolved into a multi-billion-dollar market (Li & Whinston, 2020; Van der Merwe, 2021). Due to the swift market growth, cryptocurrencies are increasingly utilized as alternative investment assets, in addition to serving as a means of payment (Almeida & Gonçalves, 2023). The safest and easiest way to enter the cryptocurrency market is to invest through a broker or trading exchange. Trading through brokers increases the cost of purchasing cryptocurrencies, but it also reduces risks (Qoqiauri, Mosiashvili, & Bebiashvili, 2023).

Because of the multitude of different cryptocurrencies, investing in the crypto market requires a good understanding of the blockchain technology and the unique characteristics of specific crypto projects (Qoqiauri, Mosiashvili, & Bebiashvili, 2023). Van der Merwe (2021) stresses that not all cryptocurrencies are equal, and investors need to conduct strong research to recognize potential investment opportunities. Investors are increasingly interested in the possibilities and returns of cryptocurrencies

but are also showing concern about the volatility, lack of regulation, and crimes related to cryptocurrencies (Binsi, 2025). Binsi (2025) emphasizes that investors need more knowledge and understanding about investing in cryptocurrencies.

Bitcoin is the most famous and widely used cryptocurrency in the world (Li & Whinston, 2020; Tredinnick, 2019; Vejačka, 2014). It has been the market leader in the cryptocurrency market ever since the first-ever bitcoin was mined in 2009 (Lee, Guo, & Wang, 2017). Bitcoin transactions operate by moving code from one digital wallet to another. Initial growth of Bitcoin was powered by dark web implementations due to the privacy it offers, but more recently its value is driven by speculation and utilization as an alternative investment asset (Tredinnick, 2019). Bitcoin has become such a relevant investment asset that the Chicago Mercantile Exchange and the Chicago Board of Trade launched cash-settled bitcoin futures in 2017, highlighting the institutionalization of crypto markets (Faucette, Graseck, & Shah, 2018; Fuscaldo, 2018). The success of Bitcoin has led to the creation of numerous different cryptocurrencies and so-called altcoins like Ether and Litecoin that employ similar cryptographic principles but different algorithms (Lee, Guo, & Wang, 2017; Tredinnick, 2019).

Decentralization of cryptocurrencies reduces transaction costs and enables fast global transactions without additional currency exchange costs (Tredinnick, 2019). Cryptocurrencies typically offer good liquidity and low correlation with traditional assets (Lee, Guo, & Wang, 2017). Despite often generating high returns, cryptocurrencies experience high risks due to high volatility, lack of regulation, market manipulation, and financial fraud (Binsi, 2025; Tredinnick, 2019). Cryptocurrencies do not possess intrinsic value, and their value is mostly determined by investor sentiment, which results in high volatility (Härdle, Harvey, & Reule, 2020; Lee, Guo, & Wang, 2017; Tredinnick, 2019). Bitcoin, just like most cryptocurrencies, has a fixed supply and does not generate any cash flows and therefore can't be valued similarly to fiat currencies or by using discounted cash flow valuation (Lee, Guo, & Wang, 2017; Tredinnick, 2019). In addition,

mining of cryptocurrencies such as Bitcoin requires large energy consumption and causes significant environmental impacts (Tredinnick, 2019).

2.3.2.4 ESG Investing and Green Assets

The growing significance of Environmental, Social, and Governance (ESG) factors in the financial markets is one of the most important trends of the 21st century. Sustainability concerns influence the investment decisions of both institutional and retail investors, driving them towards ESG-investment opportunities. This is demonstrated by a substantial growth in ESG fund inflows and the introduction of roughly 170 new sustainable funds worldwide in early 2004 (Enders, Schmedders, & Lontzek, 2025). Sustainable development has become a global priority, and governments are progressively supporting and promoting different green development initiatives (Duan, Liu, Yang, Yang, & Gao, 2023). Green investment assets channel capital into environmentally friendly and climate-oriented firms and projects (Ramlall, 2024). Intensified focus on climate change-related risks has increased the interest in these assets among investors (Cepni, Demirer & Rognone, 2022; Krueger, Sautner & Starks, 2020).

Green bonds are recognized as a leading method for financing and supporting environmentally friendly projects and firms (Ferrer, Shahzad & Soriano, 2021). Previous studies suggest that green investment assets such as green bonds offer diversification benefits and show potential for substantial risk reduction (Naeem & Karim, 2021; Naeem, Karim, & Tiwari, 2023; Narayan, Rizvi, & Sakti, 2022; Rehman, Zeitun, Vo, Ahmad, & Al-Faryan, 2023). Combining green assets with broader market indices in the same portfolio has been demonstrated to generate higher yields and Sharpe ratios compared to benchmark portfolios (Lalwani, 2024). The inclusion of green bonds into conventional portfolios has also shown safe-haven features in times of high stock market volatility, like during the COVID-19 pandemic (Yousaf, Suleman & Demirer, 2022). Green bonds can be utilized to hedge climate-related risks that are reflected in stock market valuations (Cepni

et al., 2022). ESG investors typically demonstrate stronger price inelasticity, placing stronger upward pressure on stock prices than conventional investors (Goldstein, Kopytov, Shen, & Xiang, 2022).

Despite the benefits of green assets and ESG investing, investors with notable commitment and preference for sustainability might have to trade off some returns, as finance theory indicates a potential cost for green investment preferences (Pástor, Stambaugh & Taylor, 2021; Lalwani, 2024).

2.4 Benefits

Despite the diversity of different alternative assets and their differing characteristics, alternative investments are considered to have the potential to improve portfolios' risk-adjusted performance by enhancing portfolio diversification (Baker & Filbeck, 2013). Alternative assets tend to display low or non-existent correlation with traditional asset classes, which improves portfolio diversification and reduces volatility, increasing the likelihood of achieving long-term investment objectives (Chowdhury, 2025; Skully, 2007). According to modern portfolio theory, portfolios allocated across uncorrelated assets generally offer more stable long-term returns and lower volatility (Chowdhury, 2025; Chambers, Black & Lacey, 2018). Diversification is considered a key concept in finance, famously described as *"the only free lunch in investing"* by Henry Markowitz (as cited in Wong, 2024).

Since their returns are largely unrelated to traditional markets, alternative assets can also help to mitigate losses and maintain portfolio value during economic crisis periods like the Global Financial Crisis and COVID-19 as well as during geopolitical uncertainty (Chowdhury, 2025). Many real assets, such as infrastructure, real estate, and commodities, are proven to preserve value in times of financial stress (Liu et al., 2017). Therefore, a well-diversified portfolio containing alternative assets can decrease overall risk without a significant decrease in expected returns (Skully, 2007).

In addition to diversification benefits, alternative investments can offer opportunities for alpha generation. Especially hedge funds and private equity have delivered historically superior risk-adjusted returns (Skully, 2007). Real assets also often generate appealing returns on investment as well as stable cash flows (Liu et al., 2017). Holding relatively illiquid alternative assets like private equity and real estate is also often compensated for with liquidity premiums (Baker & Filbeck, 2013).

Alternative investments contribute significantly to the asset allocation of institutional investors with a long-term investment horizon. Alternative assets are utilized most efficiently as complements to traditional assets, not as substitutes for them (Cumming, Haß & Schweizer, 2014). In line with modern portfolio theory, combining assets with differing return patterns, including both alternative and traditional assets, often leads to more efficient portfolios at the same level of risk (Constantinides & Malliaris, 1995).

2.5 Risks

Investing in alternative assets exposes investors to a range of distinct risk factors that differ from those of traditional assets. Compared to traditional assets, alternative investments are generally considered less liquid and often traded exclusively through private markets. Many alternative assets are considered to bear notable liquidity risk, as they are relatively illiquid and difficult to trade swiftly. Alternative investment markets are also associated with lower regulation and transparency and limited data on historical returns and volatility, as well as high heterogeneity in returns across managers (Wong, 2024). Each alternative asset has unique characteristics and risk factors, signifying that knowledge acquired, for example, in traditional markets or cryptocurrency markets might not be directly applicable to other alternative assets (Skully, 2007).

In addition to liquidity risk, alternative investments are subject to risks arising from inefficiency and non-normality of returns (Skully, 2007). Alternative investments are

prone to estimation errors, have higher transaction costs, and have greater non-normality of returns compared to traditional assets. Data biases, including appraisal smoothing and stale pricing, can further reduce the returns, and the comparatively high skewness and kurtosis of most alternative assets make standard deviation-based optimization less reliable and often inaccurate (Cumming, Haß & Schweizer, 2014). If not carefully managed, these factors can lead to weaker out-of-sample performance (Platanakis, Sakkas & Sutcliffe, 2019).

The complex nature of alternative assets, together with limited regulatory oversight and reduced information requirements, exposes alternative investment markets to a wide range of risks. Due to these market characteristics, alternative investments are affected by management, operational, data, and transaction transparency. Limited information and oversight particularly often result in investment decisions being made based on incomplete or erroneous data. These factors also increase the risk of non-transparent transactions and the risk of fraud (Sokołowska, 2015). The operational complexity of utilizing alternative assets highlights the importance of investor and manager expertise, particularly in the post-investment phase. It is essential for investors to understand the benefits and risks associated with different alternative assets, as management risk arises from the heavy dependence of returns on manager skill (Liu, Sun, Huang, Tang & Wu, 2017; Sokołowska, 2015).

In addition to these specific risks, alternative investments are also affected by systematic risks, which stem from uncontrollable external factors impacting the entire financial market. These include interest rate fluctuations, inflation, and geopolitical instability. The extent to which different alternative assets are influenced by systematic risks varies, with some assets being more sensitive than others (Sokołowska, 2015).

Due to the factors and limitations discussed earlier in this chapter, Platanakis, Sakkas, and Sutcliffe (2019) note that diversification through alternative assets could, in some cases, expose investors to additional risks. Their study also suggests that the inclusion of

alternative assets into a portfolio can even have negative effects if the risks are not properly taken into account.

2.6 Relevant Theoretical Frameworks

This chapter presents theories that are relevant to the analysis of alternative investment assets and to understanding portfolio construction, asset pricing, and market efficiency. Modern Portfolio Theory, Neoclassical Value Theory, and Efficient Markets Theory form a strong theoretical framework for understanding the role, economic value, and performance of alternative investments relative to traditional assets.

2.6.1 Modern Portfolio Theory

Modern Portfolio Theory (MPT), presented by Markowitz (1952), forms the foundation for modern portfolio construction by suggesting that portfolios can be optimized through portfolio diversification using assets with limitedly correlated returns. By measuring risk as the variance of return and considering covariances across assets, MPT demonstrates that the overall risk of a portfolio can be reduced without lowering expected returns (Markowitz, 1959). MPT is especially relevant for alternative investments considering that they often display low correlations with traditional asset classes (Ibbotson, Chen, & Zhu, 2011). It is well documented that including alternative assets like real estate, hedge funds, and commodities in a portfolio can improve risk-adjusted returns and portfolio efficiency (Anson, Fabozzi, & Jones, 2010; Etebari, 2016; Balaban et al., 2021). The diversification benefits detailed in Section 2.4 are directly aligned with MPT, which defines diversification as a fundamental mechanism for mitigating volatility without correspondingly lowering expected returns.

The applicability of MPT to alternative investments also has its limitations due to the risk factors discussed in Section 2.5. Especially risk factors such as illiquidity, appraisal-based

pricing, and non-normal return distributions that do not align with underlying assumptions of normally distributed returns and liquidity of MPT (Amin & Kat, 2003; Cumming, Haß, & Schweizer, 2014). Alternative investment also often exhibits high skewness, excess kurtosis, and limited historical return and volatility data, which can lead to misleading risk assessments if standard deviation is used as the only indicator of risk (Platanakis, Sakkas, & Sutcliffe, 2019).

2.6.2 Neoclassical Value Theory

Neoclassical value theory by Arrow and Debreu (1954) provides a strong theoretical foundation for understanding the pricing mechanics of alternative investment assets. The theory suggests that asset prices are determined by rational investors that strive to maximize utility and operate in competitive equilibrium markets, where returns reflect compensation for risk and other investment constraints rather than systematic mispricing. According to the neoclassical value theory, higher expected returns associated with alternative investments are explained by investors demanding premiums due to factors like illiquidity, long holding periods, and asymmetric information associated with the private markets and alternative asset classes (Amihud & Mendelson, 1986; Liu et al., 2017; Garay, 2016; Georgiev et al., 2003). This is also supported by empirical research and existing literature that note the presence of illiquidity premiums in private markets that are results of restricted tradability, high transaction costs, and extended holding periods (Baker & Filbeck, 2013; Kräussl, Lehnert, & Rinne, 2017; Skully, 2007). Private equity and real estate markets especially serve as a great example of the link between neoclassical value theory and alternative asset pricing (Baker & Filbeck, 2013).

2.6.3 Efficient Markets Theory

The Efficient Markets Theory (EMT) by Fama in the 1960s implies that asset prices accurately reflect all the available information in the market, limiting the opportunities to achieve above-average returns without taking additional risk (Fama, 1970; Malkiel, 2003). EMT is applicable to alternative investment assets that are often traded in markets that have lesser transparency, more complex strategies, limited historical data, and limited regulatory oversight (Benmahi, 2023; Stulz, 2007; Wong, 2024). According to EMT, in order to achieve abnormal returns in these types of markets, investors need to access non-public information or generate value through operational expertise rather than entirely depending on publicly available data and historical returns. For example, hedge fund managers utilize complex strategies and instruments like derivatives, leverage, and long and short positions to achieve alpha generation (Agarwal & Naik, 2000; Crockett, 2007; Sokołowska, 2015; Stulz, 2007). EMT highlights the importance of skilled asset management as one of the key factors for achieving absolute returns in alternative investment markets that are less liquid and less efficient compared to traditional financial markets (Agarwal & Naik, 2000; Gârleanu & Pedersen, 2016; Liu et al., 2017; Sokołowska, 2015).

3 Counter-Strike Weapon Cases as an Alternative Investment

The popularity of digital goods and the market of virtual assets have experienced significant growth in the past decade, creating new opportunities for investing in alternative assets. Especially video game items, particularly those used in popular competitive online games, have received considerable attention as serious investment assets. The increased interest in these types of digital assets is driven by factors such as scarcity, tradability, and the presence of active secondary markets, as well as very high returns and price appreciations of some video game items in the past (Faye & Le Fur, 2023; Dobrynskaya & Strelnikov, 2025; Lehdonvirta, 2009; Glaser, 2022; Wang, 2018). Counter-Strike serves as one of the prime examples of how the popularity of the game and extensive in-game ecosystem can create demand for video game items, resulting in significant financial activity and investment opportunities (Faye & Le Fur, 2023; Glaser, 2022; Nguyen, 2022)

This chapter presents an overview of the virtual goods market, introduces CS digital in-game items, and examines factors such as the nature, acquisition, trading mechanisms, pricing, and market size of CS weapon cases for the purpose of forming a foundation to analyze them as an alternative asset class later in the study.

3.1 Virtual goods market

Virtual goods and different digital assets have gained a lot of popularity among consumers, investors, and academic researchers. This phenomenon has resulted in rapid growth, appropriation, and exchange of virtual goods and digital collectibles, reflecting broader structural changes regarding purchasing, consumption, entertainment, and ownership shifting towards online digital ecosystems. This shift is referred to as digitalization of consumption (Faye & Le Fur, 2023; Lehdonvirta, 2009). What was previously viewed as a revenue model for online services has now evolved into notable secondary markets that also offer investment opportunities. These secondary markets

are often associated with scarcity, price dispersion, and speculative behavior (Yamamoto & McArthur, 2015; Glaser, 2022).

Lehdonvirta (2009) defines virtual goods as digital objects like items, characters, cosmetics, currencies, and tokens without any physical form that only exist in online environments, such as video games. Due to the digitalization of consumption, virtual goods have evolved from purely hedonic consumption goods to potential alternative investments (Dobrynskaya & Strelnikov, 2025; Lehdonvirta, 2009).

To be considered as potential alternative assets, virtual goods must show authenticity and clearly defined ownership (Dobrynskaya & Strelnikov, 2025; Faye & Le Fur, 2023). This is currently achieved through two primary methods. Virtual goods that are separable from their virtual environment are commonly authenticated via non-fungible tokens (NFTs) that provide ownership rights recorded on blockchains and can be traded in decentralized marketplaces (Barrington, 2022; Taherdoost, 2022). For virtual goods that are non-separable from their digital environment, like most video game items, authentication and ownership of the items are guaranteed by the game developer (Faye & Le Fur, 2023; Nguyen, 2022; Yamamoto & McArthur, 2015).

Non-separable digital objects (NSDOs) like CS weapon cases exhibit similar characteristics to traditional alternative assets. These characteristics include limited replaceability, some level of scarcity or uniqueness, and the ability to be traded in secondary markets with varying levels of liquidity and price transparency (Faye & Le Fur, 2023). Unlike many traditional financial assets, NSDOs do not provide fundamental cash flows, and their value heavily depends on the popularity, continuity, accessibility, and growth of the game or the underlying virtual platform (Reichenbach, 2025). Demand and prices of NSDOs are also heavily influenced by psychological and behavioral finance factors such as trends, social status signaling, and fear of missing out. For these reasons, NSDOs are often labelled emotional or consumption-driven assets (Dobrynskaya & Strelnikov, 2025).

Due to the growing demand for virtual items and various in-game cosmetics, major video game publishers like EA Sports, Epic Games, and Valve have implemented microtransaction-based revenue models into their games, allowing their players to purchase in-game digital items directly from developers (Lehdonvirta, 2009; Macey & Hamari, 2019). In addition, few games offer developer-managed community marketplaces for secondary trading that enable peer-to-peer transactions between the players (Faye & Le Fur, 2023). The best example of such a marketplace is the Steam Community Market, launched in 2013 by Valve. The Steam Community Market allows players to buy and sell virtual goods, mostly in-game items, from other players. Since 2013 this virtual marketplace has generated billions of dollars in total transactions, becoming one of the most important and established virtual goods markets in the gaming industry (Yamamoto & McArthur, 2015; Thorhauge, 2024; Shen, 2015; Glaser, 2022).

3.2 Counter-Strike 2

Counter-Strike 2 (CS2) is an online multiplayer tactical first-person shooter (FPS) developed by Valve and distributed via their online platform Steam. The game features two teams of five players competing in round-based matches. CS2 was released in 2023 as a free update to the very popular Counter-Strike: Global Offensive (CS:GO) and continues the legacy of previous titles like Counter-Strike 1.6, which was one of the most influential online FPS games of the early 2000s. CS2 enhanced the gameplay with upgraded graphics and a modernized game engine while preserving the core mechanics of the previous titles, resulting in the growth of the player base. Another key moment regarding the popularity of the Counter-Strike game series was CS:GO's transition to a free-to-play model in 2018, which significantly grew the number of active players. This growth was also boosted by the COVID-19 period, and the number of players has remained consistently high ever since (Faye & Le Fur, 2023; Young, 2021; Tang et al., 2023). As shown in Figure 1, the active player base of Counter-Strike games has increased

steadily over the years, reaching an average of over 900,000 monthly active players by 2025.

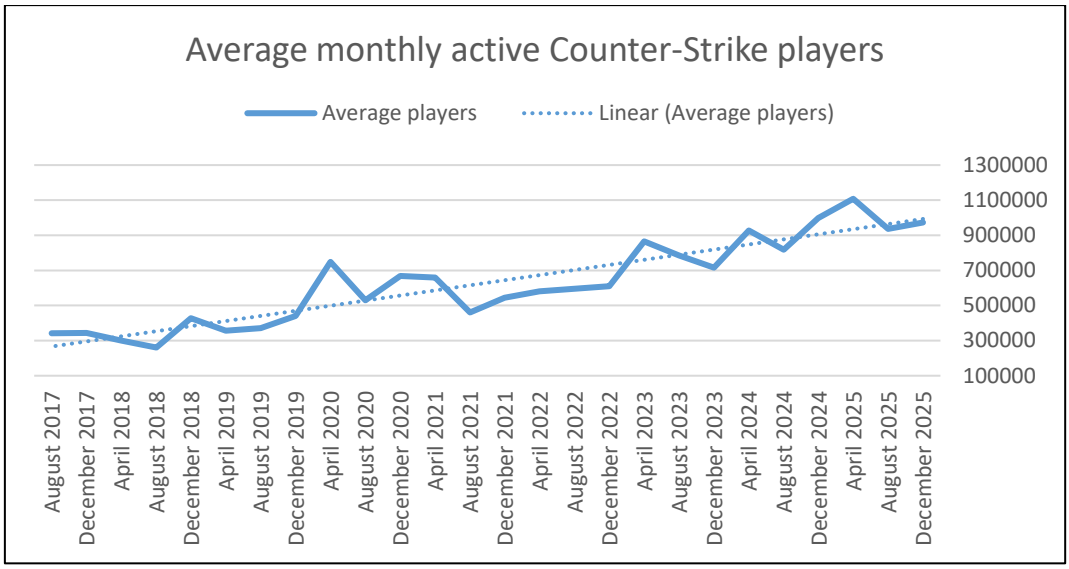

Figure 1. Average monthly active Counter-Strike players from August 2017 to December 2025 (Live Player Count, n.d.).

Counter-Strike has also successfully created a notable esports ecosystem around their game. This ecosystem consists of professional teams, big international tournaments, and significant streaming viewership and following. Counter-Strike is among the most consistently viewed and popular esports titles worldwide consumed via streaming platforms (Gasparetto & Safronov, 2023; Young, 2021). According to csgo.com, the latest major international professional CS2 tournament, the StarLadder Budapest Major 2025, accumulated an average of 518,000 online viewers per match, with a peak of 1,540,000 viewers (csgo.com, 2025).

In addition to the Counter-Strike series' popularity among the casual players and esports viewers, the game also features a notably large-scale in-game economy that offers different virtual items, most notably weapon skins and weapon cases. This in-game economy has gathered the attention of both investors and players (Dobrynskaya & Strelnikov, 2025; Reichenbach, 2025; Antunes et al., 2025). The following section

introduces the weapon skins and the CS in-game economy, forming the basis for their analysis as an alternative asset class in this thesis.

3.3 CS2 Weapon Skins

Among video games, the Counter-Strike series is particularly well known for its in-game economy, which offers different virtual items, most notably loot boxes and weapon skins. Weapon skins allow players to alter the appearance of their weapons in-game. These weapon skins offer only cosmetic value to the player and do not affect player performance or provide any other gameplay advantages. Rare and expensive skins can be compared to physical luxury goods, and some players use them similarly for status signaling and to gain social recognition (Dobrynskaya & Strelnikov, 2025; Hamari et al., 2017; Lehdonvirta, 2009).

Because people spend an increasingly large portion of their time online, the demand for digital assets like weapon skins has experienced rapid growth. This growth has also affected the Counter-Strike weapon skins market, leading to attractive returns, increased interest, and trading volumes. The evolution of weapon skins from items that offer only cosmetic value to players into assets that also provide investment opportunities for both players and non-players serves as a clear example of digitalization (Faye & Le Fur, 2023).

The value of the weapon skins is driven by various factors. B Fear of missing out, self-expression, and status signaling are some of the behavioral finance factors that affect the demand and prices of rare and visually unique skins. (Dobrynskaya & Strelnikov, 2025; Hamari & Macey, 2017; Lehdonvirta, 2009). The popularity of weapon skins and the overall market prices are further boosted by historical returns and previous success stories. For example, one of the rarest Counter-Strike weapon skins, the AWP Dragon Lore Souvenir, was sold for USD 61,052.63 in February 2018. This sale generated a profit of approximately USD 23,000 for the seller (Faye & Le Fur, 2023). In recent years, individual weapon skins have been sold for even higher prices, some sales reaching several hundred thousand dollars, and a new record transaction of approximately USD 1

million was reported in 2024 (Bernardo, 2023; Taylor-Hill, 2023; Li, 2023; D'Anastasio, 2025).

Rarity and scarcity are the main factors that influence the value of weapon skins. Weapon skins that have a limited supply due to event-specific releases or discontinued loot boxes often experience higher long-term price appreciation (Faye & Le Fur, 2023; Dobrynskaya & Strelnikov, 2025). The cosmetic factors of weapon skins also affect is demand and value. Trends, player preferences, and the opinions of major Counter-Strike influencers regarding visual patterns, color combinations, and wear conditions can have a significant impact on the popularity and valuation of otherwise very similar items (Böffel, Würger, Tara, & Schlittmeier, 2025). The game developer Valve is also known to create price fluctuations when publishing updates for the game. Together, these factors have evolved the Counter-Strike skins market into a multibillion-dollar virtual asset ecosystem and transformed weapon skins into serious modern alternative assets (Antunes et al., 2025; Böffel et al., 2025).

3.4 Acquisition and Trading of CS Weapon Skins

CS weapon skins are part of the Valve ecosystem that is built around their Steam platform. This ecosystem is developer-controlled but heavily market-driven. Valve does not sell the individual weapon skins directly to the players; the weapon skins enter the ecosystem when players open weapon cases or receive weapon skins as rewards for playing the game. The weapon cases can be either earned as a free reward for playing the game or purchased from the Steam marketplace from other players. Opening a weapon case requires a key, which can be purchased directly from Valve, making the keys a core source of revenue for the developer. When players open a weapon case, they will receive one random weapon skin that can then be sold on the Steam Community Market. This weapon skin will be of one of the previously mentioned rarity tiers and will have one of the previously mentioned wear levels, which greatly affect its value (Faye & Le Fur, 2023; Macey & Hamari, 2019; Glaser, 2022).

CS weapon cases are fundamentally a form of digital gambling, as players spend real money to open a case without knowing which skin they will receive. Despite criticism for this gambling-like feature, weapon cases remain extremely popular among players. In 2023, approximately 400 million weapon cases were opened, generating an estimated USD 980 million in revenue for the developer (D'Anastasio, 2025; Faye & Le Fur, 2023; Dobrynskaya & Strelnikov, 2025). Due to the popularity and tradability of the weapon cases, they will be examined as a possible alternative investment asset later in this thesis.

Players can list their weapon skins and cases for sale on the Steam Community Market at seller-determined prices. Demand for the weapon cases and other items on the Steam Community Market is generated by the players as well as an increasing number of investors that do not play the game. Buyers freely decide what they are willing to pay on the basis of rarity, cosmetic appeal, and perceived future value. The Steam Community Market is highly competitive, liquid, and dynamic due to the large number of sellers and buyers, the volume of transactions, and prices being determined by supply and demand (Yamamoto & McArthur, 2015; Dobrynskaya & Strelnikov, 2025). This ecosystem is quite unique, as in most of the video games, developers sell their cosmetic items directly to the players at a fixed price and in unlimited supply, thus eliminating the peer-to-peer secondary markets (Lehdonvirta, 2009; Thorhauge, 2024).

However, the Steam Community Market has its limitations. Valve sets limits on the pricing of the items with the maximum listing price of USD 1,800 per item and also limits the maximum Steam Wallet balance to USD 2,000 per user (Steam Support, 2026). Valve also charges an approximately 17,25% transaction fee on Steam Market sales, which is quite high when compared to many other assets (D'Anastasio, 2025). The biggest problem from the investors' point of view is that Steam Wallet funds cannot be directly withdrawn to a bank account. Once the funds are added to your Steam Wallet, the funds are locked into the Steam ecosystem and can only be used to purchase games or in-game items (Steam Support, 2026).

Due to the above-mentioned downsides of the Steam Community Market, CS weapon skins are often traded on third-party platforms such as Skinbaron, SkinWallet, CS.Money, and Lootbear. There are many different platforms and websites that buy and sell CS in-game items, generating a thriving secondary market for these digital assets bypassing the Steam Wallet restrictions (Antunes et al., 2025; Nguyen, 2022). These platforms offer lower transaction fees and real currency withdrawals to bank accounts, which makes them appealing options for both players and investors (Aramonte & Avalos, 2021; Dobrynskaya & Strelnikov, 2025). These platforms also allow users to sell higher-priced items than would be possible on the Steam Market (Faye & Le Fur, 2023; Glaser, 2022). CS in-game items are additionally traded directly between players, similar to over-the-counter trades in traditional financial markets, which adds to the liquidity of these digital assets. Peer-to-peer trading is possible without using any intermediary platforms (Wang, Lyu, & Lu, 2025).

The CS in-game item market is a key example of how digital video game items can be seen as a digital alternative asset class, not just a video game cosmetic. The CS weapon skin market, with an estimated valuation of 4.1 billion USD as of February 2025, blends elements of collectibles markets and financial derivatives (D'Anastasio, 2025). Traded without centralized exchanges and formal order books, CS skins also display similarities to many alternative assets, including high volatility, uneven liquidity, and sensitivity to non-financial factors (Faye & Le Fur, 2023; Reichenbach, 2025). CS weapon skins as well as other videogame items can be viewed as speculative alternatives that can offer both significant risks and potential investment opportunities.

Although existing studies have analysed investing in Counter-Strike weapon skins and other non-separable digital objects (Faye & Le Fur, 2023; Yamamoto & McArthur, 2015), research specifically assessing Counter-Strike weapon cases as an alternative investment remains limited. Therefore, this study focuses on analysing Counter-Strike weapon cases as a potential distinct digital asset class.

3.4.1 Criticism of Loot Boxes and Counter-Strike Weapon Cases

In-game loot boxes and randomized weapon-case systems just like Counter-Strike weapon cases have received a lot of criticism and concern for resembling gambling. This is mostly due to the variable reward mechanisms that is also utilized within the gambling industry (King & Delfabbro, 2019). The main concern regarding weapon cases is that players pay for a randomized outcome which has actual real-world monetary value. This strongly aligns with the traditional definition of gambling (Zendle & Cairns, 2018; Drummond & Sauer, 2018). Studies have reported a relationship between loot boxes and problem gambling behaviour, suggesting these systems such a loot boxes can be harmful especially to younger consumers (Zendle & Cairns, 2018; Zendle, Meyer, & Over, 2019).

The presence of third-party secondary markets and gambling sites further strengthens the criticisms and concerns towards Counter-Strike weapon cases regarding the gambling aspect and the young players. Hardenstein (2017) highlights that the Counter-Strike in-game items can be used as virtual currency on unregulated third-party betting platforms, enabling gambling outside traditional oversight and age restrictions. Assael (2017) implies that the Counter-Strike in-game economy has evolved into a large ecosystem that involves speculation, betting, and real-money transactions, blurring the line between gaming, financial activity, and gambling.

4 Data and Methodology

This chapter describes the data sample, introduces the assets that are selected to the study, and presents the performance and risk measures used to assess the investment potential of the weapon cases as well as the benchmark assets. It explains the data collection process, including how the observations are gathered and how the data is adjusted to produce reliable results. The selected Counter-Strike weapon cases are introduced as part of the sample selection, followed by the benchmark assets that are used for assessing the significance of the results. Finally, the chapter describes the construction of the equal-weighted index and what methods are used to examine the correlation, diversification, and hedging properties of Counter-Strike weapon cases.

4.1 Data sample: Asset selection

The data sample of this study consists of price observations of 14 Counter-Strike weapon cases released between February 2018 and February 2023. The sample period begins in 2018, aligning with the game's transition to a free-to-play model. Starting the dataset in 2018 ensures relevance to current market conditions, as the transition to the free-to-play model significantly increased the number of active players and trading activity in the market. The selected cases are analyzed in monthly intervals until January 2026, resulting in between 36 and 96 monthly price observations per case (Table 1). The selected cases provide an adequate time frame for analyzing risk and return characteristics of the weapon cases while avoiding the scarcity effects associated with older cases. All the selected cases have at least three years of available sales data, providing sufficient sample size for return and risk analysis. Selected cases also exhibit appropriate liquidity with average daily trading volumes on the Steam Community Market ranging from approximately 5,257 to 93,743 trades per day (Table 1). Liquidity is important to guarantee that the observed prices reflect active trading rather than isolated transactions and that the price data is suitable for financial analysis.

Table 1 presents the Counter-Strike weapon cases that are selected for the study and their observation periods, sample sizes, and average daily trading volumes. The data in Table 1 are acquired from the Steam Community Market and consist of monthly observations over the sample period.

Table 1. Counter-Strike weapon cases, observation periods, number of observations, and average daily trading volume.

Case name	First observation date	Last observation date	Number of observations (N)	Average daily trading volume
Clutch Case	**16.2.2018**	**16.1.2026**	**96**	**56448**
Horizon Case	**3.8.2018**	**3.1.2026**	**90**	**24711**
Danger Zone Case	**6.12.2018**	**6.1.2026**	**86**	**48383**
Prisma Case	**13.3.2019**	**13.1.2026**	**83**	**37095**
CS20 Case	**18.10.2019**	**18.1.2026**	**76**	**19499**
Shattered Web Case	**18.11.2019**	**18.1.2026**	**75**	**5257**
Prisma 2 Case	**31.3.2020**	**28.1.2026**	**71**	**45989**
Fracture Case	**7.8.2020**	**7.1.2026**	**66**	**93743**
Operation Broken Fang Case	**3.12.2020**	**3.1.2026**	**62**	**19094**
Snakebite Case	**3.5.2021**	**3.1.2026**	**57**	**61469**
Operation Riptide Case	**29.9.2021**	**28.1.2026**	**53**	**10784**
Dreams & Nightmares Case	**21.1.2022**	**21.1.2026**	**49**	**81688**
Recoil Case	**1.7.2022**	**1.1.2026**	**43**	**91968**
Revolution Case	**10.2.2023**	**10.1.2026**	**36**	**82834**

Representing multiple release dates and market cycles, the 14 selected Counter-Strike weapon cases form a representative data sample whose long price histories and consistently high liquidity allow analysis of the broader development of the Counter-Strike case economy over the years, making them suitable for systematic financial analysis and comparison with traditional assets.

4.1.1.1 Benchmark Asset selection

The Counter-Strike cases are compared to three benchmark assets to meaningfully analyze their risk and return properties. The selected benchmarks represent major segments of traditional and alternative investment markets: the S&P 500 (EUR) as a proxy for global equities, Bitcoin (BTC–EUR) as a highly traded digital asset, and gold (XAU/EUR) as a conventional store-of-value commodity. All benchmark series are collected at a monthly frequency over the period January 2018 to January 2026, resulting in 97 monthly observations for each asset.

Table 2 presents the benchmark assets selected for the study, together with their observation periods and total number of monthly observations, based on data obtained from public financial market sources

Table 2. Benchmark assets, observation periods, and number of monthly observations.

Asset	Category	First observation date	Last observation date	Number of Observations (N)
S&P 500 (EUR), iShares Core S&P 500 UCITS ETF (SXR8.DE)	**Equity Index**	**1.1.2018**	**1.1.2026**	**97**
Bitcoin (BTC–EUR)	**Cryptocurrency**	**1.1.2018**	**1.1.2026**	**97**
Gold (XAU/EUR)	**Commodity (Spot Price)**	**1.1.2018**	**1.1.2026**	**97**

4.2 Data collection

The monthly price data used as the foundation of this study is manually collected to fully control data quality, sampling consistency, and the monthly observation rules applied throughout the dataset. Manual data collection is especially essential for the Counter-Strike case prices, as the Steam Community Market does not provide a standardized

historical data export function, and third-party databases often lack complete, reliable, or publisher-verified price histories.

4.2.1.1 Weapon case price data

Historical price data of the Counter-Strike cases is collected in euros from the Steam Community Market, the official marketplace operated by the game's publisher Valve. The Steam Community Market provides the most reliable historical data for studying the trading prices and volumes of Counter-Strike weapon cases, and it is the most used marketplace for buying and selling in-game items regarding games published by Valve.

The first observation of each case is gathered from the day that the case is released and sold on the Steam Community Market for the first time. All observations after this follow a one-month-forward rule, meaning that every price is gathered precisely one month after the previous observation and always on the same calendar day as the first observation. This approach is selected to maintain consistent monthly intervals for the historical price of the cases despite their staggered entry into the market.

4.2.1.2 Benchmark Asset Data

The historical price data for the selected benchmark assets is collected from well-known and reputable financial data providers to ensure accurate data together with consistency with standard financial research practices. The following sources were used to collect the historical asset prices:

- S&P 500 (EUR): iShares Core S&P 500 UCITS ETF (SXR8.DE), retrieved from Yahoo Finance
- Bitcoin (BTC–EUR): Monthly BTC–EUR spot prices from Yahoo Finance
- Gold (XAU/EUR): Monthly gold spot prices in EUR from Investing.com

All benchmark historical asset prices were sampled in euros at a monthly frequency, using prices of the first day of each month over the period January 2018 to January 2026.

4.3 Data Adjustments

Before the empirical analysis, the data sample is adjusted to ensure consistency, comparability, and reliability across assets. The most fundamental adjustment concerns the initial trading period following the release of each weapon case. The weapon cases enter the market at a very high price relative to the price that cases are sold at later. This is due to high demand and lower supply regarding newly released cases. To eliminate the distortion in the price data, the first six months after each case's release are excluded from the adjusted data sample. The exclusion of the first six months of price data for all observed weapon cases is supported by the observation that most cases exhibit substantial price declines in the first six months after their release.

The first return included in the adjusted data set is the price change from month 6 to month 7, which serves as a meaningful starting point while filtering out price fluctuation for the first six months after the release of each case. Table 3 presents the adjusted observation periods of each case and the number of observations per case, as well as the price drops of the cases in the first six months after the release.

Table 3. Adjusted Observation Periods, Number of Observations, and Six-Month Price Drops for Counter-Strike Weapon Cases

Case name	Adjusted Observation Period	Number of observations (N)	Price drop in first six months (%)
Clutch Case	**16.8.2018-16.1.2026**	**90**	**-99,61 %**
Horizon Case	**3.2.2019-3.1.2026**	**84**	**-99,62 %**
Danger Zone Case	**6.6.2019-6.1.2026**	**80**	**-97,39 %**
Prisma Case	**13.9.2019-13.1.2026**	**77**	**-97,87 %**
CS20 Case	**18.4.2020-18.1.2026**	**70**	**-99,46 %**
Prisma 2 Case	**30.9.2020-28.1.2026**	**65**	**-99,82 %**
Fracture Case	**7.2.2021-7.1.2026**	**60**	**-96,05 %**
Operation Broken Fang Case	**3.6.2021-3.1.2026**	**56**	**-55,56 %**
Snakebite Case	**3.11.2021-3.1.2026**	**51**	**-99,66 %**
Operation Riptide Case	**28.3.2022-28.1.2026**	**47**	**-50,00 %**
Dreams & Nightmares Case	**21.7.2021-21.1.2026**	**43**	**-92,22 %**
Recoil Case	**1.1.2023-1.1.2026**	**37**	**-96,64 %**
Revolution Case	**10.8.2023-10.1.2026**	**30**	**-91,72 %**

The risk and return metrics are calculated over the adjusted observation periods listed in Table 3. Due to different number of observations (N) between cases due to the different release dates, the individual series are not perfectly aligned in time. For more consistent market-level analysis and accurate analysis of the overall weapon-case market, an equal-weighted Case Index is constructed. The index ensures that performance, diversification, and hedging properties can be evaluated reliably.

4.4 Return and Risk Metrics

The performance analysis of the Counter-Strike weapon cases and the benchmark assets is calculated from the monthly return series derived from the adjusted data sample presented in Table 3. The following subsections introduce the return and risk metrics used in this study. The selected metrics provide a detailed review of the investment characteristics and potential investment opportunities of the studied weapon cases and allow for meaningful comparison with the benchmark assets.

4.4.1 Return Metrics

Monthly returns serve as the primary metric in this study, as they are used to calculate most of the other performance and risk measures. Monthly returns for each asset are calculated using simple percentage returns:

$$R_t = \frac{P_t}{P_{t-1}} - 1. \quad (1)$$

The other performance metrics used in the study, all derived from monthly returns calculated using Equation (1), are presented in Table 4 below.

Table 4. Return metrics used in the study, formulas, and interpretation.

Metric	Formula	Use in the study
Monthly return	$R_t = \frac{P_t}{P_{t-1}} - 1$	**The core input for all performance measures month-to-month price change.**
Average monthly return	$\bar{R} = \frac{1}{N}\sum_{t=1}^{N} R_t$	**Representative value of average monthly performance; used to compare typical returns across assets.**
Annualized return	$(1 + \bar{R})^{12} - 1$	**Converts the average monthly return into an annual rate for direct comparison with financial markets.**
Cumulative return	$\prod_{t=1}^{N}(1 + R_t) - 1$	**Total return over the observation period; shows the overall gain/loss from start to end of the study period.**
Compound annual growth rate (CAGR)	$CAGR = (1 + Cum)^{\frac{12}{N}} - 1$	**A smoothed long-term growth rate assuming constant compounding, comparable across assets with different N**

4.4.2 Risk metrics

Monthly returns are also used as the basis for the risk analysis in this study. Risk metrics are used to assess the volatility of monthly price movements, downside exposure, risk-adjusted performance of each asset, and the magnitude of potential losses over time. The risk metrics are calculated using the same return series that is also used in performance metrics calculations.

The risk metrics applied in the study, including volatility, Sharpe ratios, and drawdown measures, are derived from the monthly return series using the formulas defined in this section and presented in Table 5 below.

Table 5. Risk metrics used in the study, formulas, and interpretation.

Metric	Formula	Use in the study
Monthly volatility	$\sigma_m = \sqrt{\frac{1}{N-1}\sum_{t=1}^{N}(R_t - \bar{R})^2}$	**The dispersion of monthly returns; key measure of overall risk.**
Annualized volatility	$\sigma_{a=}\sigma_m\sqrt{12}$	**Converts monthly volatility into annual terms**
Sharpe ratio (monthly)	$Sharpe_m = \frac{\bar{R} - r_f}{\sigma_m}$	**Risk-adjusted performance relative to the monthly risk-free rate**
Sharpe ratio (annualized)	$Sharpe_a = Sharpe_m\sqrt{12}$	**Annualized risk-adjusted return; comparable with financial market benchmarks**
Drawdown	$DD_t = \frac{L_t}{RollMax_t} - 1$	**Measures the decline from the most recent cumulative return peak at time t**
Maximum drawdown	$MaxDD = min_t(DD_t)$	**Captures the worst peak-to-trough loss; indicator of downside and tail risk**

The Sharpe ratio requires a risk-free rate for computing possible excess returns. The 10-year euro area government bond yield is selected as the proxy for the risk-free rate, as it is commonly used in academic research for euro-denominated assets and represents a near-riskless long-term investment (He, O'Connor, & Thijssen, 2022). During the study period (2018–2026), the annualized yield on euro area 10-year government bonds was on average approximately 3,0%, which corresponds to a monthly risk-free rate of 0,25% (Eurostat, 2024; YCharts, 2024). The monthly rate of 0,25% is used in all Sharpe ratio calculations for the weapon cases, the Equal-Weighted Case Index, and the benchmark assets to ensure consistency and comparability.

4.5 Construction of the Equal-Weighted Case Index

The Equal-Weighted Case Index is created to capture the overall behavior of the Counter-Strike weapon market and to create a unified timeseries from the separate case observations. The equal-weighting approach also helps to mitigate the influence of individual cases. The index starts from the first month when the market contains at least six cases, ensuring that the index reflects the broader market rather than being driven by only a few individual cases.

The six-month exclusion rule discussed in Section 4.3 is also applied in the index construction. Cases are included in the index starting from the seventh month after release similarly to the return and risk calculations. The index starts in May 2020, as it is the first month that at least six cases are simultaneously available on the market, taking into account the six-month exclusion rule. The index is updated at a monthly frequency until January 2026, consistent with the overall study period. The study period of the index consists of 69 consecutive monthly price observations, providing sufficiently long continuous time series for reliable performance, risk, correlation, and hedging analyses.

4.5.1 Index Construction

The Equal-Weighted Case Index is calculated by first identifying the eligible cases in each month and then averaging their monthly returns. As L_t represents the number of eligible cases in month t, the monthly index return is computed as the simple average of the individual case returns:

$$R_t^{Index} = \frac{1}{|L_t|} \sum_{i \in L_t} R_{i,t}. \quad (2)$$

The start level of the index is set to 100, and the following monthly index levels are calculated by compounding the monthly returns:

$$Level_t = Level_{t-1}(1 + R_t^{Index}). \quad (3)$$

This results in an Equal-Weighted Case Index that reflects the broader market development instead of being influenced by the performance of individual cases.

The empirical performance results of the Equal-Weighted Case Index relative to benchmark assets are presented in Chapter 5.

4.6 Correlation Analysis

Correlation analysis is used to study how the case index covaries with the selected benchmark assets to assess possible diversification benefits of the Counter-Strike weapon cases. The correlation analysis is based on the monthly return series of the index and the benchmark assets.

All correlation calculations use the aligned observation window from May 2020 to January 2026, the period during which the Equal-Weighted Case Index is available, and all benchmark assets have corresponding monthly observations. The fully aligned dataset ensures that the computed correlations reflect true co-movement and are affected by differences in sample length.

The static, full-sample correlation between the index and each benchmark is calculated using the Pearson correlation coefficient:

$$\rho XY = \frac{Cov(X,Y)}{\sigma_x \sigma_Y}. \quad (4)$$

Where X denotes the monthly return of the Case Index and Y the monthly return of the benchmark asset. These correlations capture the average linear relationship between the weapon-case market and traditional asset classes during the study period.

36-month rolling correlations are also calculated to examine whether correlations are stable over time or vary across market conditions. For each month after the first 36 observations, the correlation is calculated using the most recent 36-month window of returns. This approach enables identification of periods with lower or higher co-movement and evaluation of potential diversification benefits throughout the sample period.

4.7 Hedging Methodology

Hedging analysis is performed to examine whether the Case Index can be used to reduce the return volatility of the benchmark assets. Hedging analysis is conducted using a minimum-variance hedging framework based on the monthly return series used in the correlation analysis and enhances it by evaluating whether the observed correlations translate into concrete risk-reduction benefits. The empirical results for the hedge ratios and hedging effectiveness of each benchmark asset are presented in Chapter 5.

4.7.1 Minimum-variance hedge ratio

The minimum-variance hedge ratio h^* is estimated using a simple ordinary least squares (OLS) regression, where the benchmark asset return Y_t is regressed on the return of the Equal-Weighted Case Index X_t:

$$Y_t = \alpha + h^* X_t + \varepsilon_t. \quad (5)$$

The estimated slope coefficient h^* represents the optimal hedge ratio in a variance-minimizing sense. Once $h^*$is obtained, the hedged return series is computed as:

$$Y_t^H = Y_t - h^* X_t. \quad (6)$$

4.7.2 Hedging effectiveness

Hedging effectiveness (HE) is used to measure the percentage reduction in variance achieved by applying the hedge:

$$HE = 1 - \frac{Var(Y^H)}{Var(Y)}. \quad (7)$$

If the HE-value is positive, it indicates that combining the benchmark with the Case Index reduces return volatility, while a negative value suggests that the hedge would increase volatility (Ederington, 1979; Hull, 2018).

5 Results

This chapter presents the empirical results of the study. The chapter provides the results of the key calculations introduced in Chapter 4, including return and risk metrics for all assets, as well as the correlation and hedging analyses, which assess the Case Index's potential for risk reduction.

5.1 Return Performance Results

Table 6 presents the return performance metrics for all assets introduced in chapter 4. The table records the average monthly return, annualized return, compounded cumulative return, and compound annual growth rate (CAGR). These metrics are calculated using the methodology described in Section 4.4.

Table 6. Average monthly returns, annualized returns, cumulative returns, and CAGR of Counter-Strike weapon cases, the Equal-Weighted Case Index, and benchmark assets.

Asset	Average monthly return	Annualized return	Compounded cumulative return	Compounded annual growth (CAGR)
Clutch Case	7,38 %	134,92 %	2940,00 %	79,56 %
Horizon Case	6,58 %	114,84 %	6233,33 %	80,87 %
Danger Zone Case	8,33 %	161,26 %	1590,00 %	52,82 %
Prisma Case	5,89 %	98,74 %	207,55 %	19,13 %
CS20 Case	10,19 %	220,37 %	2940,00 %	79,56 %
Shattered Web Case	4,93 %	78,18 %	701,11 %	43,60 %
Prisma 2 Case	9,91 %	210,86 %	1844,44 %	72,95 %
Fracture Case	5,62 %	92,78 %	103,23 %	15,24 %
Operation Broken Fang Case	6,19 %	105,63 %	1135,21 %	71,37 %
Snakebite Case	7,09 %	127,55 %	461,54 %	50,08 %
Operation Riptide Case	9,21 %	187,91 %	2875,51 %	137,81 %
Dreams & Nightmares Case	4,81 %	75,79 %	134,85 %	26,90 %
Recoil Case	0,91 %	11,47 %	-41,38 %	-15,90 %
Revolution Case	-2,42 %	-25,49 %	-70,49 %	-38,63 %
Case Index	7,73 %	144,36 %	6481,26 %	107,12 %
S&P 500 (EUR), iShares Core S&P 500 UCITS ETF (SXR8.DE)	1,19 %	15,31 %	185,92 %	14,03 %
Bitcoin (BTC–EUR)	3,98 %	59,76 %	705,69 %	29,80 %
Gold (XAU/EUR)	1,46 %	18,97 %	279,31 %	18,13 %

The results show that the Counter-Strike weapon-case market has generated notably high long-term returns throughout the observation period. However, the returns vary greatly between individual cases. Multiple cases display annualized returns exceeding 100-220% and CAGRs ranging from 15% to more than 100%. This suggests strong long-term price appreciation. The cumulative returns of some individual cases reach as high as thousands of percent, highlighting the potential for high returns in the weapon case market.

The Case Index presents more reliable representation of the entire weapon case market by mitigating the impact of extreme outcomes of individual cases. The case index displays an average monthly return of 7,73%, an annualized return of 144,36%, and a CAGR of 107,12%. These numbers confirm that the weapon case market has experienced strong growth during the study period.

The difference in the return of the case index relative to benchmark assets is notable. Bitcoin, another speculative digital alternative asset, also shows great long-term performance (annualized return 59,76%, CAGR 29,80%), but still underperforms the Case Index in both annualized return and long-run growth. The S&P 500 exhibits much lower but steady performance (annualized return 15,13%, CAGR 14,03%), while gold also delivers moderate gains (annualized return 18,97%, CAGR 18,13%). These results suggest that weapon cases behave more like a high-growth alternative asset than a traditional investment, as return characteristics are more similar to Bitcoin than to equity or commodity markets.

5.2 Risk results

Table 7 provides the calculated risk metrics for all studied assets. The table includes monthly volatility, annualized volatility, monthly Sharpe ratio, annualized Sharpe ratio, and maximum drawdowns. All these metrics are calculated according to the methodology described in Section 4.4. These findings enable the evaluation of both the volatility of returns and the downside risk associated with each asset over the observation period.

Table 7. Monthly and annualized volatility, Sharpe ratios, and maximum drawdowns for Counter-Strike weapon cases, the Case Index, and benchmark assets

Asset	Monthly volatility	Annualized volatility	Sharpe Ratio (monthly)	Sharpe Ratio (annualized)	Maximum drawdown (%)
Clutch Case	34,68 %	120,13 %	0,2055	0,712	-70,00 %
Horizon Case	19,14 %	66,30 %	0,3307	1,146	-40,00 %
Danger Zone Case	33,07 %	114,57 %	0,2444	0,847	-86,36 %
Prisma Case	31,90 %	110,52 %	0,1768	0,612	-92,68 %
CS20 Case	40,97 %	141,91 %	0,2426	0,840	-53,40 %
Shattered Web Case	21,90 %	75,87 %	0,2137	0,740	-61,79 %
Prisma 2 Case	31,90 %	110,52 %	0,1768	0,612	-92,68 %
Fracture Case	33,15 %	114,82 %	0,1621	0,561	-94,34 %
Operation Broken Fang Case	19,66 %	68,11 %	0,3022	1,047	-49,12 %
Snakebite Case	28,55 %	98,91 %	0,2396	0,830	-66,67 %
Operation Riptide Case	20,90 %	72,39 %	0,4289	1,486	-40,80 %
Dreams & Nightmares Case	28,02 %	97,08 %	0,1628	0,564	-62,96 %
Recoil Case	22,04 %	76,34 %	0,0299	0,104	-87,37 %
Revolution Case	17,51 %	60,64 %	-0,1526	-0,529	-81,15 %
Case Index	19,14 %	66,30 %	0,3908	1,354	-52,65 %
S&P 500 (EUR), iShares Core S&P 500 UCITS ETF (SXR8.DE)	4,35 %	15,06 %	0,2171	0,752	-17,64 %
Bitcoin (BTC–EUR)	19,48 %	67,49 %	0,1915	0,663	-70,93 %
Gold (XAU/EUR)	3,52 %	12,18 %	0,3436	1,190	-14,39 %

Across the data sample, all the weapon cases exhibit consistently high levels of volatility, indicating that price fluctuations in the Counter-Strike weapon-case market are considerably larger than those typically observed in traditional financial assets. Monthly volatilities of all the observed weapon cases exceed 17%, and the highest values (CS20 Case at 40,97% and Clutch Case 34,68%) translate into annualized volatilities of 141,91%

and 120,13%. The considerably high levels of risk are also reflected in the maximum drawdowns, which are at least -40% across all the weapon cases, many of which exceed –80%, demonstrating that large and rapid price declines are common considering individual cases.

The Case Index demonstrates a significantly lower and more stable risk profile compared to individual weapon cases, with a monthly volatility of 19,14%, an annualized volatility of 66,30%, but a maximum drawdown of –52,65% still highlights the risk of large and rapid price declines. The Case Index manages to mitigate the idiosyncratic risk present in single-case returns by diversifying across multiple items. This confirms that the index meaningfully reduces case-specific price fluctuations, even if market-wide risk remains substantial. The Case Index is still highly volatile compared to the S&P 500 and gold but demonstrates very similar volatility to Bitcoin with less maximum drawdown. However, Bitcoin still exhibits generally less extreme volatility than most of the individual weapon cases.

5.3 Sharpe Ratios and Risk-Adjusted Performance

Sharpe ratios provide additional insight into the relationship between return and risk by measuring excess returns relative to their associated volatility, therefore offering a relevant risk-adjusted performance metric (Deng, Dulaney, McCann, & Wang, 2013).

Sharpe ratios of individual weapon cases are generally moderate to good. Most cases show values between 0,56 and 1,24, with the exception of the poor risk-adjusted performance of the Recoil case (0,104) and the Revolution Case (-0,529). This indicates that despite the high volatility reported in the case market, most cases are still able to produce excess returns relative to their risk.

The Case Index displays a very good risk-adjusted return. With an annualized Sharpe ratio of 1,354 it outperforms all benchmark assets, including gold (1,190), the S&P 500 (0,752),

and Bitcoin (0,663). The Case Index also outperforms all the individual cases except the Operation Riptide Case, which demonstrates an annualized Sharpe ratio of 1,486. This superior performance demonstrates that diversification within the weapon case market substantially improves risk-adjusted performance. While individual cases show substantial idiosyncratic risk, a broader market index reduces this noise and produces a risk-adjusted return that is competitive and superior to both traditional financial asset benchmarks and the digital asset benchmark. The Case Index achieves a significantly higher annualized Sharpe ratio than Bitcoin (1,354 vs. 0,663), which is especially interesting given that Bitcoin is widely regarded as a high-risk, high-return digital asset. The notably higher annual Sharpe ratio highlights how the case market can produce exceptionally strong risk-adjusted performance even relative to one of the most famous digital assets.

These results reveal that although individual weapon cases are extremely volatile and prone to large drawdowns, the market-level performance demonstrated by the Case Index is significantly more stable and exhibits strong risk-adjusted returns.

5.4 Correlation and Hedging Results

This section reveals the results of the correlation between the Case Index with the benchmark assets and evaluates whether the index can reduce benchmark asset volatility through hedging. The analysis is based on both static correlations and 36-month rolling correlations, complemented by a minimum-variance hedging test conducted over the aligned sample period from May 2020 to January 2026.

5.4.1 Static Correlations

Table 8 presents the full-sample Pearson correlation coefficients between the Case Index and every benchmark asset calculated from monthly return data.

Table 8. Static correlations between the Case Index and benchmark assets

Benchmark asset	Correlation with Case Index
S&P 500 (EUR)	**-0,04932**
Bitcoin (BTC–EUR)	**-0,03416**
Gold (XAU/EUR)	**-0,02498**

The correlations between the Case Index and the benchmark assets are very close to zero: −0,049 with the S&P 500 (EUR), −0,034 with Bitcoin (BTC–EUR), and −0,025 with Gold (XAU/EUR). These reported correlations reveal very weak negative linear relationships. This suggests that price movements in the Case Index do not systematically align with movements in benchmark assets. The slightly negative correlation values imply a marginal offsetting effect during certain periods, but their magnitudes are too small to indicate a proper meaningful inverse relationship.

The reported correlations indicate that the Case Index moves largely independently from the benchmark assets. According to portfolio theory, near-zero correlation is often considered a potential source of diversification benefits because assets with limited co-movement can reduce overall portfolio volatility (Fabozzi, Markowitz, & Gupta, 2008; Statman, 1987). Holding assets that do not respond similarly to systematic market factors can smoothen portfolios return profiles in the long run (Elton & Gruber, 1997).

The findings are consistent with previous research showing that alternative assets often exhibit correlations close to zero relative to traditional markets (Baur & Lucey, 2010). The results suggest that the returns of the Counter-Strike weapon-case market are primarily driven by ecosystem-specific factors like the popularity of the video game, rather than systematic macroeconomic factors.

The near-zero correlation does not automatically guarantee useful hedging properties. Hedging effectiveness depends also on the volatility characteristics of the hedging asset. Given the high experienced volatility of the Case Index, its ability to reduce the volatility of the benchmark assets needs to be tested empirically.

5.4.2 Rolling Correlations

36-month rolling correlations are calculated to verify the static correlations results over time. As shown in Table 8, the rolling correlations remain low and generally near zero across the observation period. Correlation with the S&P 500 ranges from –0,2168 to 0,0538, indicating a systematically weak and often slightly negative relationship with equity markets. Rolling correlations with Bitcoin fluctuate between –0,0943 and 0,0494, and those with gold range from –0,0714 to 0,0790, both of which suggest minimal and unmarkable correlation with the Case Index.

Table 9 presents descriptive statistics of 36-month rolling Pearson correlation coefficients between the Case Index and each benchmark asset, calculated using monthly return data.

Table 9. Descriptive statistics of 36-month rolling correlations between the Case Index and benchmark assets

Statistic	Case Index – S&P 500	Case Index – Bitcoin	Case Index – Gold
Count	**34**	**34**	**34**
Latest value	**-0,21683**	**0,00887**	**-0,04698**
Minimum	**-0,21683**	**-0,09435**	**-0,07138**
Q1	**-0,17162**	**-0,04305**	**-0,02339**
Median	**-0,14593**	**0,00783**	**0,02050**
Q3	**-0,06537**	**0,02793**	**0,06330**
Maximum	**0,05377**	**0,04935**	**0,07903**

The rolling correlation results confirm the static results: the Case Index shows no consistent co-movement with the benchmark assets, and the returns in the Counter-Strike weapon market are primarily driven independently by market-specific factors. The consistent low correlations imply potential diversification benefits but do not guarantee effective hedging properties, which will be assessed in the next section.

5.4.3 Hedging Results

To evaluate whether the low correlations translate into actual risk-reduction benefits, a minimum-variance hedge test was conducted using ordinary least squares (OLS), in line with the methodology described in Section 4.7. For each benchmark asset, monthly returns were regressed on the Case Index returns to obtain the minimum-variance hedge ratio with Equations (5) and (6), after which hedged return series were constructed and hedging effectiveness (HE) was computed with Equation (7). The results of these calculations are presented in table 10.

Table 10. Hedge ratios and hedging effectiveness across benchmark assets

Benchmark asset	Hedge Ratio	Hedging Effectiveness (HE)
S&P 500 (EUR)	**-0,01041**	**0,00243**
Bitcoin (BTC–EUR)	**-0,03231**	**0,00117**
Gold (XAU/EUR)	**-0,00480**	**0,00062**

The estimated hedge ratios are small and negative across all benchmark assets (–0,0104 for the S&P 500, –0,0323 for Bitcoin, and –0,0048 for gold). These values are consistent with the near-zero static correlations observed previously. The hedged return series further confirms that the Case Index exposure has only a limited effect on the returns of the benchmark assets.

The reported hedging effectiveness values are positive but extremely small, ranging from 0,0006% (gold) to 0,243% (S&P 500). These values reveal that the inclusion of the Case Index in the portfolio together with the benchmark assets produces only a minimal decrease in the variance of benchmark returns. The low hedging effectiveness is a result of the volatility of the Case Index being substantially higher than that of the benchmark assets. High volatility in the hedging instrument can reduce hedging effectiveness, because unstable return dynamics often weaken hedge performance (Cotter & Hanly, 2012).

Overall, the hedging results indicate that the Case Index could offer diversification benefits in a broader portfolio due to its low correlation with traditional assets, but it does not function as an effective hedging tool. The results support the findings that Counter-Strike weapon cases should be viewed primarily as a high-risk alternative asset, rather than a hedging instrument against traditional financial markets.

6 Conclusions & Suggestions for Future Research

The purpose of this thesis was to examine Counter-Strike weapon cases as a modern digital alternative investment asset and to evaluate their performance, risk characteristics, and possible diversification benefits relative to selected benchmarks: S&P 500, Bitcoin, and gold. The study is motivated by personal interest in the topic as well as the growing relevance of digital assets and the lack of academic research concerning non-separable video game items as an investment asset. This thesis contributes to the existing literature by analyzing Counter-Strike weapon cases through the Modern Portfolio Theory (MPT), neoclassical value theory, and behavioral finance. With the construction of the Equal-Weighted Case Index and comparing its performance against the benchmark assets, the study provides solid evidence on the investment properties of Counter-Strike weapon cases.

The study examines returns, volatility, Sharpe ratios, correlation structures, and hedging effectiveness to evaluate the investment potential of Counter-Strike weapon cases and the role that they could play in a diversified investment portfolio. The results allow a direct assessment of the four hypotheses introduced at the beginning of the study.

Hypothesis 1 that the correlation between CS weapon cases and the S&P 500 index is low or negative, indicating diversification benefits, is strongly supported. Static correlations between the Case Index and the S&P 500, Bitcoin, and gold are very close to zero (–0,049, –0,034, –0,025), and 36-month rolling correlations also remain weak and unstable over time. These findings confirm that the weapon-case market moves largely independently of equity, commodity, and cryptocurrency markets. The low co-movements indicates possible diversification benefits in the context of MPT.

Hypothesis 2 that CS weapon cases generate a positive average return over the study period is fully supported. 13 out of the 14 observed weapon cases experience positive average monthly returns and strong long-term performance, 12 of the weapon cases annualized returns exceeding 75%. The Case Index displays an average monthly return

of 7,73%, an annualized return of 144,36%, and a CAGR of 107,12%. These returns are substantially higher than those of the S&P 500, Bitcoin, and gold, indicating strong long-term appreciation of weapon cases.

Hypothesis 3, that the volatility of CS2 weapon cases is higher than that of the S&P500 index, is also clearly supported by the results. The study shows that individual weapon cases exhibit extreme volatility (17–41% monthly), translating to annualized volatilities above 60–140%, far higher than the S&P 500 (15%). Even the diversified Case Index experiences considerably higher volatility than the S&P 500.

Hypothesis, 4 that the Sharpe ratio of CS weapon cases is lower than that of the S&P 500 index, receives mixed support. Many individual cases indeed show lower Sharpe ratios than the S&P 500 as expected due to high volatility. However, the Case Index achieves an annualized Sharpe ratio of 1,354, outperforming all benchmark assets, including gold (1,190), the S&P 500 (0,752), and Bitcoin (0,663). This demonstrates that diversification across cases can significantly improve the risk-adjusted returns over time.

Overall, the results of the study reveal that Counter-Strike weapon cases exhibit distinctive characteristics as an alternative investment class. Firstly, both weapon cases and the Case Index generate exceptionally strong long-term returns. Secondly, they are associated with high risk, extreme volatility, and significant drawdowns. Thirdly, they demonstrate strong risk-adjusted performance when diversified, as the Case Index exhibits a high Sharpe ratio and more stable return dynamics than any individual case. Fourthly, the results report low correlations with other markets, suggesting that the weapon case marker behaves largely independently of equity, commodity, and cryptocurrency markets. Finally, their hedging abilities are limited, as despite low correlations, the Case Index indicates minimal hedging effectiveness due to its high volatility.

In summary, the Counter-Strike weapon cases represent a promising speculative digital alternative investment class that offers substantial return potential and possible diversification benefits when combined into a broader market index. While especially the individual cases shoe high volatility and asset-specific risks, the diversified Case Index enhances overall portfolio performance and demonstrates notably strong risk-adjusted returns, even relative to established digital assets such as Bitcoin. As virtual economies continue to expand and digital ownership rises in popularity, Counter-Strike weapon cases together with other digital alternative assets form a compelling foundation for future academic research.

A natural extension to this study would be to continue the dataset beyond 2026 or to analyse how events like major game updates, new case releases, esports tournaments, or broader economic conditions affect the prices of the weapon cases. Future research could also compare Counter-Strike weapon cases to other digital alternative assets, such as NFTs or other video game items from games like Fortnite or Dota 2. This would help determine whether the return and risk patterns observed in this study are specific to the Counter-Strike ecosystem or reflect a broader trend within virtual goods markets. The returns reported in this study do not account for transaction fees, platform frictions, or liquidity constraints, which could affect realized net returns in practice. Future research could take these factors into account to provide a more comprehensive assessment of investor outcomes. The Steam Community Market’s transaction fees, withdrawal restrictions, price limits, and the role of third-party platforms all affect the yields of the investors. Incorporating platform-specific transaction costs and examining how prices differ across marketplaces could offer an even more accurate view of actual net returns in the Counter-Strike weapon case market.

7 Disclosure of AI Usage

Artificial intelligence tools (ChatGPT and Microsoft CopilotAI) were used to assist with language-related tasks, such as checking grammar, improving wording, and occasionally restructuring sentences. The author takes full responsibility for the content, results, and academic integrity of this work.

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