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Decomposition of ETFs: building a synthetic portfolio of ETFs major positions and measuring their performance and risk

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Abstract

This paper investigates the performance of benchmark indices and according ETFs against the synthetic portfolios that were built using the five major holdings of the selected benchmark index and its ETF. Not only do we test the synthetic portfolios, but from them, we make optimal (re-balanced) portfolios using mean-variance optimization (with short-selling constraints). We test and examine the returns and characteristics of constructed portfolios against the benchmark indices and their ETFs to come up with the best investment strategy. By comparing the historical returns, Sharpe ratios, and VaR we analyze the performance of each financial instrument to determine its pros and cons for the three different investor types: risk-averse, risk-neutral, and risk-loving. Moreover, we construct GARCH models for the analyzed portfolios to estimate their volatility and compare them against each other since the analyzed time period contains regular and high volatility returns.

We conclude that by constructing synthetic portfolios a retail investor is able to beat the returns of the benchmark index and its passive ETF while having slightly worse risk-to-return metrics. If an individual chooses to compare synthetic portfolio to an actively managed benchmark ETF, the results are quite similar and so the choice of investment strategy is not as straightforward. For re-balanced (optimal) portfolios, stock allocation is extreme and is only recommended for risk-loving investors. For the GARCH models, we captured that a synthetic portfolio usually has a better performance in terms of lower volatility over time.

Keywords: ETF, Portfolio optimization, Sharpe ratio, VaR, GARCH.

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1. Introduction

This thesis focuses on Exchange Traded Funds (ETFs), which, from their first appearance as an investment instrument in 1993, have since gained in popularity substantially and aims to replicate the ETFs benchmark index portfolio's return (in the best scenario to outperform it) by creating a synthetic portfolio. Furthermore, this paper aims to investigate the advantages related to ETFs and compare them to their cons to determine the most appropriate investment strategy for a retail investor seeking to replicate the index (comparison to passively managed ETFs) or beat the ETF benchmark (comparison to actively managed ETFs) by investing in a passively or actively managed ETFs.

ETFs have become a prevalent financial instrument as more and more individuals explored investing and tried to purchase their first asset, these days having more than a few trillion in assets under management. ETFs themselves have become a desirable investment option for a beginner investor as the difficulty of choosing between all the equities publicly listed on the stock exchanges and requiring thorough analysis to avoid losing money on them has been increasing. To put it into simple words, ETFs are baskets full of equities or other financial instruments (depending on the ETF type and the index that it replicates) that allow investors to invest in selected equities based on the risk tolerance and required return. Furthermore, ETFs make the investment process effortless for the retail investor as they can save a vast amount of time by skipping all the equity research, financial modelling, due diligence, price tracking, and purchasing financial instruments at the right time. This work can be transferred to a fund manager who controls an ETF and makes investment decisions based on his financial knowledge, expertise, and market sentiment. In addition, for a beginner investor, it seems safer to invest with ETFs as one minimises all the risk associated with the incompetence related to investment by trusting professionals to manage one money, except that the individual chooses ETF he is willing to invest in.

Moreover, it is a complex process if someone would like to replicate the benchmark indices since it includes costs associated with the tracking and trading of all the assets, as well as it takes substantial time to do so. As fund managers and the analysts who work for them do all the work, they have to be compensated through fees part of the ETF contract. Currently, fees are getting lower because of significant competition among the funds that offer ETFs, such as management fees, operating expense fees, brokerage commission, bid-ask spread, success fees,

and numerous others depending on the specific product and company offers it. Usually, those fees amount to a low percentage of less than 1.0% (in most cases), and most people think this is a fair amount paid regarding the work done. Although some retail investors believe that sometimes those fees do not comply with the work managers have done if they do not beat the index returns or match them. In addition, while the percentage paid in fees might have a low absolute value, if calculated to the comparative amount (if the invested amount is bigger), it may have a noticeable relative difference between the expected return without fees and the returns after all the costs have been deducted. Fees and costs associated with the ETF management have been a hot topic in all investment debates as investors think those fees are still too high and give excessive compensation to the fund managers. The main punchline for the individual investors is that they still pay all the fees and cover all the expenses even though fund managers do not match the benchmark index return or underperform it given their poor management. As there are multiple examples of such occasions, retail investors might be right to demand more effective management from the fund managers as some feel they are not doing their job properly. With this argument, multiple individual investors believe that they can create a synthetic portfolio that does not necessarily have an absolute match to the benchmark index portfolio but is sufficiently similar given the weights that one made. Furthermore, some retail investors claim that only actively managed ETFs can match or beat the index, while if one offers a passively managed ETF - there is little to zero chance that the benchmark index returns would be matched. Therefore, investors believe that they can match the returns of an ETF with the same effort by creating a so-called synthetic portfolio that has major positions of the benchmark index or the respective ETF that tracks the benchmark.

Khan (2021) has produced the index price chart showing the difference between the S&P 500 index with and without its five biggest stocks, emphasising a significant discrepancy starting from 2021 April till November of the same year. This gives an edge in the debate for retail investors as they can prove their strategy of replicating an index with five major positions to seem worthwhile. Consequently, the situation exists where there is an inner debate with retail investors perceiving their ability to match or even beat the benchmark index by simply taking the major positions of the benchmark index.

To see whether a synthetic portfolio would outperform the actively and passively managed ETFs, the methodology included testing performance and measuring the risk of selected ETFs and synthetic portfolios themselves. The Sharpe ratio was chosen for synthetic portfolio

optimisation and risk-adjusted-performance measurement because of a standard application in finance and the goal set - maximisation of synthetic portfolios' returns and ETF outperformance. The chosen risk and volatility measurement methods were Value at Risk (VaR) and Generalized Autoregressive conditional heteroskedasticity (GARCH (1, 1)) models, selected for the common application in finance in the case of VaR (Basel rules) and for the ability to detect time changing-volatility (GARCH) to which financial returns are known to be subject to. First, the investment strategy was to pick leading ETF positions (the five biggest holdings) to construct a synthetic portfolio for the empirical tests. Then, synthetic portfolios were set to have equal weights on all of the positions included in the portfolio while we attempted to maximise the Sharpe ratio by re-balancing weights every month. When all the assets' weights in the portfolio were equal, it tested what return and risk a passive investor could expect while choosing the current strategy. In the case where rebalancing of weights was done, it was tested what would be the performance of an active investor who, while choosing ETF's positions, builds a portfolio that maximises one of the performance ratios. The given return of synthetic portfolios was compared with the ETFs considering all the possible fees: management, administrative, and performance. The data for testing were extracted from the database of FactSet and the websites of companies that offer ETFs: BlackRock, Vanguard, State Street, and Invesco.

To our knowledge, while ETFs have been researched thoroughly, there hasn't been a closely compatible empirical study performed where synthetic portfolios would be built from indices' major positions and a comparison would be made between the performance of ETFs, respective indices and synthetic portfolios themselves, increasing the value and importance of the thesis. Consequently, an increased demand exists for research to determine whether it is more worthwhile for an investor to stick with investing in ETFs or if it is beneficial to construct a simplified synthetic portfolio that would yield better returns. The existing literature focuses on valuing ETF's underperformance in relation to indices that arise from tracking error and cost inefficiency (Svetina, 2010), ETF's inability to outperform the market (Svetina, 2010), (Pinheiro et al., 2019), (Gastineau, 2014). Furthermore, considerable research has been done in analysing ETF costs (Box et al., 2020). Some analysis has also been performed on issues related to ETFs liquidation (Akhigbe, 2020) and ETF commodities (Moncrief, 2020) (Kothari et al., 2012).

Our examination of synthetic portfolios against the most popular indices yielded detailed results that could be applied differently based on varying investor's risk tolerance. As for the most popular indices, we have selected S&P 500, Nasdaq Composite, and Dow Jones Industrial Average for the study. For our synthetic portfolios, we have selected five major holdings by weight of each index and afterwards, we constructed two different synthetic portfolios as S&P500, and Nasdaq Composite major holdings by 2019-01-01 were the same. We then found the ETFs that replicate the benchmark indices, and for S&P 500 and Nasdaq Composite, we used both - passive and active ETFs to check two different approaches to beating (replicating) the benchmark. We then compared our synthetic portfolios against ETFs based on three measurements: cumulative return over the selected period, Sharpe ratio, and VaR. We have also calculated the GARCH (1, 1) models and re-balanced synthetic portfolios to get a maximum Sharpe ratio.

The results from our analysis yield that synthetic portfolio with major holdings tend to outperform the benchmark indices and their ETFs, while the active ETFs (comprised of benchmark holdings) tend to show similar results relative to the performance of our portfolio. We have noted that during high uncertainty periods, our synthetic portfolios offer better returns compared to benchmark ETFs with a slight edge on the active ETFs as well. Nevertheless, synthetic portfolios have slightly worse Sharpe ratios and slightly higher daily VaR (%). We argue that these measurements show the benefits of diversification, but we point out that, i.e. VaR metrics are quite similar therefore, risk-neutral individuals might benefit from the given strategy of synthetic portfolios composed of major benchmark index holdings. In addition, we have maximised the Sharpe ratio on our synthetic portfolios, which yielded one/two stocks for the maximum Sharpe ratio. While this maximum Sharpe ratio is not the perfect fit for risk-averse or risk-neutral individuals, we state that risk-loving investors might sacrifice the benefits of diversification and go for better cumulative returns. The results from GARCH (1, 1) model further support our previously stated conclusion of synthetic portfolios outperformance relative to ETFs as, in most cases, synthetic portfolio carried lower risk or reached lower levels of variance during volatility outbreaks that occurred because of the COVID-19 pandemic as well as in the period after the outbreak.

2. Literature Review

The following chapter reviews existing empirical studies in relation to exchange traded funds. First of all, the background on ETFs is presented, including a brief description of ETFs history, two different structures and management styles as well as their rise in popularity. Secondly, a comparison is made between ETFs and mutual funds – an alternative to exchange traded funds. Then, reasons for frequent underperformance of the instrument are presented, as well as related market frictions are discussed. Afterwards, the dynamics of ETFs costs as well as issues associated with the investment vehicle liquidation are analysed, ending the literature review section of the thesis with ETFs relation to commodities.

2.1. ETFs background

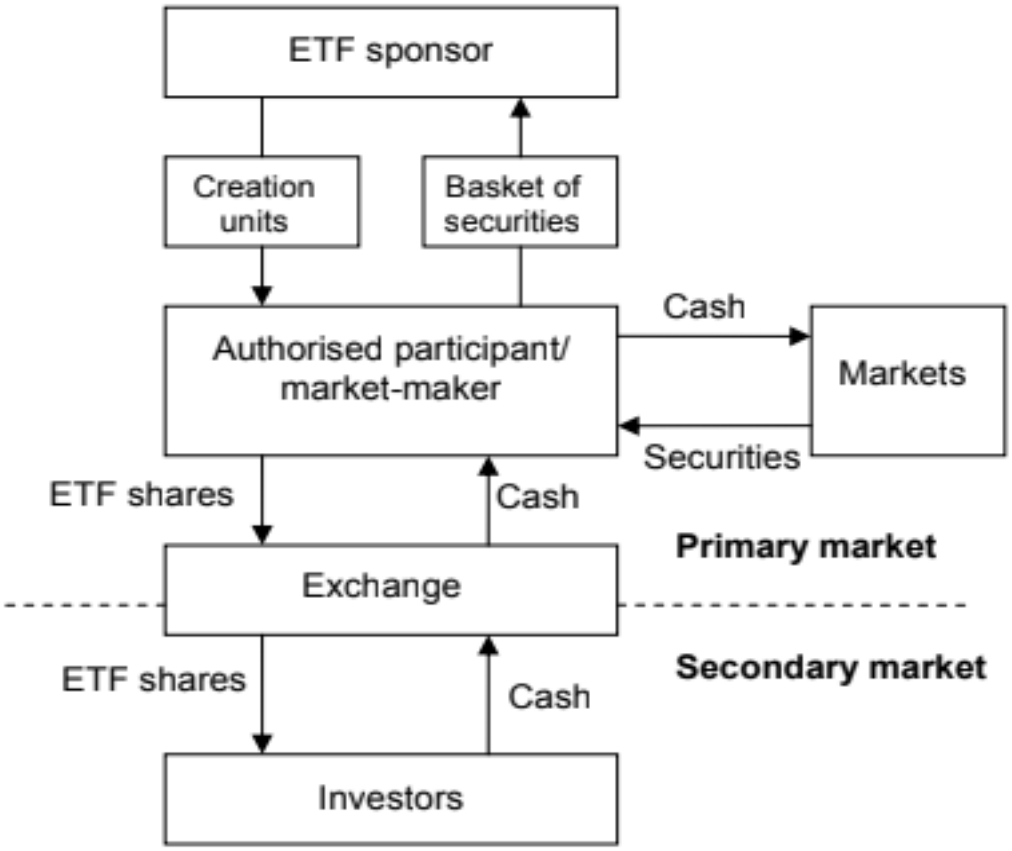
As an investment vehicle, ETFs, also called SPDR, were first introduced on January 23rd 1993, by SPDR (Standard & Poor's Depositary Receipt) as of January 23, 1993, in the result of increased demand for a single product (a basket of securities) to be traded on stock exchanges after the Black Monday on October 19th, 1987 (Liebi, 2020). ETFs can be classified as either synthetic or physical based on their architecture. Whereas physical ETFs hold the underlying assets of the index, such as stocks or bonds, physically based on their weights in the index, synthetic ETFs use financial derivatives such as total return swaps to replicate the price of an index (Liebi, 2020). Depending on how ETFs are constructed, physical and synthetic ETFs are subject to different counterparty risks (Ben-David et al., 2017). As physical ETFs engage in security lending, the fund becomes subject to the risk related to the security borrower. This comes as ETFs, like stocks, create an opportunity to short-sale an investment vehicle (Lettau & Madhavan, 2018). Meanwhile, synthetic ETFs are exposed to default risk linked with the derivative contract used to construct the ETF. Even though synthetic ETFs are more prevalent in Europe than in the United States, physical ETFs constitute a majority of all ETFs. Overall, a synthetic ETFs structure may be chosen if the tracked index is rather large, as using a physical structure could be relatively more costly (Ramaswamy, 2011).

To properly comprehend the structure of physical ETFs, figure 1 is presented below (Ramaswamy, 2011). First of all, it should be noted that authorised participants such as market-makers purchase a basket of securities from markets that are intended to replicate a specific index, S&P 500 making stocks, for example, and deliver them to the ETF sponsor. In exchange

for that, creation units (shares issued by an ETF sponsor in large blocks) are received by the market-makers. While this transaction takes place in the primary market, further transactions between the investors who wish to purchase or sell the ETF take place already in the secondary market via brokers on stock exchanges. The value held by ETF investors is determined by the NAV of the basket of securities held by the ETF sponsors.

Figure 1. Physical ETF structure.

The figure depicts physical ETF structure, illustrating all relevant parties in the set up of such ETF.

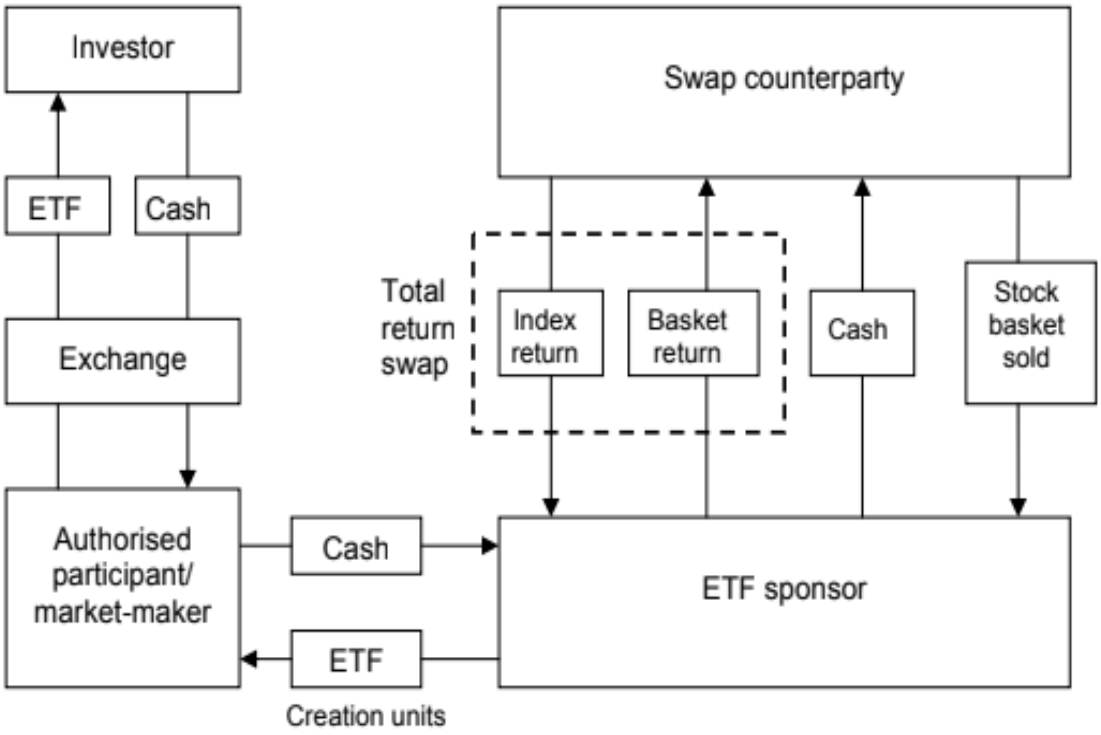


Similarly, figure 2 depicts a structure of synthetically created ETF (Ramaswamy, 2011). Synthetic ETFs allow for a replication of the index using derivative instruments rather than owning the underlying physical assets. The use of total return swaps, or an unfunded swap structure, usually starts with the authorised participant receiving the creation units from the ETF sponsor in return for cash rather than for a basket of the underlying index securities, as was seen in the previous case of physical ETFs. Meanwhile, an ETF sponsor enters into a total

return swap with a financial intermediary, usually a bank, to receive the ETF index's total return for a particular nominal exposure. With this being the first leg of the swap, cash is afterwards transferred to the swap counterparty equal to the national exposure. Then, the swap counterparty transfers a basket of collateral assets to the ETF sponsor. Finally, the total return of the basket is transferred to the swap counterparty, that is the second leg of the total return swap.

Figure 2. Synthetic ETF structure.

The figure depicts synthetic ETF structure, illustrating all relevant parties in the set up of such ETF.



Exchange traded funds, while replicating a performance of an index, are traded continuously on public exchanges and are often set up as open-ended investment companies though they entail characteristics of both open and closed-ends funds (Ben-David et al. 2017). The attributes of open-ended funds can be found in ETFs as the instrument allows for new shares creation and redemption, while closed-end details are seen through the possibility of trading ETFs on exchanges. In the United States, ETFs are set up under the Investment Company Act of 1940

(Ramaswamy, 2011), allowing them to be more tax-efficient than mutual funds (discussed further in the comparison to the mutual fund's section).

Considering an individual investor's perspective, it is almost impossible to replicate the benchmark indices - S&P 500, Dow Jones Industrial Average, and Nasdaq Composite using the physical replication method. These indices consist of multiple equities that are part of the index based on their weight or other parameters that are subject to the specific index. First of all, to replicate such an index, an investor has to have a considerable amount of capital to invest, as buying all the index sub-parts is inevitable if one wants to replicate it. This, for a beginner investor, might look like an irrational decision, as one has to buy all the equities through a broker and leave the transaction fee, which at this point, when one buys enormous amounts of equities, would have a significant impact on one's returns while re-calculating year-on-year returns given the transaction fees together with safekeeping/depository fees. Also, it may be inefficient for a single investor to buy all the components of the given index. Some of them might be unavailable at one's current broker, or there might be a substantial bid-ask spread that would drive returns that include all the expenses down. Nevertheless, even if the investor manages to buy all the equities and replicates the index based on the proportions of financial assets, it would be impossible for one to keep the exact weights of positions in relation to the index as positions within major indices vary throughout the day and that requires a purchase or disposal of some assets to keep the same proportions of a benchmark index that an individual investor tries to replicate. Likewise, synthetic ETF replication and the use of derivatives for an average investor might prove to be too complex of a task.

Unlike individual investors, fund managers or ETF boutiques can avoid the inefficiency problem as they usually have vast amounts of cash under their management. This situation helps them effectively buy all the necessary assets if their goal is to replicate the benchmark index with multiple components. In some cases, those funds do not necessarily have to purchase the assets in the markets - as often they have thousands of assets under management, they can simply purchase them from the company's fund, and if that is the case, transaction fees and significant bid-ask spreads are avoided. Furthermore, for these asset management companies, it is way easier to replicate benchmark indices as they have multiple analysts following the

changes, announcements and all other news associated with the benchmark index so they can immediately report to the manager or traders, that can then execute the trades and therefore correctly replicate the index. Alternative of using derivative products such as total return swaps because of knowledge and expertise further enabling them to replicate the return of an index.

In addition, while previously described ETFs were based on a passive management style, ETFs can also be managed actively. As was mentioned, passive ETF management is based on tracking a specific index or benchmark through physical or synthetic replication methods and replicating its performance, meanwhile, active investment strategies are aimed at beating the underlying benchmarks. (Rompotis & Gerasimos, 2013). With leveraged ETFs being one of the active management methods, the investment strategy is designed to deliver a performance of twice or three times in relation to the one achieved by the benchmark. However, the active ETF management method has experienced substantial criticism, as while being a simple method to obtain leverage with low management expenses, the method remains weak to counterparty risk resulting from the employment of derivative products required to use leverage in the first place. Likewise, Rompotis and Gerasimos (2013) found that while active ETFs show lower returns than passive ETFs, the former also exhibits higher riskiness, making it a poor investment choice from return/risk perspectives. When considering risk-adjusted performance, researchers also concluded no evidence of active ETF managers achieving excess returns relative to the average market returns or the risk-adjusted returns of passively managed funds. Whereas such results could be explained by efficiency within the US ETF market, on which the research was based, and hence, natural restrictions for abnormal returns, scholars agreed that the explanation could also be the lack of skillfulness from the manager's side or of ability to time the market. Given the limitations of actively managed ETFs, passive management remains the dominant ETF management method.

Since the introduction of the first ETF product in 1993, various ETFs have been launched. While the US-listed SPDR, which is based on the S&P 500 index, remains the largest ETF globally with an asset value of 178 billion USD as of 2017, there has been a substantial rise in exchange-traded funds, tracking broad domestic as well as international indices or rather specific sector, region and country indexes. Because of their rapid surge in popularity, ETFs have increased substantially in their assets under management, reaching a value of 4.3 trillion in 2017 and a total of 6300 investment vehicles (Lettau & Madhavan, 2018). For comparison

purposes, the total market value of equity and fixed income securities in global terms were equal to 160 trillion USD in the same period.

2.2. ETF comparison to mutual funds with a focus on differences

Within the academic literature on ETFs, the instrument is often presented against or in relation to mutual funds. The two are among the main investment alternatives when it comes to resource allocation for investors. Thus, this section is intended to quickly compare the two investment vehicles, focusing on their significant differences.

First of all, as was mentioned at the beginning of the literature review, ETFs are hybrid instruments, hence, having features of open-ended trusts (creation and redemption process) and closed-end funds (stock market tradability). Conventional mutual funds, on the other hand, when subject to redemption, must, most often, buy back their units for cash, with investors being able to trade only once per day at the net asset value of the fund, calculated after the close. As a result, mutual funds are obliged to keep a portion of the portfolio invested in cash to meet possible redemption outflows. ETFs, having some features of closed-end funds, manage to avoid the necessity to keep a fraction of investments in cash, this way being able to avoid a "cash drag" however, they may be traded at above or below their net asset value depending on demand and supply conditions (Zopounidis et al., 2008).

Secondly, according to Martin Lettau and Ananth Madhavan (2018), exchange traded funds benefit from a possibility of offering substantial tax advantages in comparison to open-ended mutual funds. This advantage exists because while mutual funds are required to sell shares for investors' redemption, possibly resulting in capital gains distributed to investors and later taxed, ETFs are not obliged to sell shares to meet redemptions. This reduction in capital gains distribution is, in turn achieved via what is known as in-kind distribution, which involves not a monetary payout but an offer of positions underlying securities on a pro-rata basis (Poterba and Shoven, 2002). While mutual funds can require shareholders to take an in-kind redemption that allows for higher tax efficiency, the majority of such funds are reluctant to do so because of relatively insignificant positions held by investors within the fund (Gastineau, 2001). Consequently, when a substantial share redemption happens in mutual funds, it happens for cash, and hence, a sell in shares of portfolio stocks must occur - those shares that have appreciated from the original value or cost. As these gains for redemption are distributed to shareholders, it is shareholders that end up paying the gains tax, even though it is the fund

which has been a net buyer of securities. As a result, tax-sensitive investors are inclined to opt for ETFs, whereas tax-exempt, also called tax-insensitive investors, tend to value conventional mutual funds (Agapova, 2010), resulting in the two investment instruments being imperfect substitutes. ETF managers, on the other hand, while having the ability to choose which securities to distribute, distribute assets with substantial embedded capital gains, reducing tax burdens on their shareholders (Poterba and Shoven, 2002).

Overall, from comparing exchange traded funds to mutual funds, one develops the impression that ETFs are more efficient and a more probable choice for an investor, however, for such a claim to be made, an in-depth analysis should be performed, which is out of scope of this thesis.

2.3. ETFs underperformance to their benchmark due to tracking error and costs inefficiency

Exchange Traded Funds have become so popular nowadays as they can offer retail investors greater diversification of their portfolio with lower costs and minimum effort. This phenomenon that ETFs have multiple trillions of assets under management is the outcome of its key features as well as the lower exposure to the risk due to high diversification. In addition, ETFs are considered to be a great approximation of market indices as usually they are constructed based on the leading market indices, i.e. S&P 500, Dow Jones Industrial Average, and Nasdaq Composite. Nevertheless (Svetina, 2010), some of the ETFs constructed based on the market indices usually have slightly lower returns for various reasons. In their paper, the authors explain that ETFs usually underperform the indices they have set as their benchmark because of two reasons: tracking error and costs associated with the trading. If we begin with the tracking error, the standard deviation of daily return differences may occur for different reasons as per the authors, but as costs are to be discussed separately, we assess the timing and unsuitable replication here only (although they can be thought as a part of tracking error). Regarding the tracking error, authors have established tracking errors for domestic and international ETFs, hence, based on the fund's domicile, one can assess the performance of their both - domestic and international products. Researchers have found that domestic ETFs underperform according to the benchmark by about 0.47%, while for international ETFs, the underperformance number reaches as high as 1.13%. The tracking error established by the authors is high compared to the expectations of a maximum 0.1% -0.3% error for both domestic and international ETFs. This finding of authors leads us to further testing in our approach

whether a simulated portfolio of ETFs position could outperform not only the ETF that it would have as its benchmark but also the index that is a benchmark for the given ETF. The issue of poor ETF management can lead to lower returns for investors, and even though lower returns by 0.47% or 1.13% may not be significant for low-value positions (<50.000 USD), it may be decisive when selecting ETFs for the positions with high value (>1mn USD).

Even though tracking error might be one of the main reasons for underperformance, the cost structure for an individual owning an ETF should also be discussed. Even though costs related to buying and holding an ETF are closely related to the tracking error, we decided to split the reasons for underperformance as they have different drivers that lead to poor performance compared to the benchmark. To begin with the transaction costs (Svetina, 2010), international ETFs underperform their benchmark by 0.19%, while domestic ETFs are considered to underperform their benchmark by 0.26%. This finding by the authors gives a little warning since one would expect to pay less fees for a domestic ETF than for the one issued offshore. On one side, this might be true as some of the funds offer zero transaction fees for the domestic ETFs and for international ETFs, one should pay either a fixed or floating fee, depending on the investment plan or account status (Interactive Brokers, SEB, Swedbank). On the other hand, the reason that domestic ETFs are less cost-efficient in terms of overall expenses might be true for a couple of reasons. First of all, some of the ETFs included in the research might have country-specific expenses resulting from the poor liquidity of their products. This usually happens when one tries to buy any financial asset (Interactive Brokers, 2022), as there might be more costs or administrative resources used by the broker to fulfil the order depending on the country. As it happens that the US is considered a home for the most popular ETFs and becomes an international domicile, if an ETF is bought in Europe or outside the US, fees might be lower. This is the opposite reasoning for the problem stated before since the US does not have a country-specific premium regarding liquidity concerns. In addition, the good infrastructure of financial markets and trading of securities overall allows investors and fund managers to keep the costs lower than buying domestic funds. Therefore, while trying to optimise the portfolio of ETFs, one should consider whether it is a domestic or international ETF as solely costs regarding the trading are lower for international ETFs. Nevertheless, we shall not forget that authors include transaction costs in their ETF performance calculation, therefore, the bigger picture should be assessed. International ETFs might be really attractive due to their lower transaction costs, but it is way more challenging to keep the overall underperformance lower than for domestic funds. Thus, for our further testing and research,

we will try to estimate the underperformance of the selected ETF based on its underlying index and check whether our approach of inside ETF stock picking could lead to the outperformance of the underlying ETF and whether our portfolio underperforms ETFs benchmark.

2.4. Can ETFs beat the market? The role of market frictions

As ETFs were primarily constructed to replicate the index funds, they shall represent the market portfolio or have a beta close to the one of the market portfolio. Nevertheless, there are multiple ETFs nowadays that track the index funds and create alternative funds that try to outperform the benchmark index itself and, therefore, beat the market. Initially, it seems impossible since the ETF is tracking one of the index funds and tries to match the index fund's returns, given the fact that it is subject to transaction costs and tracking error. If we recall the main takeaways from prior authors (Svetina, 2010), one could say that outperforming an index fund while investing in the ETF that replicates one is a pure luck and lack of tracking error or costs associated with the trading of these securities. The requirement to adjust ETF weighting to follow its benchmark (Pinheiro et al., 2019) is crucial in terms of tracking the index with the lowest costs possible. Fund managers have their main task to perform better than the index they are tracking, and, at this point, it seems impossible to achieve it if they have a task to mimic index weights at the end of the trading day. Nevertheless, the authors referred to other findings (Gastineau, 2004) where the test of ETFs from two different companies was performed to check whether they matched the benchmark returns or even outperformed them. The findings suggested that two ETFs - the iShares Russell ETF and the Vanguard Small Cap Index Fund performed oppositely of each other regarding their benchmark index Russell 2000. Prior ETF, as expected, had a worse performance than the index and, purely without any additional fees or costs included, underperformed the benchmark index by 0.53%, while the latter surprisingly outperformed the given benchmark by 0.76%. As fund managers are required to match the weights of the benchmark index, they must adjust their fund according to the changes that happened in the index for those to be reflected in their funds. Therefore, fund managers have to choose when to change the structure of their ETF, taking into account all the costs, transaction times and delivery dates, so the transition would be smooth and reflect the actual changes the manager was intended to achieve. In the latter approach, we think that the often trading of ETFs positions not only causes underperformance due to the tracking error but is simply useless if main ETFs positions could keep up with the returns de facto following the index.

In their further analysis, (Pinheiro et al., 2019) authors take the so-called spider (Standard & Poor's Depositary Receipt) and perform a thorough analysis of the costs associated with handling the SDPR. As the authors conclude, SPDR underperforms the benchmark S&P 500 by 0.26%, which is a relatively low number considering the type of the investment of SPDR. Nevertheless, the authors conclude that in this case, tracking error (it's part) is not the main reason why the fund underperformed the benchmark, but the management fees, in addition to other management expenses, resulted in worse performance compared to the benchmark. As one may argue that such a small absolute difference between the actual performance of the benchmark and the ETF is not significant, it may be correct if we are analysing investments whose relative value is low, and the difference under 10 USD may not be noticed. On the other hand, if one is dealing with the investments whose value exceeds six or seven figures, then this mismatch between the index returns and the returns of the ETF that was supposed to replicate the benchmark may have a substantial relative value and affect investors' choice regarding the investment opportunity. As for this analysis, it is clear that investors have a goal to replicate the benchmark index (most popular indices) so they invest accumulated savings together with professional fund managers. Unfortunately, even if the tracking error is as low as possible and market frictions are disabled, management fees and other expenses related to this category can lead to lower than expected returns. This happens as a minor difference of returns in absolute terms transfers into bigger amounts if investments include seven-figure funds such as pension and retirement funds. Then, a small difference in absolute terms transfers into a bigger relative loss as the underlying investment is more than one million or billion dollars.

2.5. ETF costs and dynamics behind them

A rational investor would always try to maximise its return and avoid all direct costs considered towards its investment, such as those lower yearly returns and relative value of the invested position. While equities are the most popular type of investment, they are subject to some fees that the investors expect. Those fees typically include a transaction fee, which is deducted in both acquisition and disposal of these assets, and a depository fee (safekeeping), that is still charged by some of the banks, even though the competition from financial brokers drove the price of such fees down significantly. On the other side of the possible investment, one could consider an ETF as a diversified and less risky investment than equities, however, which includes more expenses than equities. Besides the regular transactions on depositorium costs,

ETFs are subject to expenses that usually include management fees, fund expenses, and other incurred expenses. These expenses are subtracted from the net asset value at the end of the day (or otherwise if determined by the fund manager), and then the true return is calculated. For example, if an ETF at the end of the month does not yield any return and this day matches the NAV calculation, including expenses, one could expect a negative return on its investment. Nevertheless, these situations when the returns are negative or just positive are quite often, and if the timing of investment is poor – the investor loses money. For example, index ETFs are subject to volatility as any other ETF, but their monthly returns are not expected to be abnormal, somewhat stable and in line with market expectations. In this case, it is important for such a financial instrument to have an expense ratio as low as possible because if the returns on the ETF are low, the NAV at the end of the accounting period may not meet an investor's expectations.

As for the fees and the development of them, starting from when the first time ETFs were introduced, some positive development is present. As expected (Box et al., 2020), fees for managing ETFs and expense ratios overall have seen a positive development towards an investor as most of them were cut substantially due to higher competition and noticeable cash influx into such funds during the years. Nevertheless, in the free market economy, an investor is entitled to choose the ETF which satisfies one's needs of yielding desirable returns, being issued by a reputable fund, and having a moderate expense ratio. Authors mentioned before noted that in 2018 they found that if investors that held the ETF, which was a part of Morningstar Institutional Category, would have switched to the one that has the lowest expense ratio, they could have saved 3.6 bn USD in fees alone. The authors mention that the final number may be lower as they did not account for the transaction expenses and capital gain taxes that must have been paid if one ETF would be liquidated at a profit. If we compare this number, which may be slightly lower if it includes all the other non-direct costs to the whole industry, the number is not that high considering the number of investors. Nevertheless, this number shows that there is still inefficiency while investing in ETFs, and in relative terms, it is quite substantial. As for the investors and other market participants, the need to maximise their returns and minimise the expenses incurred by ETF management should push for new investment strategies or new investment products that would lower the current inefficiency caused by ETF's overall expenses considering their returns.

2.6 Liquidation of ETFs and related problems

In capital markets, it is not unusual that some of the stocks get liquidated for various reasons, starting from taking a company private to a company being bankrupt. Investors could expect liquidation if one can track a pattern of poor management, as in the case of leveraged buyout (LBO) or management buyout. Usually, when a company is taken private or LBO is performed, current shareholders get an instant premium for the shares they own based on two reasons. First of all, the market anticipated that the buyout group estimated that the current equity value of a company is lower than the estimated fair value, so there might be an arbitrage or good investment opportunity. Secondly, the buyout group must pay some premium to the current shareholders for them to sell the stock. This situation drives the current stock price up as market participants are willing to price the acquisition in the current stock price. On the other hand, liquidation due to a bankruptcy drags stock price down to zero as debt holders take the residual control of the firm. Therefore, the liquidation of a stock can give either an expected 30% value-added (based on the usual acquisition premium) or drive the stock price to extreme levels while it is worthless.

Introduction to the stock price movements because of liquidation was necessary to understand the intuition behind the ETF and its purpose - if the stock goes bankrupt or is taken private, ETF price moves according to the market mood regarding the news but does not explore extreme values or a considerable increase in price due to diversification and weighting of the assets in the portfolio. Nevertheless, ETFs are still subject to liquidation (Akhigbe, 2020), as a researcher has discovered noticeable ETF price movements when the liquidation of the ETF is announced. Before we begin to examine the closure of ETFs and the effect of such activity on its price and the market overall, it is worth mentioning that the authors determined this action not to have a significant impact on the ETF market overall. This means that the ETF closures are common, but they do not cause significant distress and increase in systemic risk or value at risk, and as the authors mention – the industry is persistent regarding such closures.

Still, authors have found that announcement regarding the ETF closure creates a time period when losses for the investment can occur. As they state in their results, the closure announcement gives a window of 30 days when losses usually happen, as this is the number of days till the final closure of the ETF. Therefore, this announcement may have a negative impact on one's portfolio, even though the companies inside the ETF do not have any performance

issues or increase in risk of default. Moreover, researchers pointed out that after the announcement, as the ETF continues to trade for the remaining days till closure, an investor could either make a short-term profit or loss immediately due to information asymmetry or high-volume trading, but the investors that have decided to hold their positions, will have to take the final loss associated with the closure. As it comes from the conclusion, the best way to minimise the loss is to liquidate all the exposure in such ETF when the news of closure comes out, as then an individual could minimise the likelihood of losing more money. This strategy comes from the empirical findings that an ETF that is to be closed is subject to halting of the security trading, which has a hazardous impact on its price as investors perceive such an action in an extremely negative way. In addition, the authors pointed out that there were cases when investors at the end receive liquidation value but not the closing price which extends their losses even more. Following the intuition and conclusions behind the closure of ETFs and their price movement, we could observe inefficiency as the instrument which was designed either to replicate or follow some kind of a benchmark and is a subject to external noise that is not directly associated with the risk of investment but rather the risk that comes from the issuer of the ETF.

As it is now known that any ETF is subject to liquidation and investors that are not that well informed or use passive investment strategy will bear the costs of liquidation, the expected return should be higher than it is now for most of the ETFs. Moreover, the situation that most of the ETFs underperform their benchmark and are even more riskier brings the question of ETF inefficiency and should raise more questions on how to improve the product or get a better return than it. Usually, most ETFs (if they follow a specific index) invest a vast amount of money into equities that are investment grade and have an extremely low probability of default, thus, investing only in those positions could eliminate the risk of default of the ETF, but bring the risk that evaporates through diversification. Therefore, if one investor chooses to replicate the ETF with its main positions, the investor might increase its risk due to low diversification, but at the same time, one can cancel the risk associated with the third party that is responsible for the financial asset. Even though the researchers that have conducted this analysis state that these situations happen extremely rarely but do so, the defaults of triple A rated companies and the debate on which strategy is better goes on. To sum up, liquidation risk should be accounted in risk to return calculations not only for equities but for the ETFs as well, as they bear the risk of liquidation of assets inside the financial product and risk that financial product is liquidated itself.

3. Data Selection and Methodology

The following chapter presents the data chosen for the study and the motivation behind picking specific indices, ETFs, and stocks for synthetic portfolios. The synthetic portfolio is constructed using five major positions of indices or respective ETFs, first equally weighted and then with optimised weights which are based on a maximum Sharpe ratio. Afterwards, the synthetic portfolio's and the ETF's performance, taking into account volatility, is measured to determine the best performing portfolio.

3.1 Data selection

For data selection, we decided to take three major benchmark indices as our indicative benchmarks. Three indices happened to be S&P 500, Nasdaq Composite, and Dow Jones Industrial Average. The main reason for choosing these three is their admiration among the retail investors, great track record, and wide range of available information regarding the specifics of the indices themselves and the products created to follow them. In addition, these indices (based on the individual portfolio) could usually act as a benchmark index or so-called market that every investor tries to overperform. These indices are offered by almost every single hedge fund as an ETF, and therefore, we will have a variety of products to choose from.

For the time frame, we choose the period from 2019-01-01 till 2021-12-31 for a couple of reasons. First of all, we would like to analyse the performance of the financial product during the normal volatility, which would happen to be the year 2019 when no major events that would shake up the markets have occurred. Moving on, we are going to analyse the performance during the Covid, which is essential to understand whether our synthetic portfolio can over-perform the benchmark not only during the normal circumstances but during the high uncertainty. Lastly, the year 2021 is a mix between the rebound in the financial markets together with rising uncertainty of the second pandemic wave. All in all, the main interest is to graphically check whether the performance of our synthetic portfolio is better if taken the benchmark index active and passive ETFs.

We are subjectively choosing iShared by BlackRock as the one of the leading providers of ETFs. The main reasons for choosing this provider of ETFs is because there is a wide variety of financial products available to Europeans (due to the strict EU regulations, individuals from

Europe cannot always purchase an American ETF), a great track of record for main indices, low liquidation risk of ETFs, and good reputation among retail investors. From there, we take the following ETFs: iShares NASDAQ 100 UCITS ETF (CSNDX.SW, expense ratio – 0.33%) for Nasdaq Composite, iShares Evolved U.S. Technology ETF (IETC, expense ratio 0.18%) for active Nasdaq Composite replication, iShares Core S&P 500 ETF (IVV, expense ratio – 0.03%) for S&P 500, iShares S&P 500 Growth ETF (IVW, expense ratio – 0.18%) for an active S&P 500 replication, and iShares Dow Jones U.S. ETF (IYY, expense ratio – 0.20%) for the Dow Jones industrial average.

For the Synthetic portfolios, we take the major holdings as of 2019-01-01 based on the Ploutos (2019) and Liberto (2019) summary tables for the major assets of the three main indices discussed before. We take the five major holdings of these indices, and so it happens, that for S&P 500 and Nasdaq Composite, we take the same companies such as Apple Inc. (AAPL), Alphabet Inc. (GOOGL), Microsoft Corporation (MSFT), Amazon.com Inc. (AMZN), Facebook, Inc. (FB). Even though the split is c.40% for Nasdaq and c.13% for S&P 500, these stocks are the major five holdings for each of those indices and will take place in our synthetic portfolio. For the Dow Jones Industrial Average, we combine five major holdings that happen to be: Apple Inc. (AAPL), Boeing Co (BA), UnitedHealth Group Inc. (UNH), Goldman Sachs Group Inc. (GS), and Home Depot Inc. (HD). While constructing the two synthetic portfolios, we take the 20% weight for each stock selected from the index, so we will analyse two equally weighted synthetic portfolios against five selected ETFs from iShares by BlackRock.

3.2 Methodology

This section of the thesis shows the methods used for performance and risk measurement of the selected ETFs as well as of the synthetic portfolios. The chosen strategy is based on picking main ETF positions (five biggest holdings) to construct a synthetic portfolio for the empirical tests. In addition to this, GARCH (1, 1) models and VaR for the ETFs and synthetic portfolios would be constructed to check volatility differences between the two. In addition to constructing synthetic portfolios by giving equal weights to all of the positions included in the portfolio, we attempt to maximise returns/performance ratios by re-balancing weights. In the case where all the assets' weights in the portfolio would be set to be equal, we would test what return and risk could a passive investor expect while choosing such an investment strategy. In the strategy where weights would be rebalanced, we would try what would be the performance

of an active investor who still chooses ETF's positions but builds a portfolio that maximises one of the performance ratios. The following section is further divided into risk measurement, portfolio 27estabilized, and portfolio evaluation subsections that introduce the methods used in the thesis.

3.2.1 Portfolio optimisation

This part of the thesis presents the method used to optimise the synthetic portfolios. As the purpose of a synthetic portfolios was to outperform the ETFs and their respective indices, both synthetic portfolio optimisation and later on risk-adjusted return measurement methods were based on using the Sharpe ratio, one of the most common and practically used metrics in finance for such purposes.

The portfolio's mean excess returns are defined using the excess returns of portfolio components or assets and their weights:

$$M[r_p] - r_f = w'm \tag{1}$$

The portfolio variance is:

$$\sigma_p^2 = w'\Omega w \tag{2}$$

Where, w is a vector of weights with dimensions of 5 × 1, m is a vector of average excess returns with dimensions of 5 × 1, and Ω is the covariance symmetric matrix with dimensions of 5 × 5.

The following step includes maximising the Sharpe ratio to find the optimal combination of risky assets while setting a constraint that the weight of component assets equals one (Danthine et al., 2015)

$$max\ S_p(w) = max\ \frac{w'm}{\sqrt{w'\Omega w}} \tag{3}$$

$$s.t\ w'1 = 1 \tag{4}$$

The mean of returns (given by change in prices of asset stock prices) give us the expected return of that asset. The sum of all individual expected returns further multiplied by the weight of assets give us expected return for the portfolio. Both the expected excess returns and the sample covariance matrix of components of each portfolio are calculated monthly using daily observations.

In this thesis, the short-selling constraints were used when rebalancing the portfolio with a daily data and on a monthly basis as for a relatively inexperienced retail investor, using leverage and short-selling would be an unlikely scenario, hence, the effect of long positions on the portfolio only is analysed. The weights, set initially to be equal, were afterwards rebalanced to maximise the Sharpe ratio, and since short-selling constraints were used, the new weights of each asset were not allowed to be negative. A Python code was used to optimize the portfolio, the code generates random portfolio and gets the results (portfolio returns, portfolio volatility, portfolio Sharpe ratio) and weights for the corresponding result. Then it locates the one with the highest Sharpe ratio, which is then chosen as the final optimized portfolio.

3.2.2. Portfolio evaluation

The following section of the thesis describes the methods that were used to evaluate portfolio performance and risk. To begin with, Sharpe ratio was selected as the most appropriate risk-adjusted return measurement due to its practicality, intuitive interpretation, and common use in finance. Afterwards, the risk portion of the portfolio was measured using Value at Risk (VaR) method, as similarly to the Sharpe ratio, this metric remains a commonly applied in finance and this is so because of the Basel rules which are currently in place. Lastly, GARCH (1, 1) model is constructed and applied for all synthetic portfolios and ETFs to measure respective the risk during different economic conditions of the analysed period.

Sharpe Ratio

The Sharpe ratio is commonly used to measure return per unit of volatility or total risk, and for a portfolio, p is defined as:

$$sr_p = \frac{M[R_p] - R_f}{\sigma_p} \quad (5)$$

The ratio is the slope of the line between a riskless asset and portfolio p, with the tangency portfolio having the maximum Sharpe ratio. The exposed Sharpe ratio is widely used to measure risk-adjusted returns, and the higher the value of the Sharpe ratio, the better the portfolio's performance is. Subtracting a risk-free rate from a portfolio's mean returns in the numerator of the equation also facilitates obtaining an investor's average returns from taking a risk in excess of that given by a risk-free rate – a return in the absence of risk. Nevertheless, in the case of a negative ratio, which may occur if a risk-free rate is above the return on a portfolio, the Sharpe ratio loses its meaning and should not be used as a measure of performance. Moreover, the assumption of normally distributed returns is a weakness of the Sharpe ratio.

Garch (1, 1) model

In order to properly measure risk within the portfolios and to account for time-varying variance, GARCH (1, 1) model was selected. The method is primarily known for capturing clustering patterns of volatilities as variance within financial markets is known to not stay constant over time.

The GARCH (1, 1) model's mean equation is defined in the following way:

$$r_t = \mu + \eta_t \tag{6}$$

The conditional variance equation is defined as:

$$\sigma_t^2 = \omega + \alpha\varepsilon_{t-1}^2 + \beta\sigma_{t-1}^2 \tag{7}$$

The GARCH (1, 1) model describes the conditional variance using a single lagged squared error and one lagged variance. Two conditions must be satisfied for the model to work properly, namely the condition for stationarity and positive variance. While the first one implies the sum of α and β must be less than one, the latter implies that all parameters, or ω, α and β, have to be positive.

Lastly, to obtain the maximum log-likelihood estimates for the parameters of the model, the log-likelihood function needs to be maximised:

$$L\ (\mu, \omega, \alpha, \beta) = \sum_{t=1}^{T} \left(-\frac{1}{2} ln(2\pi) - \frac{1}{2} ln(2\sigma_t^2) - \frac{\eta t}{2\sigma_t^2} \right) \tag{8}$$

Value at risk

An alternative method of measuring risk within a portfolio is to compute its Value at Risk (VaR). Given a certain level of confidence or α, VaR can be defined as PR(L > VaR) = 1 - α, or in words, the equation states that the probability of losing more than VaR is equal to 1 - α. In this thesis, a 95.0% confidence level was chosen subjectively, and the decision was based on the fact that, oppositely to banks, our case does not involve the risk of underestimation and the metric is used entirely for comparative purposes. Describing the loss that is not expected to be exceeded with a certain confidence level, VaR has its advantages and disadvantages. On the one hand, the method benefits from simple interpretation (expressed in monetary units), focusing on poor outcomes, being applicable to all asset classes and probabilistic, applying to all asset classes, and taking all underlying risk factors into account. On the other hand, the method does not tell the size of a loss given that exception occurs – a loss higher than VaR, is not subadditive, and carries high model risk in the case when loss distribution is not normal (which is the usual case for financial returns), does not consider liquidity risk and may be destabilising during volatile periods. Nevertheless, the method is commonly used within the finance field because of Basel regulations, and hence, it is applied in this thesis as a supplementary method for the GARCH (1, 1) model for risk measurement.

4. Results and Analysis

The following chapter presents the empirical findings of the thesis and performs an analysis of the results. The results are presented in two key sections. First, the ETFs and synthetic portfolios are analysed from the perspectives of their returns, Sharpe ratio and VaR. Then, the GARCH (1, 1) model results are discussed, and a conclusion on whether the synthetic portfolios outperformed the respective ETF and indices is made. A note should be made that synthetic portfolios have equally weighted positions, while rebalanced ones are optimized portfolios.

4.1. Analysis of main results

Table 1. Comparison of Sharpe ratios and VaR with 95% confidence level

This table presents the different Sharpe ratios and VaR metrics among the ETFs that we have been selected as well as synthetic and rebalanced portfolios that we have constructed.

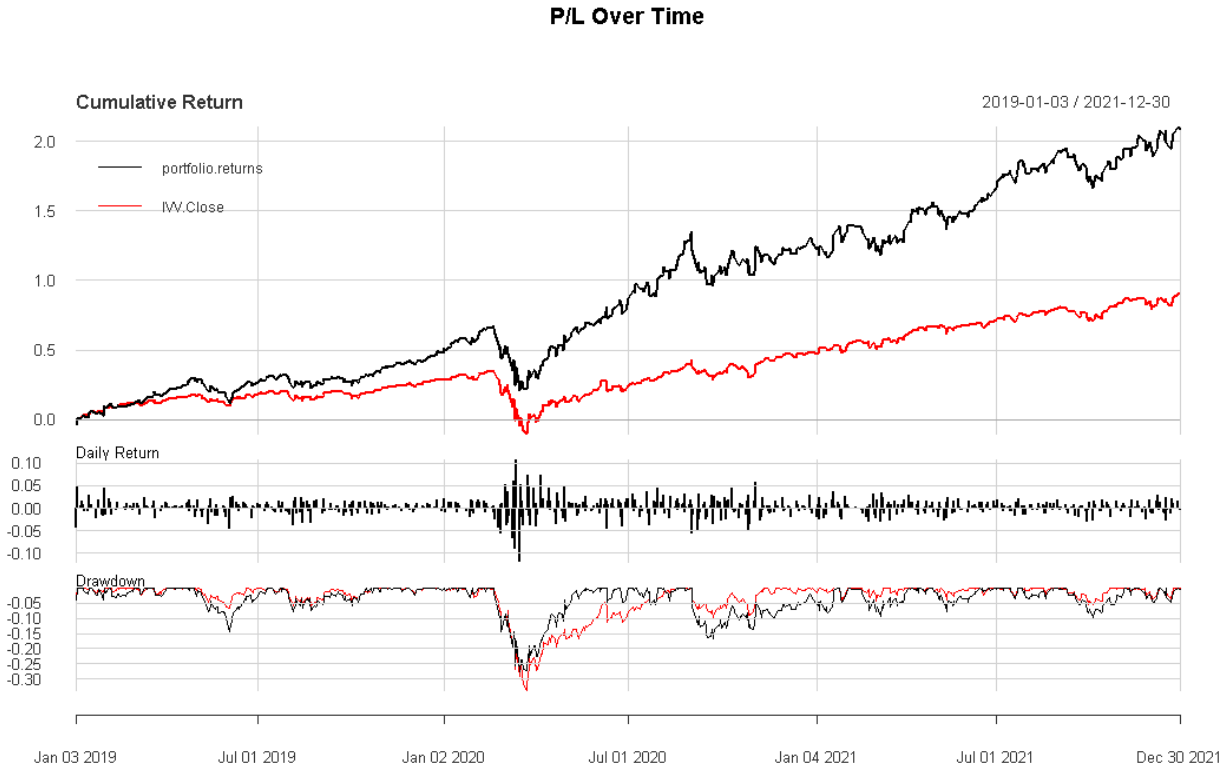
Portfolio	Sharpe ratio	VaR
IVV ETF (S&P 500)	1.02	1.84%
IVW ETF (S&P500)	1.18	2.01%
CSNDX.SW ETF (Nasdaq)	1.53	2.10%
IETC ETF (Nasdaq)	1.26	2.43%
IYY (Dow Jones)	1.01	1.81%
Synthetic portfolio (S&P500 and Nasdaq)	1.31	2.47%
Synthetic portfolio (Dow Jones)	0.81	2.21%
Rebalanced (optimised) portfolio (S&P500 and Nasdaq)	1.52	2.85%
Rebalanced (optimised) portfolio (Dow Jones)	1.5	2.67%

We have summarized the results of our analysis in Table 1. In the following sections these results are discussed and presented together with the comments regarding the returns of the synthetic portfolios, rebalanced portfolios, and ETFs. Although we measured the ratios and returns for our rebalanced portfolios as well, their performance against the benchmark indices is analysed only briefly as those portfolios give an extreme allocation. For the same reason the GARCH (1, 1) model is not applied to rebalanced portfolios as these portfolios are expected to show substantially higher volatility and risk.

First of all, the synthetic portfolio was constructed and its cumulative daily returns are plotted against the iShares Core S&P 500 ETF (later - IVV) in the chart below to visually check which of the two portfolios performed better from a cumulative return perspective.

Chart 1. Synthetic portfolio vs IVV ETF.

This chart presents the synthetic portfolio performance against the selected ETF. Upper chart focuses on cumulative return, middle one on daily return, while the last one on drawdown - a peak-to-trough decline during a specific period. Selected period for this chart is 2019-01-01 till 2021-12-31. Daily values, adj. close.



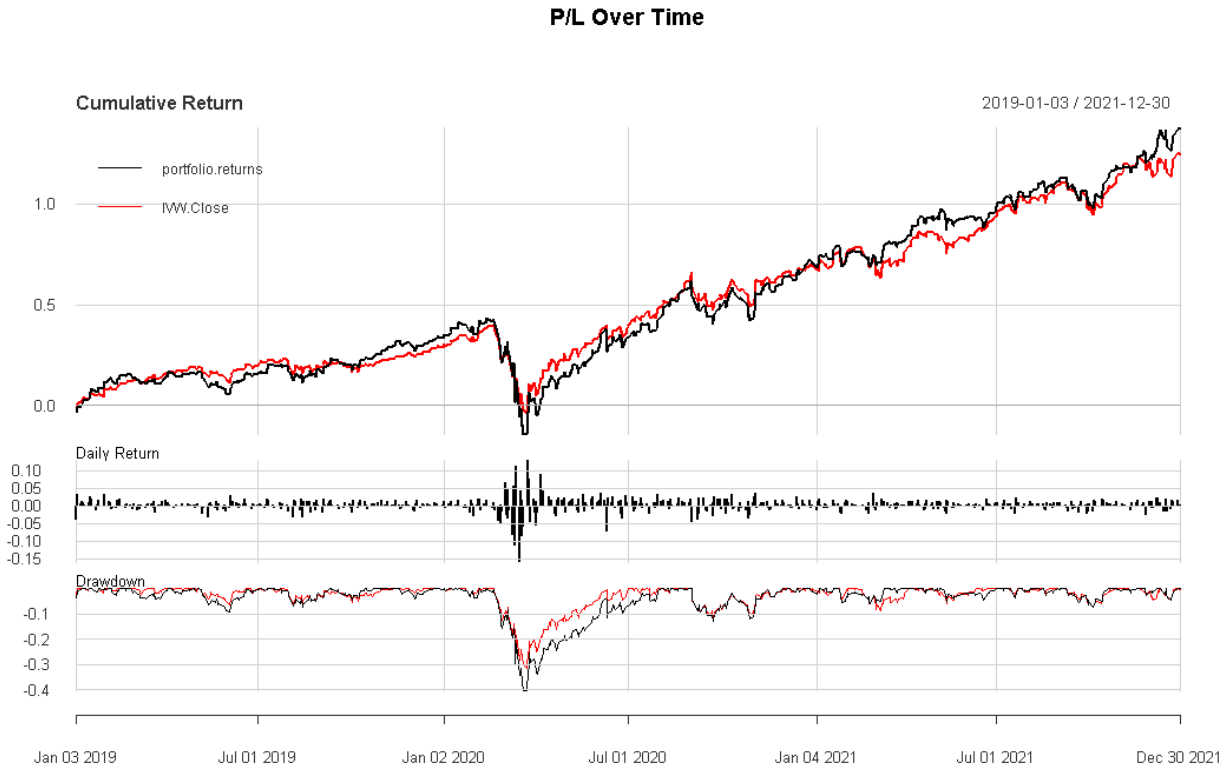
From the chart above, it can be seen that at the beginning of 2019 and until the end of the year, both portfolios, the synthetic portfolio and the portfolio that consists exclusively of IVV, performed somewhat similarly and had quite equivalent cumulative daily returns. As here we analysed long-term investments, daily values were set to depict volatility as well, and while synthetic portfolio exhibited slightly higher volatility, it can be seen that synthetic portfolio outperformed the IVV portfolio on a daily basis since the beginning of 2020, and so the hypothesis that it is possible to out-perform the benchmark ETF using its five major positions can be confirmed based on cumulative daily returns.

As was already seen, monthly cumulative returns suggest that there is only a single period of time (around February 2019) when the synthetic portfolio did not out-perform the IVV portfolio, but as the time horizon increases, it becomes straightforward - it is possible to beat the market with its own major holdings. Moreover, annual Sharpe ratio was calculated for synthetic portfolio and it yielded 1.31 against the 1.02 for the IVV portfolio. The obtained results can be explained with a simple observation that more risk was taken while benefit of diversification related to ETFs was excluded by construction a portfolio from major positions of the ETF. Furthermore, for the given portfolios, VaR was also computed to check how much of additional downside risk was taken. For the synthetic portfolio, daily VaR of a downside in the portfolio value of -2.47% was received, while the IVV portfolio yielded a daily VaR of a potential decrease of -1.85%. Given this fact, our expected loss within the synthetic portfolio was much higher than the IVV portfolio as the former is riskier. On the other hand, this facilitated us in outperforming the market.

As of now, the conclusion has been made that with synthetic portfolio it is possible to beat the market. Next, it is analysed whether the synthetic portfolio can outperform the ETF that is composed mainly of large US equities, namely the iShares S&P 500 Growth ETF (later IVW), the actively managed ETF that is constructed based on the index that tracks large-cap firms from the S&P 500 index.

Chart 2. Synthetic portfolio goes in-line with IVW ETF.

This chart presents the synthetic portfolio and the selected ETF P/L analysis. Upper chart focuses on cumulative return, middle one on daily return, while the last one on drawdown - a peak-to-trough decline during a specific period. Selected period for this chart is 2019-01-01 till 2021-12-31. Daily values, adj. close

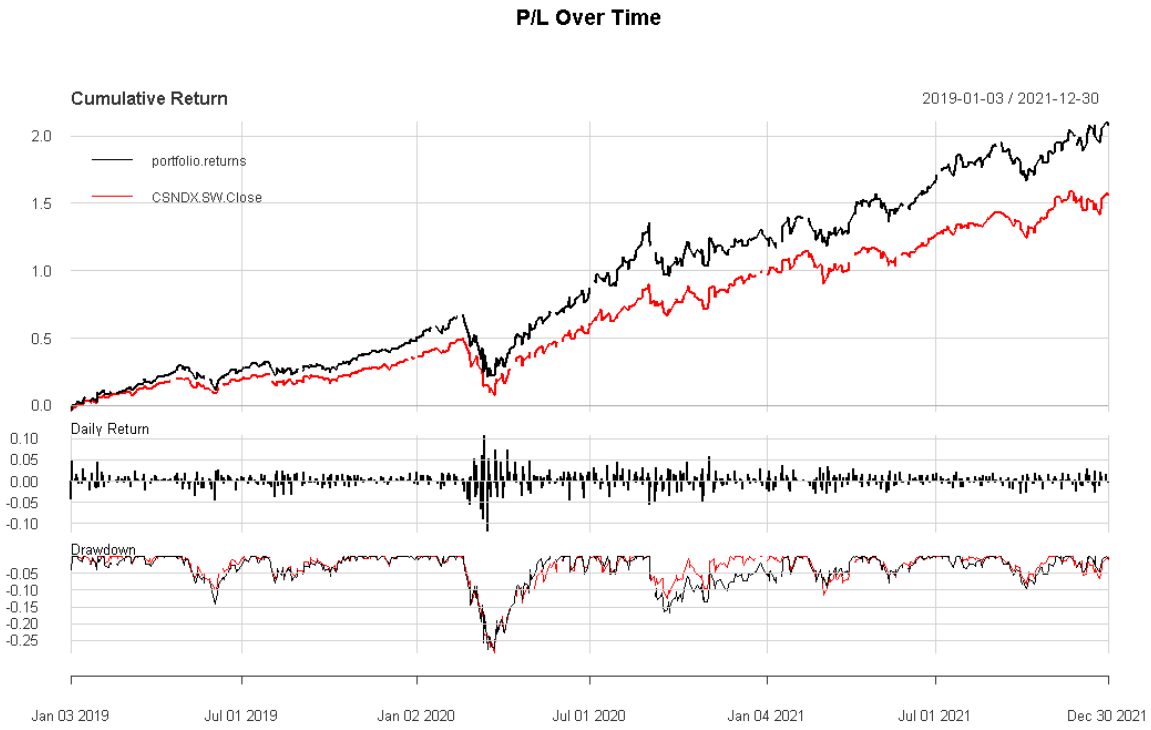


In the chart above, the results for the actively managed S&P 500 ETF and the synthetic portfolio are presented, and the results are not as straightforward as previously. From a day trading standpoint, it can be seen that there were periods when synthetic portfolio had better cumulative return whilst, later on, IVW outperformed the constructed portfolio. Furthermore, for synthetic portfolio the Sharpe ratio equaled to 1.31, and for IVW, the same ratio equaled to 1.18. Overall, there is no clear answer to whether our synthetic portfolio performed better than a single ETF. There were periods, i.e. during the Covid-19 pandemic, when our portfolio had a small edge against the ETF, but later on, in 2021, the returns stayed around the same level and it cannot be claimed with complete confidence as to which portfolio performed better by looking solely at the chart. For this reason, daily VaR values were also compared and for synthetic portfolio, daily VaR was at -2.47% and for IVW, it equaled c. -2.0%. Therefore, in this case, it cannot be confirmed which of the portfolios was better in terms of comulative returns as, while their returns performance was rather similar, comparing the Sharpe ratios, VaR, and the benefits of diversification, a conclusion has to be made that in this situation synthetic portfolio was less advantageous if we compare it with active S&P 500 ETF.

Having analysed the performance of a synthetic portfolio against the passive benchmark and the active ETF that follows the benchmark, no straight answer considering the two investment approaches can be made, same synthetic portfolio against the Nasdaq Composite passive and active ETFs is further examined.

Chart 3. Synthetic portfolio outperforms CSNDX.SW ETF.

This chart presents the synthetic portfolio performance against the selected ETF. Upper chart focuses on cumulative return, middle one on daily return, while the last one on drawdown - a peak-to-trough decline during a specific period. Selected period for this chart is 2019-01-01 till 2021-12-31. Daily values, adj. close



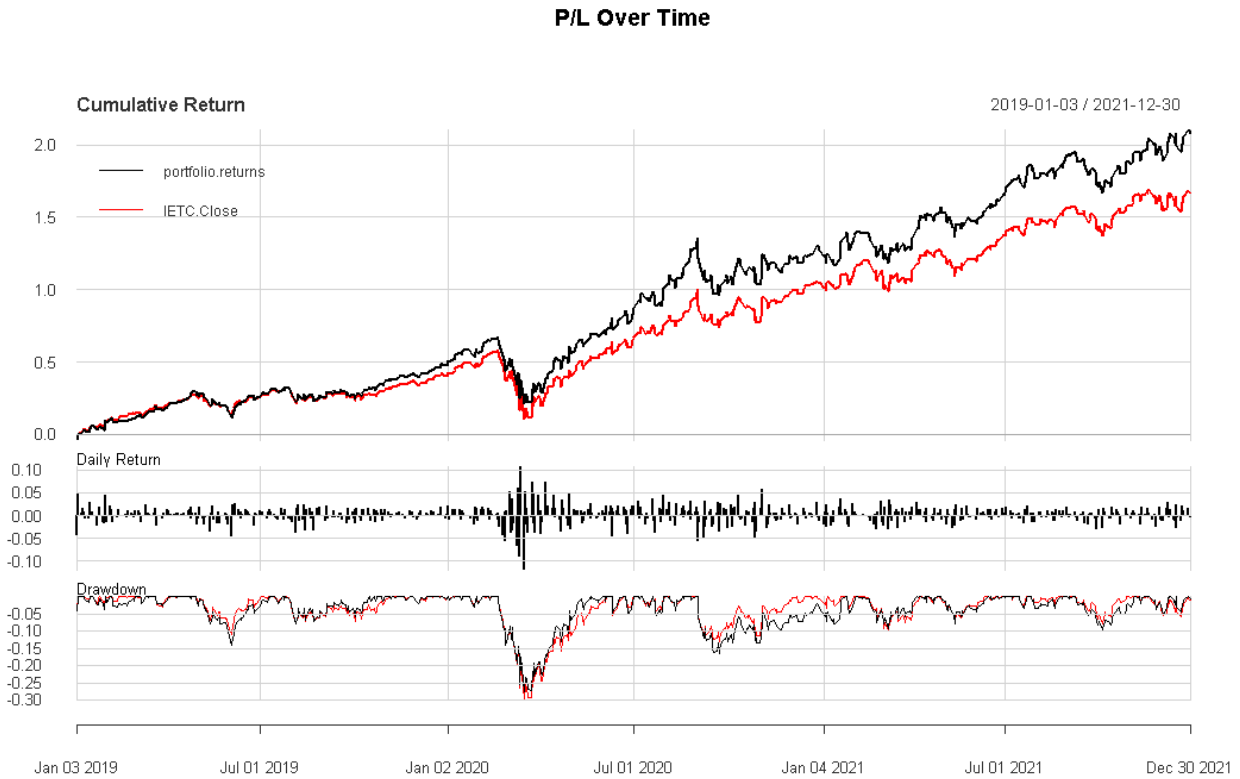
In this part of the thesis, our synthetic portfolio is compared against the benchmark ETF, which follows the Nasdaq Composite index. From visual inspection of the graph, it can be seen that the synthetic portfolio clearly outperformed the index and the benchmark ETF over the analysed period. Starting from the pandemic till the end of the year 2021, it can be further stated that during high uncertainty period, the gap between the cumulative returns among these two portfolios widened. Moreover, the Sharpe ratio for our portfolio was computed and equaled to 1.31, while for CSNDX.SW it equaled to 1.52, yielding relatively reasonable risk-to-return measures. Furthermore, while, VaR for the synthetic portfolio stayed at the same level of -

2.47% for daily expected losses, for the CSNDX.SW it equaled to c. -2.1%. In this case, even though the benchmark ETF had not as impressive performance compared to the synthetic portfolio, it showed higher Sharpe ratio and lower VaR. Even though risk parameters were better for the selected ETF since a lot of the volatility is within the fund is diversified, but as was seen before, the cumulative return over time is clearly on the synthetic portfolio's side.

In the following part of the thesis, the active Nasdaq Composite ETF is analysed relative to the synthetic portfolio as whereas conclusion of an ability to beat the market has been made, the question of whether the technological ETF that is constructed by the professional fund managers and is set to replicate and outperform the benchmark index can be beaten remains unanswered. For this exercise, we iShares Evolved U.S. Technology ETF (IETC) was selected as an active ETF that seeks to outperform the benchmark while also taking firms with technological exposure.

Chart 4. Synthetic portfolio has a slight edge over IETC ETF.

This chart presents the synthetic portfolio performance against the selected ETF. Upper chart focuses on cumulative return, middle one on daily return, while the last one on drawdown - a peak-to-trough decline during a specific period. Selected period for this chart is 2019-01-01 till 2021-12-31. Daily values, adj. close

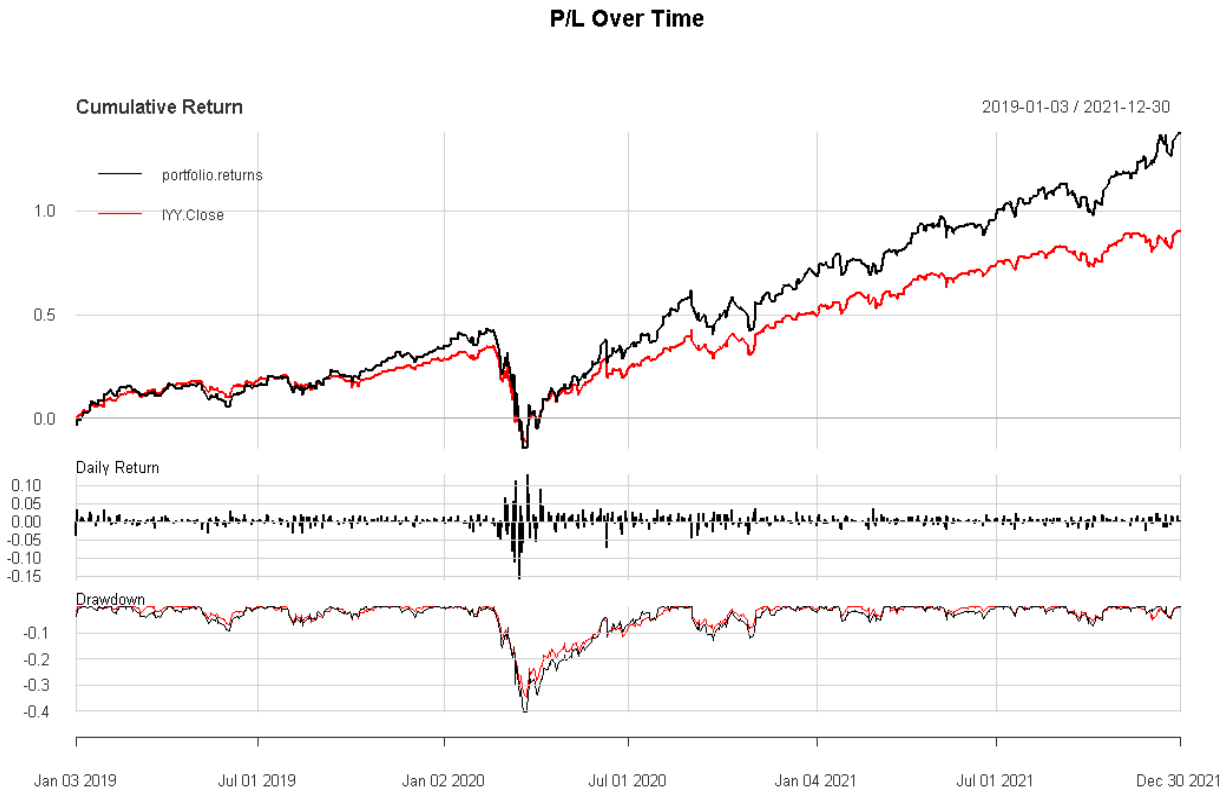


As we analyse the synthetic portfolio and IETC ETF, it can be seen that their performance regarding the cumulative return was quite similar before the pandemic. However, the performance after the pandemic implies a significant spread between the two and shows the out-performance of our synthetic portfolio. Moreover, while Sharpe ratio calculated as before for the synthetic portfolio equaled to 1.31, Sharpe ratio of the IETC portfolio equaled to 1.26. As it can be seen, similar Sharpe ratios were obtained in this case, and therefore, the compensation for the amount of risk that was taken was somewhat equivalent as well. Nevertheless, we can see that our synthetic portfolio had a better return than the benchmark portfolio throughout the period.

Synthetic portfolio had the same VaR of -2.47% on a daily basis, while the benchmark portfolio experienced a VaR of -2.43%. One could argue that such a small difference between the two portfolios on a ratio basis is not substantial. In this case, our synthetic portfolio showed better Sharpe ratio, while VaR absolute values were close and differed only by 0.04%. With this in mind, the two portfolios should be compared as equal entities and therefore, synthetic portfolio was chosen as the main investment option since, historically, it has proven its ability to show better return performance. With these conclusions, we must state that it is possible for a retail investor to outperform the benchmark portfolio if his three main criteria are the Sharpe ratio, historical returns, and VaR. These three measures are the most common risk and reward metrics used among the retail (and professional) investors, so it can be concluded that the synthetic portfolio composed mainly of technological stocks outperformed the benchmark index given this data.

Chart 5. Synthetic portfolio replicates and beats IYY ETF.

This chart presents the synthetic portfolio performance against the selected ETF. Upper chart focuses on cumulative return, middle one on daily return, while the last one on drawdown - a peak-to-trough decline during a specific period. Selected period for this chart is 2019-01-01 till 2021-12-31. Daily values, adj. close

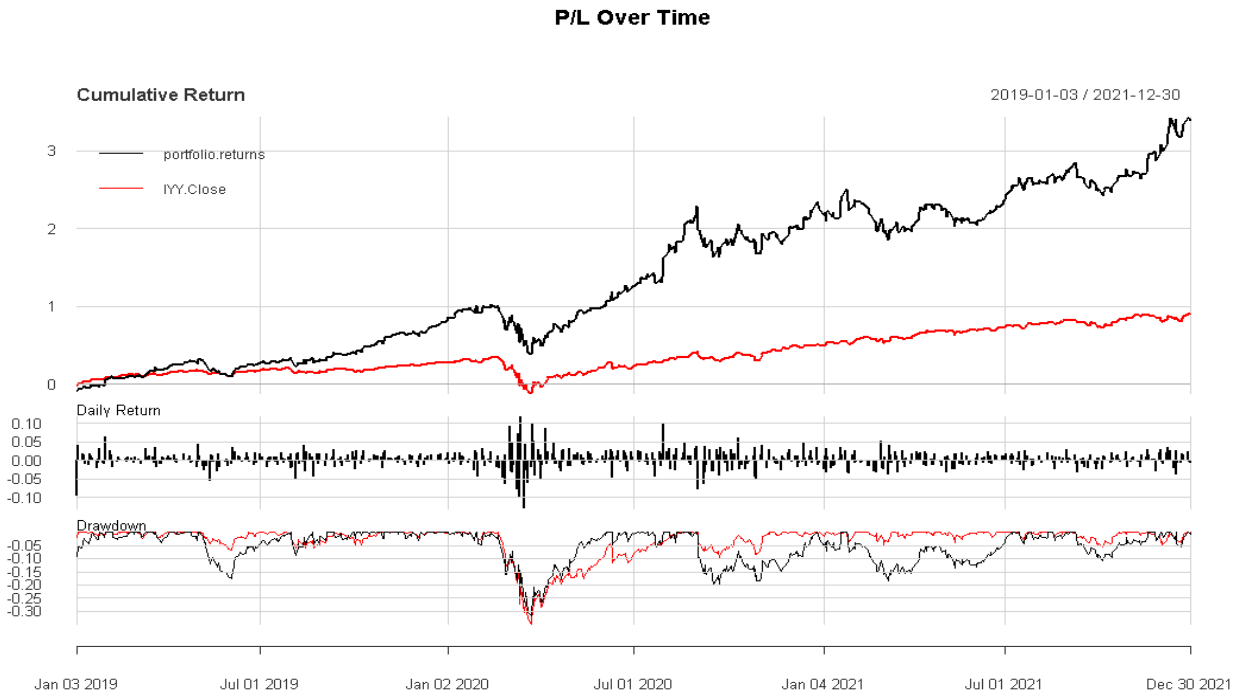


For the last check, the Dow Jones Industrial Average and its comparable benchmark ETF iShares Dow Jones U.S. ETF (later on IYY) were examined. This composition is different from the previous synthetic portfolio because the current synthetic portfolio that will be constructed from DJI will not consist entirely from technology companies since DJI combines firms from different industrial sub-sectors. Therefore, the synthetic portfolio is examined and it was anticipated that this portfolio might not have the best rally as it is not as tech-driven. As can be seen from the graph above, our synthetic portfolio underperformed the benchmark index during the beginning of 2019, but after the Covid-19 pandemic broke and the 2021 recovery came, our synthetic portfolio showed a better performance compared to its peer. It was calculated that our current synthetic portfolio had a Sharpe ratio of 0.81 while the IYY had a ratio of 1.0. In addition, we had that the VaR for our synthetic portfolio was at c. -2.21% of a loss on a day-to-day basis, while for the benchmark portfolio, it was at c. -1.8%. The VaR for the benchmark portfolio was lower than for the synthetic portfolio and the Sharpe ratio, even though the

historical returns seemed to bring an edge for the synthetic portfolio. Nevertheless, it cannot be clearly stated that for the synthetic portfolio composed of the equities that are not strictly technological, hardware, or software equipment, it is possible to have better metrics than the benchmark portfolio, even though the historical performance of cumulative returns is better.

Chart 6. Rebalanced portfolio sharply outperforms IYY ETF.

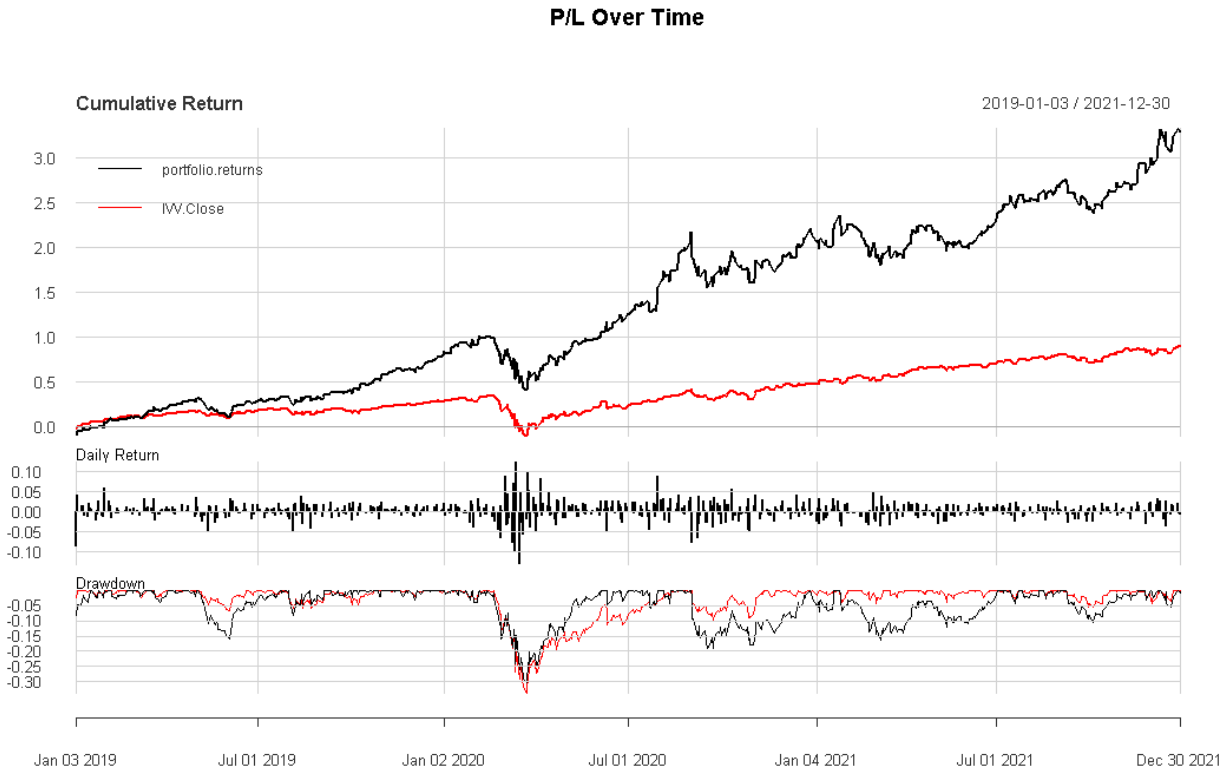
This chart presents the rebalanced portfolio performance against the selected ETF. Upper chart focuses on cumulative return, middle one on daily return, while the last one on drawdown - a peak-to-trough decline during a specific period. Selected period for this chart is 2019-01-01 till 2021-12-31. Daily values, adj. close



As we plot the rebalanced portfolio which consists of 94% of AAPL and 6% of HD stocks, we see that it outperformed its Dow Jones Industrial Average benchmark essentially over whole analysed period. Compared to the synthetic portfolio (based on DJI), it can be seen that rebalanced portfolio outperformed the benchmark significantly. Nevertheless, from the table 1, we see that the VaR of such a portfolio with an extreme allocation equaled to -2.67%, compared to -1.8% of the benchmark, whereas Sharpe ratio stood at 1.5 and 1.01 accordingly. As it stands, such allocation is recommended only for risk-loving individuals as even though it yields better returns, it brings more exposure to possible downside risk.

Chart 7. Rebalanced portfolio outperforms the benchmark IVV.

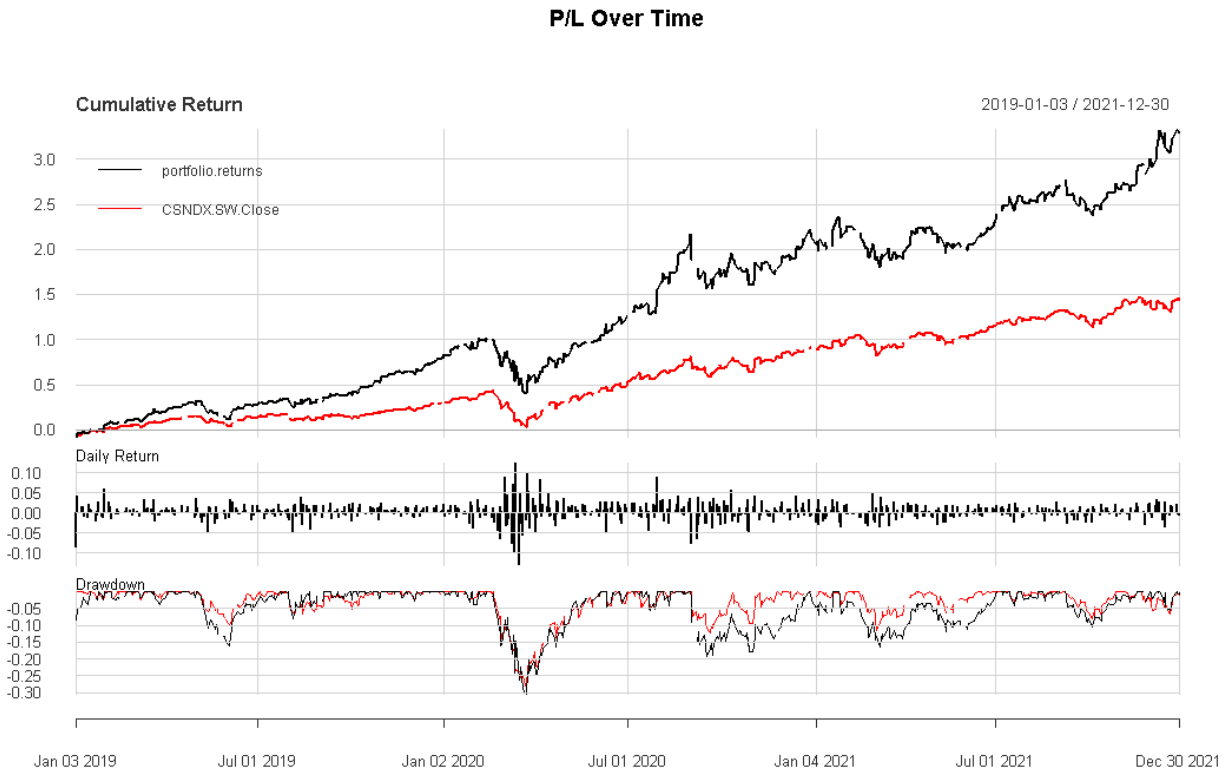
This chart presents the rebalanced portfolio performance against the selected ETF. Upper chart focuses on cumulative return, middle one on daily return, while the last one on drawdown - a peak-to-trough decline during a specific period. Selected period for this chart is 2019-01-01 till 2021-12-31. Daily values, adj. close



For the other synthetic portfolio (S&P 500 and Nasdaq), we obtained the results that the re-balanced allocation was 80% AAPL and 20% MSFT stocks. With this, we still greatly outperformed the benchmark IVV, but we faced an increase in our VaR from 2.47% to 2.85% with Sharpe ratio being 0.2 above that of the synthetic portfolio's. This implies better reward for risk, although the extreme allocation is not suitable for risk-averse and risk-neutral individuals. Again, this might seem attractive to risk loving individuals even though it brings more risk and full exposure to the technology sector without any diversification.

Chart 8. Rebalanced portfolio has an edge over CSNDX.SW ETF for the analyzed period.

This chart presents the rebalanced portfolio performance against the selected ETF. Upper chart focuses on cumulative return, middle one on daily return, while the last one on drawdown - a peak-to-trough decline during a specific period. Selected period for this chart is 2019-01-01 till 2021-12-31. Daily values, adj. close



In this part of the thesis, we compared our re-balanced portfolio against the Nasdaq ETF, and as from prior analysis, we have expected to outperform the benchmark significantly as well. However, we saw that even though our Sharpe ratio was almost the same standing at c. 1.5, our VaR of re-balanced portfolio was bigger at c. -2.8% compared to c. -2.1%. Therefore, even though our re-balanced portfolio had approximately the same Sharpe ratio, but due to the lack of diversification it had a greater expected downside and thus, is not suitable for regular retail investor.

Lastly, we check the performance of our synthetic portfolios against the according benchmarks: S&P500, Dow Jones Industrial Average, Nasdaq Composite as we analyze the according ETFs (to these benchmark indices) in the section above. As one of ETF problems stated in the literature review was that they tend to replicate the benchmark poorly and tend to relatively

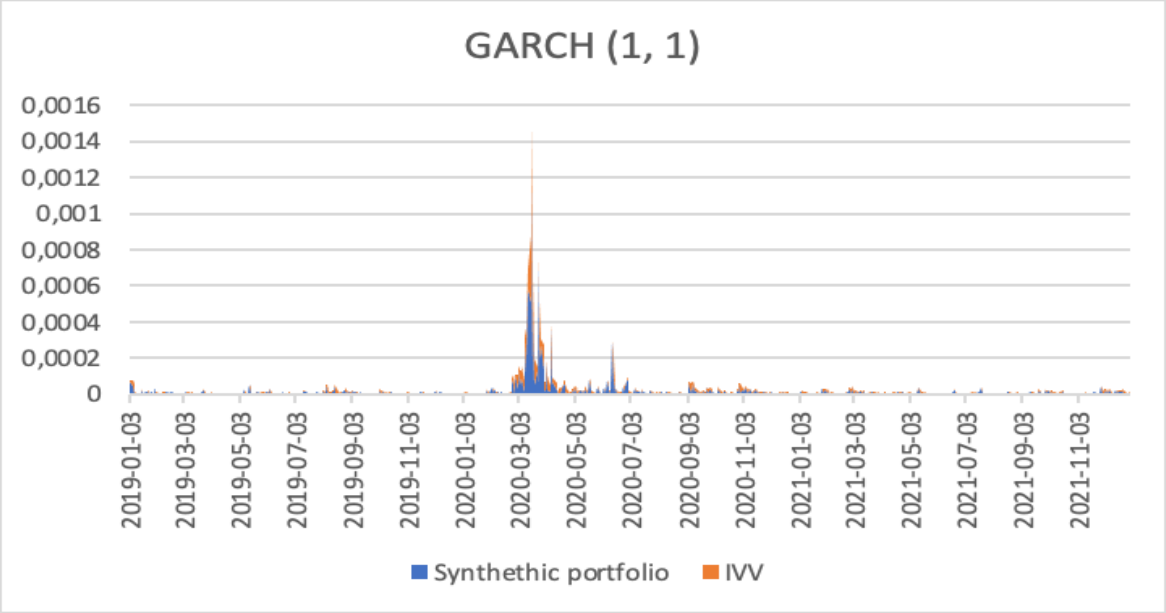
underperform, synthetic portfolios were compared against the benchmark indices as well. In our favour, synthetic portfolios, that were constructed, outperformed the benchmark indices. Thus, it can be stated that with such strategy the problem where replicated ETF underperforms its benchmark can be avoided as in all three cases that were analysed the benchmark was beaten. The visual analysis can be found in Appendix, Charts 14 to 16.

4.2. Risk measurement with GARCH (1, 1)

When comparing the synthetic portfolio built from five major positions of the S&P 500 index and the passively managed IVV ETF (iShares Core S&P 500 ETF), which is constructed based on the same index, one can see from the GARCH (1, 1) model and the chart below that, in general, the synthetic portfolio showed lower volatility throughout the analysed period.

Chart 9. Synthetic portfolio versus IVV (iShares Core S&P 500 ETF).

The chart shows daily variances for the synthetic portfolio and the respective ETF for the period from 2019-01-01 till 2021-12-31. Daily values, adj. close

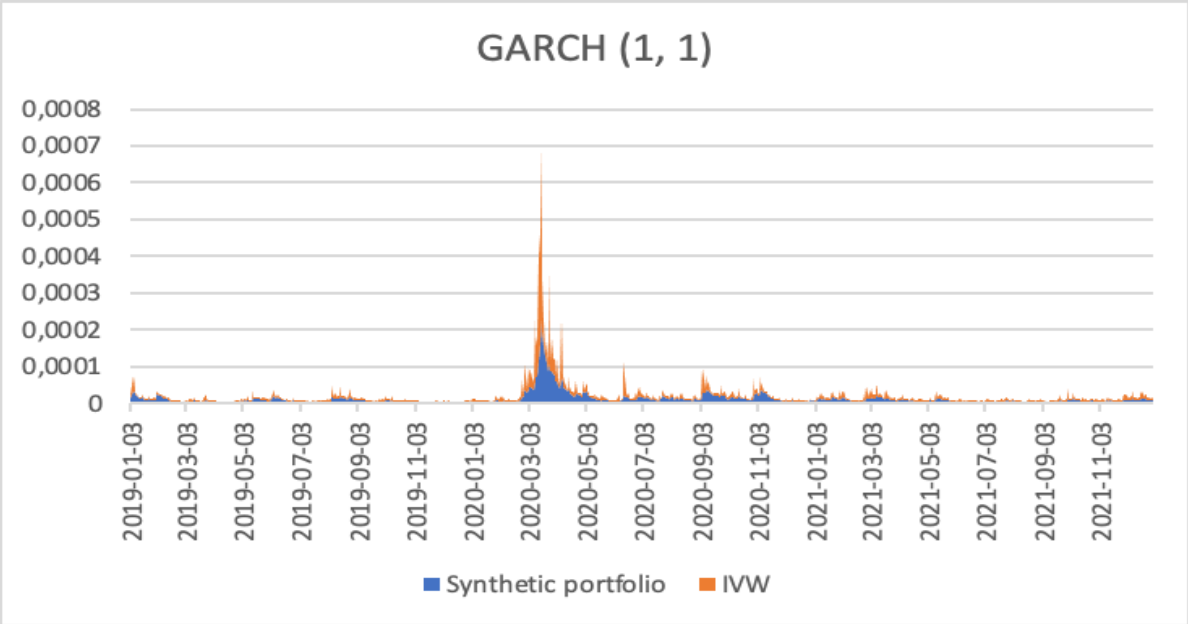


For instance, taking the period of extremely high volatility that occurred around 2020-03-03 when the COVID-19 outbreak happened and the initial lockdown period began, while the synthetic portfolio exceeded the 0,0002 mark in variance, as was already mentioned, the passively managed ETF went above the 0,0005 level and reached its peak few days before the synthetic portfolio did. Furthermore, even though the IVV ETF and the synthetic portfolio

tended to increase in volatility during the same periods, the constructed portfolio did so to a slightly lesser degree. Looking at another period of more prominent spikes in variance, between 2020-05-03 and 2021-01-03, the constructed portfolio exhibited a lower increase in (below 0,00005 for the synthetic portfolio and slightly above 0,001 for the ETF). The remaining period showed no substantial increases in variance.

Chart 10. Synthetic portfolio versus IVW (iShares S&P 500 Growth ETF).

The chart shows daily variances for the synthetic portfolio and the respective ETF for the period from 2019-01-01 till 2021-12-31. Daily values, adj. close

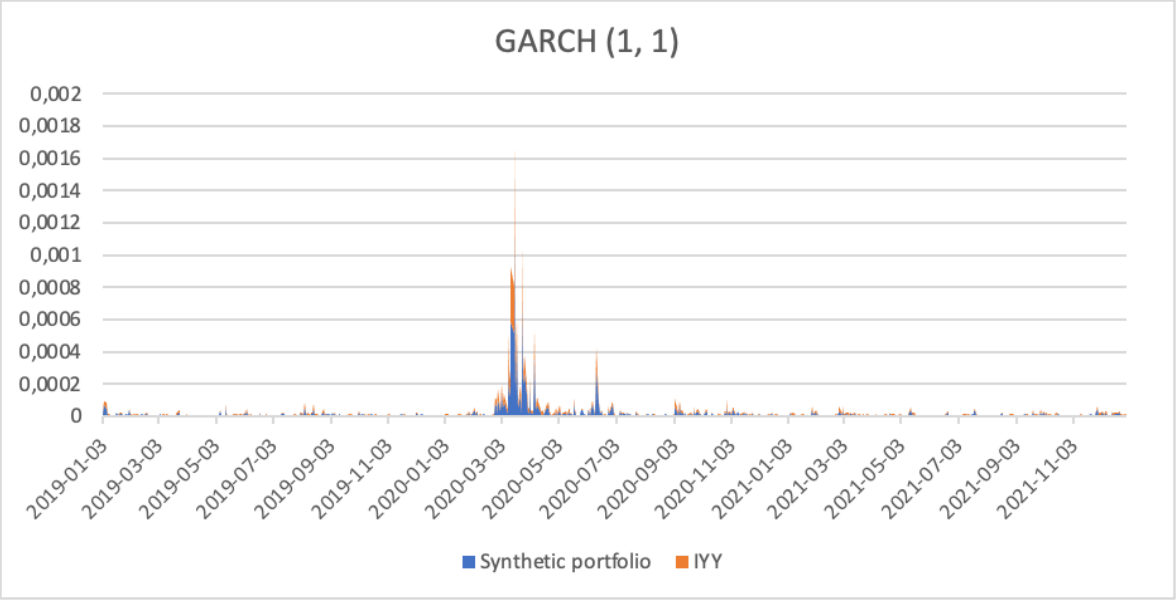


Likewise, looking at the same synthetic portfolio as previously and the actively managed ETF (iShares S&P 500 Growth ETF), the previous conclusion of lower volatility of the former, the constructed portfolio, remains valid. During the initial COVID-19 pandemic outbreak around 2022-03-03, the IVW portfolio peaked at around 0,00045 in variance, slightly below the level of the passively managed ETF; however, substantially higher in comparison to the synthetic portfolio. Throughout the rest of the period, whereas the constructed portfolio's variance, and hence, the risk, remained below the 0,00005 level, the actively managed ETF had another couple of spikes that exceeded the 0,00005 mark in variance, making it overall worse from the risk perspective in comparison to the synthetic portfolio. During the rest of the period spikes in variances stayed negligible.

In a similar manner, the synthetic portfolio, which was based on the Dow Jones Industrial Average index and built from the five major positions as the previous synthetic portfolio, had its peak in volatility, falling short of 0,0012 around 2022-03-03. However, the passively managed IYY ETF, or the iShares Dow Jones US ETF, resembled the volatility of the ETFs, which were based on the S&P 500 index, exceeding the 0,0005 level in variance thus, showing lower risk than the synthetic portfolio's. Likewise, the synthetic portfolio had relatively higher volatility during the following spike in risk that occurred between 2022-05-03 and 2022-07-03 of above the 0,0002 level in variance as opposed to the slightly above the 0,0001 level of the passively managed ETF, making the synthetic portfolio a worse performer from the risk perspective. For the rest of the period the ETF and the synthetic portfolio resembled each others variances and there were no substantial increases in risk for both.

Chart 11. Synthetic portfolio versus IYY (iShares Dow Jones U.S. ETF).

The chart shows daily variances for the synthetic portfolio and the respective ETF for the period from 2019-01-01 till 2021-12-31. Daily values, adj. close

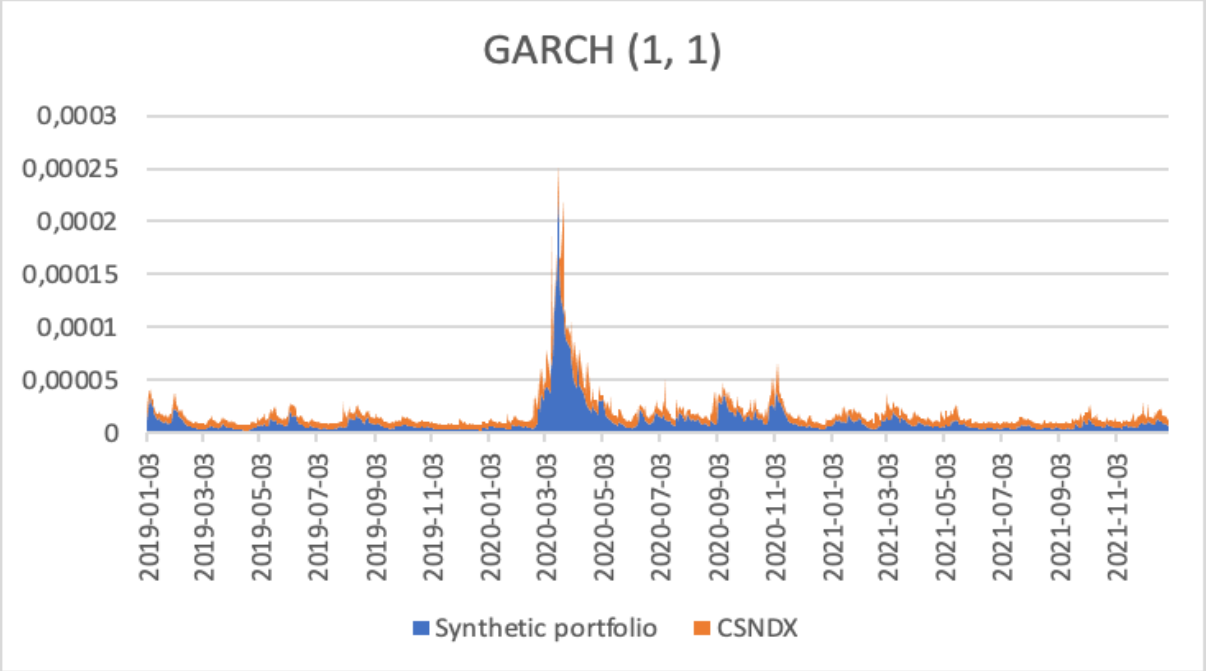


Then, comparing the synthetic portfolio with the passively managed NASDAQ ETF, whereas the constructed portfolio had a peak in variance slightly above the 0,0002 level during the COVID-19 pandemic start in 2020, the ETFs peak in volatility was at around 0,00012. Thus, the synthetic portfolio showed a higher risk than the ETF during the pandemic outbreak. Furthermore, looking at the period after the COVID-19 outbreak, the NASDAQ ETF had three spikes in volatility between 2020-05-04 and 2021-01-04, which approached the 0,00004 mark

in variance, while the synthetic portfolio had two such increases which reached a similar level in variance. Therefore, the synthetic portfolio underperformed slightly in terms of volatility in relation to the passively managed ETF.

Chart 12. Synthetic portfolio versus CSNDX (iShares NASDAQ 100 UCITS ETF).

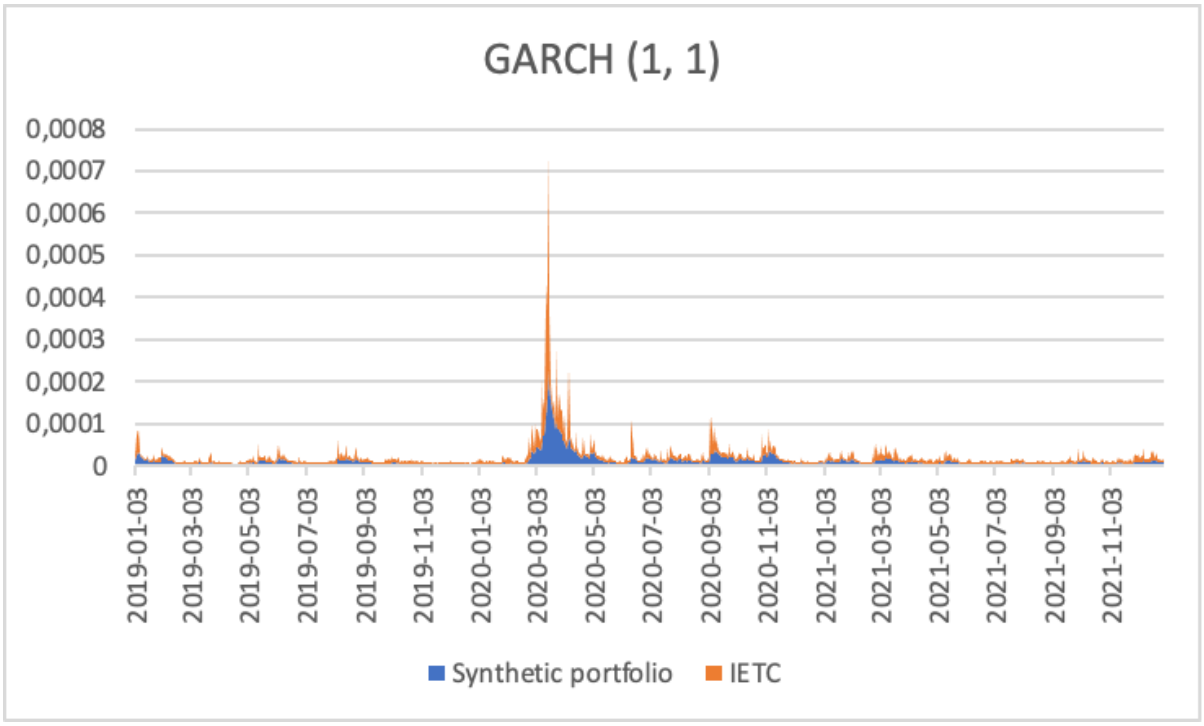
The chart shows daily variances for the synthetic portfolio and the respective ETF for the period from 2019-01-01 till 2021-12-31. Daily values, adj. close



Comparing the synthetic portfolio with the actively managed ETF, as was already mentioned, the synthetic portfolio reached 0,0002 in variance during the period around 2020-03-04. Meanwhile, the actively managed NASDAQ ETF crossed the 0,0005 level in volatility, hence, exceeding the synthetic portfolio's level and risk during extremely turbulent times. During the period after the pandemic till the end of the analysed period, the actively managed ETF had two other larger spikes in variance, all of which fell short of 0,0001, whereas the synthetic portfolio experienced two such increases as well, however, they haven't reached the variance of 0,00005, making the synthetic portfolio a better performer from the volatility and risk sides.

Chart 13. Synthetic portfolio versus IETC (iShares Evolved U.S. Technology ETF).

The chart shows daily variances for the synthetic portfolio and the respective ETF for the period from 2019-01-01 till 2021-12-31. Daily values, adj. close



5. Summary

The research performed earlier gives us unique insights into the benefits and drawbacks of ETFs as an investment vehicle. The overview presented in the literature review stated that ETFs are attractive investments due to their pool of assets that they include, as well as they allow them to invest in commodities directly, which, apart from buying them in a physical substance, is a hard thing to do for a retail investor. In addition to these benefits, we have the most important benefit of a diversified portfolio - reduced variance. For a retail investor, this benefit is extremely important as not only one should not buy all the stocks separately, leaving the vast commission for brokers at the table, but also one can get a portfolio which is well-diversified, is subject to monthly adjustments that come with a cost of a management fee. Convenience is essential as by buying an ETF, an individual holds just one investment position but gets the benefit of having a multiple asset portfolio.

Nevertheless, the discussed drawbacks might push some people away from investing through these financial instruments. The primary concern is that these benchmark index ETFs do not perform as well as their benchmark index gives a benefit of the doubt regarding their efficiency. In addition, not only do most of the ETFs struggle to meet or exceed their benchmark performance, some of them even underperform their benchmark leaving their clients (retail investors) with missed investment opportunities and poor investment performance. On top of these issues, high management costs together with the risk of a product liquidation. One might argue that some of the disadvantages apply to equities and might be correct in stating that diversification outweighs the disadvantages.

Going on, we selected the three major indices that were S&P 500, Nasdaq Composite, and Dow Jones Industrial Average. We then found the iShares by Blackrock ETFs that include all the costs in the returns that they provide, which would make our analysis more comfortable. We have selected the following passive and active ETFs that either try to replicate, or beat the index they are following. We have selected iShares NASDAQ 100 UCITS ETF (CSNDX.SW, passive) for Nasdaq Composite, iShares Evolved U.S. Technology ETF (IETC, active) for active Nasdaq Composite replication, iShares Core S&P 500 ETF (IVV, passive) for S&P 500, iShares S&P 500 Growth ETF (IVW, active) for an active S&P 500 replication, and iShares Dow Jones U.S. ETF (IYY, passive) for the Dow Jones industrial average replication. Following from these ETFs, we have selected five major holdings from each to construct a

synthetic portfolio with equal weights. For Nasdaq and S&P500 synthetic portfolios, five major holdings were the same: Apple Inc. (AAPL), Alphabet Inc. (GOOGL), Microsoft Corporation (MSFT), Amazon.com Inc. (AMZN), Facebook, Inc. (FB). For the Dow Jones Industrial Average, we selected Apple Inc. (AAPL), Boeing Co (BA), UnitedHealth Group Inc. (UNH), Goldman Sachs Group Inc. (GS), and Home Depot Inc. (HD). We started analysing the performance of single and multi-asset portfolios from 2019-01-01 till 2021-12-31 to capture three different periods of stable performance, uncertainty, and uncertainty mixed with growth.

We first examine our synthetic portfolio's performance against the according benchmark and we find that in the time span of three years, we outperform every ETF selected. This result confirms our hypothesis that it is feasible to outperform a benchmark index or benchmark ETF taking its major positions only. The only time the performance was relatively the same was when we compared our synthetic portfolio performance against IVW ETF and got that returns were almost the same, with our portfolio having a slightly higher Sharpe ratio but by a 0.5% bigger daily absolute VaR value. In this case, we cannot confidently state that one or the other portfolio is better since the two main ratios tell different results, and the return component sets a tie between the two. In other cases, we have a clear advantage regarding the returns of our portfolio against the ETF whilst slightly poorer Sharpe ratio and VaR. In this case, we believe that for a risk-averse individual, our strategy of investing in a major ETFs positions (building a synthetic portfolio) is not the best choice. On the other hand, for risk neutral investors, this might be a good idea as our strategy offers a greater return with pretty much the same risk-to-return and estimated excess loss parameters. Lastly, for risk-loving retail investors, the best strategy to outperform the benchmark and maximise their returns is to follow the optimised portfolio approach where the max Sharpe ratio portfolio is constructed. Usually, it includes only a couple of assets (top performers) and excludes any recommended diversification. This strategy is not suited for risk-averse and risk neutral investors as it excludes all the diversification and brings enormous volatility. In addition, we have checked whether our synthetic portfolios outperform the actual indices - S&P 500, Nasdaq Composite, and Dow Jones Industrial Average. We found that in all cases our synthetic portfolios have beaten the benchmark index, therefore underperformance against the benchmark with such investment strategy is avoided.

From the GARCH (1, 1) model, the synthetic portfolio, built based on the S&P 500 index and the respective ETF, showed better performance in terms of lower volatility in comparison to

the passively managed respective ETF, with the same being valid in relation to the actively managed respective ETF. The opposite was true, however, when analysing the synthetic portfolio built in accordance with the Dow Jones Industrial Average index, where the passively managed respective ETF had lower volatility or riskiness levels. Finally, comparing the synthetic portfolio built based on the NASDAQ index with the passively managed NASDAQ ETF, the latter proved to be a better performer from a lower risk viewpoint. However, the opposite was true for the synthetic portfolio and actively managed NASDAQ ETF. The synthetic portfolio proved to have considerably lower volatility levels based on the GARCH (1, 1) model, which captures time-varying variances and clustering patterns. On a general note, the synthetic portfolios and the ETFs experienced elevated volatilities and hence, risk during the COVID-19 outbreak in 2020, followed by a fall and normalization in variances afterwards. The synthetic portfolios closely resembled the patterns of increases in volatility of the respective ETFs or their respective stock indices, which in turn represent the stock markets, exhibiting lower spikes in volatility in most cases.

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Appendices

Chart 14. Synthetic portfolio against benchmark S&P 500.

This chart presents thesynthetic portfolio performance against the selected benchmark S&P 500 (ticker: ^GSPC). Upper chart focuses on cumulative return, middle one on daily return, while the last one on drawdown - a peak-to-trough decline during a specific period. Selected period for this chart is 2019-01-01 till 2021-12-31. Daily values, adj. close

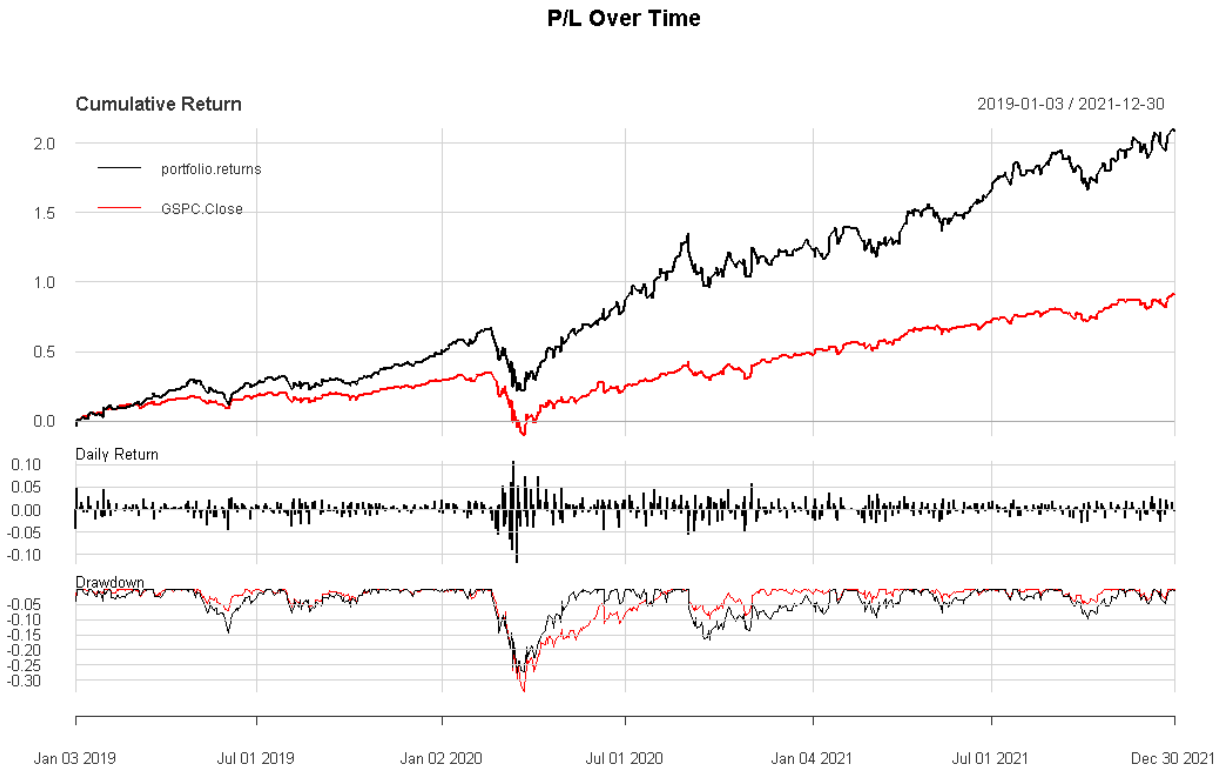

Chart 15. Synthetic portfolio against benchmark Nasdaq Composite.

This chart presents thesynthetic portfolio performance against the selected benchmark Nasdaq Composite (ticker: ^IXIC). Upper chart focuses on cumulative return, middle one on daily return, while the last one on drawdown - a peak-to-trough decline during a specific period. Selected period for this chart is 2019-01-01 till 2021-12-31. Daily values, adj. close

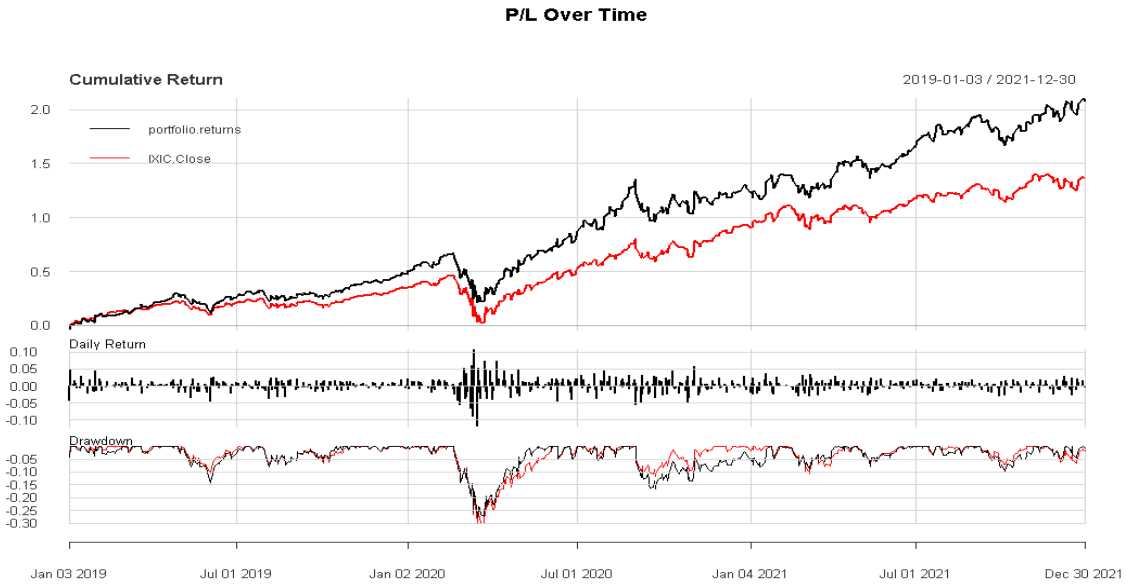

Chart 16. Synthetic portfolio against benchmark Dow Jones Industrial Average.

This chart presents thesynthetic portfolio performance against the selected benchmark Dow Jones Industrial Average (ticker: ^DJI). Upper chart focuses on cumulative return, middle one on daily return, while the last one on drawdown - a peak-to-trough decline during a specific period. Selected period for this chart is 2019-01-01 till 2021-12-31. Daily values, adj. close