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Diversifying Investment Portfolios with Collectible Sneakers: Expected Returns and Benefits of Diversification

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Diversifying Investment Portfolios with Collectible Sneakers: Expected Returns and Benefits of Diversification

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Abstract

This thesis seeks to identify if collectible sneakers can provide diversification benefits to an investor's portfolio. Using data from a global collectible sneaker marketplace, StockX, I constructed an index to compare it with other traditional assets, including the S&P 500 index and 5-year US Treasury Bills. By calculating key metrics including expected returns, volatility, and correlation, I analyzed the risk-return characteristics of the collectible sneaker asset class compared to other traditional asset classes. From the data analysis I performed, I found that collectible sneakers did not outperform returns significantly compared to traditional asset classes, but had low correlations, which provides investors with diversification benefits. I also found that an investor's knowledge on sneakers and sneaker trends were also a significant determining factor in improving the expected returns from investing in collectible sneakers.

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1. Introduction

The ever-increasing influence of globalization has created new wealth for many individuals. With the newly accumulated wealth, investors will rationally try to find the most beneficial mix of assets in which to allocate their savings. The increasing amount of wealth that high net worth individuals (HNWI) have has contributed to the rise of many new alternative asset classes. As individuals try to find new areas to allocate their savings, they have found that opportunities within the traditional asset classes such as the stock market have decreased as the number of investors entering the market trying to profit from smaller margins and higher risk has grown. It has been tougher for investors to consistently achieve high returns when investing in conventional asset classes compared to previously. According to PWC's recent report on alternative assets, this has led to a recent trend in the growth of alternative asset classes with investors looking for different ways to increase the benefits of diversification by seeking out alternative assets in which to invest. However, the evidence on diversification benefits of a few of the relatively more unfamiliar asset classes is missing. An example of one of the more unusual collectible markets is sneakers. There is little evidence about whether investing in this type of collectible will add diversification benefits to an investor's portfolio.

Collectible and sought-after sneakers have been the latest commodity to grow from a niche market into the mainstream. Investment bank Cowen Inc. has noted that relatively low barriers to entry coupled with returns that tend to match or even surpass traditional asset classes has been a major driving force behind the increasing number of millennials and working age adults investing in both the stock market whilst purchasing sneakers to hold and eventually liquidate a few years down the line.

This paper seeks to analyze potential diversification benefits that alternative assets, such as collectible sneakers, can generate for an investor's existing portfolio. We try to

closely examine the following three points to determine the risk-return trade-off in investing in sneakers:

1. What diversification benefits can sneakers bring to a portfolio? How does volatility and correlation of a sneaker index compare to a stock index?
2. What are the expected risk-adjusted returns on a sneaker investment? Are there any potential implications that we can derive from the Sharpe ratio?
3. How can we best allocate sneakers to fit in our portfolio and mitigate risk?

From the data and empirical models I analyzed, I found that collectible sneakers do not promise as high a return as I initially assumed. However, it does provide a high degree of diversification benefit as its correlation is relatively low when I compared it with the S&P 500 index and 5-year US Treasury T-bills. Upon closer review, I found that similar to other asset classes, having the ability to understand the fundamentals of an asset is key in identifying profitable investment opportunities. By comparing the data on pre-release and post-release sneaker returns, I found that market knowledge in sneakers will improve expected returns as seen with the sneaker indexes and investment portfolios I constructed.

2. Literature Review

Non-traditional asset classes, including collectibles, have generally outperformed traditional asset classes such as governments bonds and gold, according to Dimson et al. (2013). The average returns that these alternative assets have generated have been higher compared to traditional assets and this has led investors, especially high-net-worth individuals (HNWI), to seek out new avenues to allocate their wealth. In Knight Frank's 2014 Wealth Report, they highlight an evolving investor trend with HNWIs in China beginning to allocate their wealth to luxury items that align with their personal interests, such as wine and art. Investment bank Cowen Inc. has found that this relatively new trend has led to the emergence of several new alternative asset classes, with sneakers being the latest asset class that many investors have started to take notice of. A publication written by Enterprise noted how the asset class' low-risk nature along with relatively higher returns compared to traditional asset classes appealed to many investors.

Dimson et al. (2013) closely examine the financial returns from investments in collectible assets. They analyzed investments in four different alternative asset classes, including art, stamps, violins and other collectibles such as wine and diamonds and compared each to traditional assets including equities, governments bonds and bills. They took the asset data from existing research papers and marketplaces for each of the respective assets to find the geometric and arithmetic mean returns per annum. They also found the standard deviation and the lowest and highest recorded return from 1900-2012. The data was displayed in a table and the authors created a section for nominal return and another section for real returns, which were adjusted for inflation. The authors found that the correlation among the alternative asset classes were high and the correlation between alternative and traditional asset classes were low.

The authors also showed how correlations with equity returns indicated that there was a relationship between wealth generated in the traditional equity market and with alternative collectible prices. The finding of a low correlation between the alternative and traditional asset classes is consistent with the understanding that investors may have when investing in alternative asset classes to diversify their portfolios. The paper also focuses closely on transaction costs which are a major factor when purchasing and selling alternative asset classes. Although they recognize that transaction costs can lower the attractiveness of holding alternative assets, they find that investors enjoy having collectibles in their possession, which mitigates the effect of these transaction costs and hence make alternative assets attractive in comparison to traditional assets.

Dobrynskaya et al. (2018) examine another alternative asset, specifically LEGO sets. Cowen Inc. note that as opportunities in traditional asset classes have become increasingly competitive and returns from investments have decreased, investors are seeking new opportunities to diversify their investment portfolios. In this paper, the authors take data from several LEGO trading platforms to create a sample of 2,322 different LEGO sets. They constructed a LEGO price index from 1987-2015 using hedonic regression coefficients to account for the internal and external characteristics that may affect the value of each LEGO set. Interestingly, they find that LEGO sets are slightly negatively correlated with bonds and slightly positively correlated with stocks.

From their analysis, they also calculated a Sharpe ratio[1] of 0.4 and a positive skew which indicates that LEGO sets are a viable alternative asset class given their performance returns-wise. The authors also find that LEGO sets are not strongly affected by potential issues that may affect the investment performance of LEGO sets such as an underwhelming

[1] The Sharpe ratio is a metric that investors use to measure an asset's investment performance. It takes risk and return into account to find out if the asset is worth investing in based on the investor's preferred risk and return.

market and high volatility. This finding is in line with their initial belief that collectibles are an attractive alternative asset class with a strong possibility of a relatively large upside when compared to returns from the S&P 500 index.

Art has been an alternative asset class that has been more widely studied compared to other alternative asset classes such as sneakers and LEGO sets. In the paper by Mamarbachi et al. (2020), the authors discuss how art can add value and be a beneficial asset to add to an individual's portfolio if they are looking to diversify their assets. They attribute this to a potential for substantial price appreciation. In this paper, the authors analyze returns on art compared to the following composite indexes: NYSE, S&P 500, FTSE 100, hedge funds, bonds and real estate. They find that art provides investors with relatively higher returns compared to the composite indexes of the other asset classes.

However, the authors of the paper also acknowledge several issues that may hinder the performance of art investments including the general illiquidity of high-value artwork and high transaction costs. High-value art pieces often sell at auctions which take place on a predetermined date usually organized by the auction house. In relative terms, art does not have the same trading volume as other collectibles such as sneakers or LEGO sets because of there often is only one piece of any specific artwork. This factor, along with high transaction costs, may make art seem slightly less attractive as an investment compared to other traditional and alternative asset classes. However, Mamarbachi et al. (2020) found that returns on art investments generally outperform traditional asset classes significantly, making it a potentially favorable option for investors looking to diversify their portfolios beyond the traditional asset classes.

Ma et al. (2020) explores hedonic pricing within the sneaker resale market. Although they do not primarily focus on the investment performance of sneakers, the paper's extensive research on the hedonic pricing of sneakers, and the external and internal factors that

influence the value of each sneaker, provide valuable insight to this paper. The paper provides evidence on factors that affect the best time to enter and exit a particular sneaker. The authors use Twitter as a means of forecasting the “hype” around a product and hence predicting the eventual post-release values. The authors scraped data from StockX, which is a global marketplace that allows users to buy and sell sneakers and various other collectibles on the platform. The factors that Ma et al. have highlighted are specific to the sneaker market and gives us a strong benchmark in understanding how sneakers may perform relative to traditional asset classes.

3. The Market for Sneakers

I. Overview

The sneaker market has evolved significantly since the time footwear was manufactured on an industrial scale. Sneakers in the past were viewed by many as a necessity; they were an essential article of clothing for daily activities. However, as sports and culture developed, sneakers became more than just clothing; it gradually became a symbol of an individual's personality. Sneakers evolved from being a part of everyday clothing into a collectible, coveted product. With a global growth in pop culture through sport and music, sneakers began to be viewed differently. Brands pushed to associate themselves with the most relevant, successful celebrities and frequently collaborated with sport stars and musicians to create footwear products that people desired.

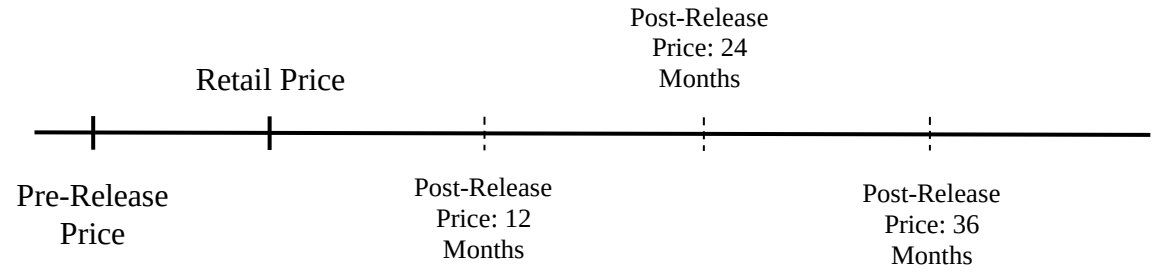
In the article by Battle, the sneaker market grew exponentially larger at a rapid pace since the mid 2000-s. There was a marked shift in the sneaker market with sneaker investors starting to enter the market. These investors were usually sneaker enthusiasts themselves and they would purchase several sneakers at retail prices to sell at resale prices. At the time, profit margins were not as large and investments were usually on a small scale. As technology developed, sneaker marketplaces started to become the norm in early 2015. With a standardized marketplace, it propelled the sneaker market incredibly quickly. Buyers could purchase an authentic pair of sneakers and sellers could sell their sneakers on these global sneaker marketplaces.

Currently, the two largest US-based companies, StockX and GOAT, have authentication facilities across the world and both companies have made global sneaker transactions seamless. Users can now list, purchase and sell their sneakers in minutes and receive their payouts within several days. The rise of sneaker marketplaces advanced the industry as a whole because it brought in many new entrants that may not have been sneaker

enthusiasts previously. Non-sneaker enthusiasts entered the market with an investor's mindset and this meant that the industry was becoming larger even though the number of sneaker collectors and average consumers was growing at a relatively slower rate. The advancement of sneaker marketplaces is unofficially recognized to be the main driving factor behind the growth of the sneaker industry and the entire asset class as noted by Canaan Partners.

II. Sneaker Collectors, Consumers and Investors

Within a sneaker market, there are three different groups of individuals: sneaker collectors, average consumers and sneaker investors. Throughout this paper, I will also refer to three different prices: pre-release price, retail price and post-release price. Each of these three prices belongs to a specific category within the sneaker timeline and relates to the different groups of individuals in the sneaker market.



Sneaker collectors are classified as individuals that will purchase sneakers for display or for their own use. Sneaker collectors are mostly insensitive to prices and will purchase sneakers at resale prices without much consideration as they are often fixated on adding the pair into their collection. These collectors will tend to purchase the sneakers at pre-release and retail prices.

Average consumers are defined as individuals that purchase sneakers for daily use and tend to only purchase sneakers at retail prices; if they do pay resale prices, it will be relatively close to the retail prices. If they miss out on a release and the resale prices are high,

they will typically not purchase the sneakers at the resale price. Average consumers also tend not to sell their shoes on because they prefer to wear their shoes regardless of the resale value.

Lastly, sneaker investors are individuals that are the most sensitive to prices as they look to make a profit on their sneaker purchases. This group of individuals within the sneaker market try to purchase sneakers at both retail and resale prices to gain a profit. Whilst the margins are much higher when a sneaker investor purchases a sneaker at the retail price, it takes considerably more effort and is much more difficult to attain. For example, a pair of Air Force 1's manufactured by Nike in 2019, which were nicknamed the 'Travis Scott Sail', retailed at $150. Sneaker investors that managed to get it at the retail price of $150 were selling it at an average price of $300 post-release. They were able to pocket the $150 and move onto the next release. Whilst some sneaker investors managed to secure pairs for $150, others speculated on the growth of the silhouette and purchased pairs at the post-release price of $300 and held onto them. This act of purchasing a sneaker at resale prices to hold is similar to buying into a stock or an index in this case. These sneaker investors believe that the asset is worth holding onto despite the risks and the opportunity cost of money.

III. Risks from Sneaker Investing

i. Physical Damage

One of the inherent risks of investing in sneakers is preserving the sneaker in its original condition. When an investor holds onto a sneaker, it can be exposed to external conditions including humidity and sunlight which can damage the materials on the sneaker. Other issues including oxidation will make the soles turn yellow and decrease the aesthetic aspect of the sneaker, which will decrease the value of the sneaker. Storing sneakers for a long period of time can also lead to other age-related defects such as crumbling and

disintegration of the upper and midsole. The risks that sneaker investors undertake are large; small defects and damages from holding the sneaker from too long can erode the gains from holding the sneaker in an unworn condition. To minimize the likelihood of these problems occurring, a survey I conducted found that sneaker investors have invested in shrink wrapping machines to wrap each sneaker and warehouses to hold their inventory, but these solutions add an additional cost to holding the sneaker.

ii. Liquidity

Liquidity is an important aspect for any asset class, but it has a much larger emphasis when it comes to alternative asset classes such as collectibles due to the scarce nature of these items. In general, the liquidity of a sneaker will depend on the design of the sneaker itself. An aesthetically-pleasing, sought-after sneaker will undoubtedly be easier to sell. If consumer preferences change, demand will also shift and hence the liquidity of a particular sneaker will also be affected. Additionally, prices are also a determining factor in the liquidity of sneakers. Sneakers with higher trading volumes tend to have a narrowed bid-ask spread whereas sneakers that are rarer with lower trading volumes have larger bid-ask spreads which can affect the liquidity of the sneaker. This is because having a larger bid-ask spread means that the market price in the eyes of the buyer and seller are different and hence it may be harder to liquidate the sneaker due to each party having differing opinions on the value of the sneaker.

iii. Economic Outlook

The health and outlook of the global economy plays a significant role in the sneaker market. In times of economic downturns, consumers have less disposable income and hence they will allocate their money differently. A shift away from the purchase of sneakers will cause a ripple effect throughout the sneaker market. As average consumers purchase less

often and prefer lower-priced over higher-priced sneakers, sneaker investors have to hold their sneakers out for a longer period of time until the economy improves which decreases their overall returns. This is because they will now be holding large amounts of inventory with effectively no returns until the economy improves and they can liquidate their inventory at market prices. This presents a large opportunity cost for sneaker investors and timing the entry and exit points will be imperative.

iv. Opportunity Cost of Time

Sneaker transactions seem simple and effortless on paper; buyers purchase sneakers from sellers and sellers sell their sneakers to buyers. However, the entire process involves many more steps. From the seller's perspective, they will need to list it on several different platforms and marketplaces, take photos and constantly reply to any questions or queries that a consumer may ask. Shipping and meet-ups are currently the two most commonly forms to transact. On platforms that are non-binding, such as Facebook or Instagram, buyers may not actually end up purchasing the good and may simply not show up for a scheduled meet-up. Unfortunately, sellers are unable to avoid this from occurring and hence they will lose out on the time they took trying to arrange the transaction. On the other hand, from a buyer's perspective, the seller may choose to not honor a sale if they received a higher offer from another buyer. Even if a transaction is mutually agreed on, a seller may back out of the transaction without giving any reason. Therefore, the buyer will lose out on the time spent negotiating with the seller.

v. Transaction Costs

One significant aspect of sneaker investing is the cost of transacting a sale. There are many different methods of selling sneakers; when selling, individuals tend to sell the

products through social media or marketplaces. When selling on social media, it is considered to be unregulated as sellers can list anything and any mutually agreed transactions are technically non-binding. Sneaker authenticity is closely related to this as it presents a major issue for both buyers and sellers. Selling on social media platforms such as Facebook Marketplace does not guarantee that the buyer receives an authentic product. Therefore, buyers may tend to want photos and proof of purchase. A confirmation of a deal through a Facebook message also does not confirm that the transaction will go through. If a seller arranges a meet-up to sell a pair of sneakers and the buyer does not show up although the buyer confirmed that they will be purchasing the sneaker, there is nothing the seller can do. This relates back to the above section where I discussed the opportunity cost of time when trying to buy and sell sneakers. Hence, due to this problem within unregulated marketplaces, there tends to be a slight discount in prices to compensate for the risks and opportunity costs involved for both buyers and sellers.

On the other hand, regulated marketplaces including GOAT and StockX are comparatively more efficient and the process is much more seamless. When selling on a regulated marketplace, a seller lists their product on the marketplace and they will only need to ship it to the authenticators at the marketplace once the buyer has paid for the sneaker in full. Sellers save time by not needing to take photos of the sneakers and provide proof of authenticity. This also means that the buyer can no longer back out of the transaction as their payment method will be charged as soon as the transaction is confirmed. However, this convenience comes at a cost and these marketplaces charge sellers approximately 10% to cover their authentication and payment processing costs according to an article published by Business Insider in 2019.

IV. Sneaker Market Phenomena

The sneaker market has distinct characteristics which sets it apart from alternative asset classes. In this section, I will discuss the two main causes of sneaker price fluctuations which are unique to this market.

i. Pre-Release

Before a sneaker is released, sneaker-related news outlets often release mockups and leaked photos of an actual sneaker. This creates excitement and hype amongst sneaker fans. Occasionally, these sneakers make it to the market before the slated release date and there are individuals that purchase them early at a much higher price just to have them before the release date. The higher prices are due to the difficult nature of acquiring an authentic pair before the sneaker's release date. Sneaker retailers and boutiques are technically not allowed to sell these sneakers before the release date, so any pairs that are released early are a breach of contract with the sneaker manufacturer itself, which naturally is a high-risk decision for the retailers and boutiques. This risk is reflected through the high pre-release prices. Pre-release prices tend to be several times higher than regular post-release resale prices, which often are higher than the retail prices.

ii. Restocks

A restock is a phenomenon that is specific to the sneaker market and does not normally occur within other alternative asset classes. Alternative asset classes including wines and art cannot be replicated or reproduced. For example, wine-makers can't regrow grapes from their 2002 harvest to make wine in 2021. This example shows how the nature of the comparatively more traditional alternative assets differs significantly from sneakers. Although restocks tend to be rare due to brands wanting to create hype and preserve

exclusivity, sneakers do occasionally have restocks. This can be due to certain factors, including brands trying to boost their quarterly revenues or to simply make the product more accessible for their fans.

Regardless of the motivation behind a restock, restocks can affect the demand and appeal of a sneaker. A large restock of a pair of sneakers with a resale price just above the retail price could potentially decrease the appeal of a sneaker just because consumers that purchase these products tend to want exclusivity and the fact that the product is now more accessible can decrease the overall demand of the product. A smaller restock can also decrease the overall appeal of a sneaker, however, resale prices tend to maintain constant. The reason why sneaker investors classify restocks as small or large is because brands do not officially announce the exact number of pairs being restocked. Therefore, it is difficult to gauge how a restock has impacted resale prices, demand, and supply and this is why sneaker investors tend to either classify a restock being small or large. Brands need to be strategic when striking the right balance between supply and demand for these exclusive sneakers otherwise they risk losing out on the public perception of their product being exclusive.

The sneaker market is similar to the stock market in the sense that there is always news about sneakers and the stock market in the media. The sneaker market is often flooded with information on new products, rumored releases and potential restocks. With a large amount of news to process and filter through for legitimacy and validity, forecasting restocks is not an easy task; it requires experience and extensive knowledge of the sneaker market. However, it is not entirely impossible. An investor in the sneaker market can observe market trends with experience. Although an experienced investor may not be able to accurately predict it correctly all the time, there is a high likelihood that they will predict it correctly most of the time. Recently, Adidas has been identified by sneaker investors as a brand which is highly likely to restock pairs. Therefore, investors have been increasingly cautious about

holding pairs from the brand. Similar to insider trading, there are also sneaker investors that have connections to employees within a company and as a result, they gain an unfair advantage over others and can forecast a sneaker restock with confidence months in advance.

4. Data

In this paper, I gathered data from both traditional and alternative asset classes to analyze how sneakers as an asset class fare compared to the S&P 500 index with dividends in terms of returns. I scraped all the sneaker data from the global sneaker marketplace called StockX. It is currently the most transparent and expansive marketplace which tracks sneaker transactions. I used a custom Python scraper tool which gathered data from 30 different random sneaker designs from the website's 'Featured' page, which is a showcase of random sneakers in no particular order or brand. The 30 random sneakers I used to construct the sneaker index can be found in Appendix A. This method was chosen to ensure that the composite sneaker index I constructed consisted of the widest breadth of sneakers to get a reliable representation of various sneakers.

From there, I converted the scraped data into a Microsoft Excel file with the following categories: name of product, date, price sold at and whether there has been a restock. For each sneaker on the marketplace, there were 100 different data points. The time period between each data point depends on the release date of the sneaker. An older sneaker has longer time periods between each data point whilst a newer sneaker has shorter time periods.

When constructing the 'Sneakers: Pre-Release' index, I excluded all the data points before the official release date. For example, if a sneaker released on the 6th of February 2019, I excluded all the data points before the release date so that the index was adjusted for pre-release prices. On the other hand, when constructing the 'Sneakers: Restocks' index, I removed the data points following the restock. If a sneaker restocked on the 10th of March 2020, I excluded all the data points occurring after the restock date. By excluding the data points after the restock, I was able to create the index adjusted for restock data.

Then, I collated all the data from the Microsoft Excel file to create the three different sneaker indexes which I compared with the S&P 500 index. As each sneaker had a different

release date, I grouped all the sneakers with data from a specific month and year, added all the expected returns and divided it by the number of sneakers with data within the specific time period to come up with an aggregated return for each month of each year for which I had data.

I used the scraped data to find the returns on each individual sneaker each month since its release to see if there were any underlying trends that may have impacted the results when compared to traditional asset classes. I did this to ensure that the sneaker dataset was random and not biased. For the S&P 500 index including dividends, I retrieved the data on the index by using YCharts' database. The database had data on the opening and closing price of each trading day along with the monthly returns of the S&P 500 index including dividends. Then, I entered all the data into Microsoft Excel and calculated each compounded monthly return by taking the data points from the closing value of the S&P 500 index from the first and last trading day of each month. One of the reasons why I selected the first and last trading days of each month is because the trading dates across the sneaker and stock market were difficult to match. Sneakers trade continuously throughout the year whereas the stock market has specific non-trading days due to public holidays and weekends. Taking data from the opening and closing trading dates of each month allowed me to match the data points in a consistent manner which reduced potential fluctuations compared to if I were to interpolate the data points to account for the S&P 500's non-trading days.

When using the Markowitz model to identify the optimal portfolio allocation for the different traditional and alternative asset classes, I used the 5-year US Treasury Bill rates to calculate the average risk-free rate of return to use for my model. I chose the 5-year rates as it was the time period which was the closest match to my dataset for the various asset classes. I aggregated the 5-year rates for each month beginning from the start to the end of my dataset and took the average 5-year rate to use in the Markowitz model. The expected returns,

standard deviation, correlation, and Sharpe ratio for the model were calculated using the existing dataset that I collected to construct the composite sneaker index.

5. Empirical Models and Results

I. Compounded Monthly Returns

To calculate the index returns for both the sneaker and S&P 500 index, I used the following model to find the compounded monthly returns:

$$(\frac{\boldsymbol{P_1}}{\boldsymbol{P_0}})^{\frac{\boldsymbol{1}}{\boldsymbol{n}}} - \boldsymbol{1} = \boldsymbol{rt}$$

t: number of months between two observed data points P_0 and P_1

P_0: value of the sneaker/S&P 500 index at time x

P_1: value of the sneaker/S&P 500 index at time y

n: number of months between P_0 and P_1

where rt is the compounded monthly return.

I used the above formula to calculate all the compounded monthly returns in a Microsoft Excel file. As previously stated in the data section, I used the opening and closing trading dates of each month for each of the indexes to ensure that the timing for the data points were matched, eliminating the need to interpolate the data thus reducing the standard deviation.

II. Sharpe Ratio

I also used the Sharpe ratio formula below to analyze how sneakers and the S&P 500 index compared when we take risk and returns into consideration.

$$\boldsymbol{S_a} = \frac{\boldsymbol{E(R_a - R_b)}}{\boldsymbol{\sigma_a}}$$

S_a: Sharpe ratio for asset a over time period b

E: expected returns

R_a: asset returns a returns

R_b: risk-free rate of return over time period b

σ_a: standard deviation of the asset a returns.

Table 1
Sharpe Ratios

Index Number:	Name of Index:	Sharpe Ratio (S_a):
1	S&P 500	0.2981
2	Sneakers	-0.4984
3	Sneakers: Pre-Release	0.6893
4	Sneakers: Restocks	0.7568

The Sharpe ratio calculations in table 1 except for the sneaker index which has not been adjusted for pre-release and restock data show that the three out of the four indexes are worth investing in. The sample period in table 1 was between February 2017 and March 2021. The S&P 500's Sharpe ratio of 0.2981 is higher than the sneaker index's Sharpe ratio, which is a negative value. The negative value indicates that the investment is not sound and the investor should not enter into the investment at it is loss-making. However, the sneaker indexes which were adjusted for pre-release and restock data showed that sneakers are a better investment compared to the S&P 500.

The Sharpe ratios for the pre-release and restock-adjusted sneaker indexes are almost two times higher than the S&P 500. However, it must be noted that investors must have a strong understanding in sneakers to avoid purchasing sneakers at pre-release prices and must be able to foresee restocks; otherwise, they may be exposed to risk-adjusted returns which are negative as exhibited from index 1. The Sharpe ratios for sneakers adjusted for pre-release and restock data are almost two times higher than the S&P 500, which highlights the

attractiveness of sneakers as an asset to investors that currently have allocated their wealth in sneakers.

III. Markowitz Model

Lastly, I used the Markowitz model which looks at how a portfolio can be constructed and optimized. The model tries to find the efficient frontier; for a given level of risk, it will try to find the highest return. The Markowitz model will provide us insight into how we can optimize traditional asset classes with alternative asset classes. Below are the equations I used in my Microsoft Excel file to calculate and estimate the portfolio with the highest reward-to-variability and the most optimal portfolio given a risk aversion coefficient.

Portfolio expected returns:

$$\boldsymbol{R_p = \sum_{t=1}^{N} x_i R_i}$$

R_p: expected returns on portfolio

x_i: weight of total portfolio in asset i

R_i: expected returns from asset i

Portfolio standard deviation:

$$\sigma_p = \sqrt{\sum_{i=1}^{n} {w_i}^2 {\sigma_i}^2 + \sum_{i=1}^{n} w_i w_j cov_{ij}}$$

σ_p: standard deviation of portfolio

w_i: weight of asset i in total portfolio

σ_i: asset i rate of return variance

w_j: weight of asset j in total portfolio

cov_{ij}: assets i and j rate of return covariance

where i is the investor's sneaker holdings and j is the investor's stock market holdings.

Table 2
Portfolio Composition

	Composition							
Portfolio 1	S&P 500	50%	Sneakers	50%	Sneakers: Pre-Release	-	Sneakers: Restocks	-
Portfolio 2	S&P 500	50%	Sneakers	-	Sneakers: Pre-Release	50%	Sneakers: Restocks	-
Portfolio 3	S&P 500	50%	Sneakers	-	Sneakers: Pre-Release	-	Sneakers: Restocks	50%
Portfolio 4	S&P 500	25%	Sneakers	25%	Sneakers: Pre-Release	25%	Sneakers: Restocks	25%

Table 3
Markowitz Model

	Expected Return	Standard Deviation	Sharpe Ratio
Portfolio 1	0.38%	4.2%	0.09
Portfolio 2	0.79%	4.0%	0.19
Portfolio 3	1.08%	3.5%	0.30
Portfolio 4	0.43%	3.5%	0.12

Table 4
Markowitz Model (1.74% risk-free rate)

	Expected Return	Standard Deviation	Sharpe Ratio
Portfolio 1	0.38%	4.2%	-0.32
Portfolio 2	0.79%	4.0%	-0.23
Portfolio 3	1.08%	3.5%	-0.18
Portfolio 4	0.43%	3.5%	-0.37

Table 2 depicts the composition of the four different portfolios which I constructed to calculate the Sharpe ratios from investing different amounts into each index. Portfolios 1-3 all include a 50% weight of the S&P 500 whilst the other 50% is invested into one of the other three sneaker indexes. Portfolio 4 consists of an equal 25% weight across all four indexes.

Table 3 shows each portfolio's expected investment performance. Portfolio 3, which is composed of the S&P 500 and sneaker index adjusted for restocks, outperforms the other three portfolios with an expected return of 1.08% and standard deviation of 3.5%. The corresponding Sharpe ratio is 0.30 for portfolio 3, which is comparatively higher than the other portfolios. This aligns with the initial notion that sneakers are an alternative asset that provide satisfactory expected returns along with benefits from diversification. However, sneaker investors need to be well-versed about the sneaker market. This is evidenced in portfolio 1, which is an equal split between the S&P 500 and the sneaker index not adjusted for pre-release and restocks. Portfolio 1 is the poorest performing portfolio amongst the four portfolios with a Sharpe ratio of 0.09.

In table 4, I calculated the Sharpe ratios using the average 5-year US Treasury bill data from 2017 to 2021. The risk-free rate I derived from the dataset was 1.74%. This is significantly higher than the expected returns in any of the four portfolios. Hence, all the Sharpe ratios had negative values, indicating that the investments were not worth entering. However, the data may have been skewed slightly since there is not a significant amount of data on sneakers available. The data I collected from 2017-2021 only spans close to 5 years, which is relatively short and therefore easily affected by erroneous data. Portfolio 3 has the highest Sharpe ratio value of -0.18 which is consistent with our findings in table 3, whereby portfolio 3 is the highest performing portfolio. However, one point to note is that portfolio 1 outperforms portfolio 4 in table 4, which is unlike table 3.

Table 5
Markowitz Portfolio Optimization Model

S&P 500	Sneakers	Sneakers: Pre-Release	Sneakers: Restocks
39.8%	5.0%	12.4%	42.8%

Expected Return: 0.87%

Standard Deviation: 3.49%

Sharpe Ratio: 0.249

Using Markowitz's portfolio optimization model, I calculated the most optimal portfolio weighting given the expected returns, correlations, standard deviation, and covariance data from each index. I used Microsoft Excel's solver function to calculate the portfolio with the most optimal return-to-variability. Using the Sharpe ratio as the objective function, the weights as the variable cells and a minimum constraint of 5% invested in each index to ensure that the portfolio consisted of all four indexes, I calculated the metrics as shown in table 5.

Table 5 shows that the optimal portfolio comprises mainly of the 'Sneakers: Restocks' index with a weight of 42.8%. The S&P 500 is also a strong index to invest in with an allocation of 39.8%. The 'Sneakers: Pre-Release' and 'Sneakers' index have the lowest weights compared to the aforementioned indexes. This relationship is consistent with the metrics that I calculated in previous tables, whereby both indexes had comparatively lower risk-adjusted returns when compared to the 'Sneakers: Restocks' and S&P 500 indexes.

The Sharpe ratio of this optimal portfolio is similar to portfolio 3 in table 3, which is the portfolio that invests into both the S&P 500 and 'Sneakers: Restocks' indexes equally. The expected return in portfolio 3 is slightly higher compared to the optimal portfolio whilst

the standard deviation is virtually identical; the optimal portfolio shares similar risk-return characteristics with portfolio 3. This aligns with our findings that the highest performing indexes, the S&P 500 and the 'Sneakers: Restocks' indexes, are the indexes that we will want to invest as much as we can into. One of the reasons why the expected return in this optimal portfolio is slightly lower than portfolio 3 is because of the constraints that I set. I set a minimum investment allocation constraint of 5% because I wanted the optimal portfolio to factor in the benefits from the low correlations between the S&P 500 and sneaker indexes as evidenced in Figure 5. The correlation between the unadjusted 'Sneakers' index and the S&P 500 is the lowest with a value of 0.22; investing into the unadjusted 'Sneaker' index will provide diversification benefits to a portfolio even though the expected return is low.

Depending on an investor's risk profile, an investor is likely to choose to invest in the optimal portfolio if they are risk-averse. On the other hand, an investor that is willing to risk more will likely choose to invest solely into portfolio 3, which has the highest expected return, the lowest standard deviation, and the highest corresponding Sharpe ratio. For investors that prioritize diversification and a portfolio with the lowest risk, the results from table 3 show that portfolio 4 is another viable option. With equal investments into each of the four indexes, a moderate expected return of 0.43% and a comparatively low standard deviation of 3.5%, portfolio 4 can deliver reasonable risk-adjusted returns.

6. Conclusion

I hypothesized that the returns from sneakers would be higher than returns from traditional asset classes such as the S&P 500. However, it turns out to be that if an investor was to invest into sneakers, the expected returns may be significantly lower than that of the S&P 500, especially in the case of the sneaker index which does not account for pre-release and restock prices. The investor must be able to identify and focus their investments on sneakers that they know will stay in trend by using information on restocks and historical sneaker data. As seen from the data and tables above, going in blind into a sneaker investment may not be the wisest method; the sneaker indexes which are adjusted for pre-release and restock prices outperform the index without the adjustment.

Figure 5 which calculates index correlations reaffirms my initial assumption on the relatively low correlations between the S&P 500 and sneaker index. The low correlations can offer investors insulation from market volatility on their investment portfolio. The diversifications benefits derived from sneakers not only provide investors with protection from volatility, but the sneaker indexes can also deliver significant expected returns. Portfolio 3's comparatively high Sharpe ratio in table 3 also points out how the risk-return characteristics of an investment in a sneaker index, if well-designed and structured correctly, can be a suitable alternative option for investors.

Although the sneaker market is an alternative asset class that has still not fully matured, it is growing at a rapid pace. With Cowen Inc. estimating the sneaker resale market alone to be worth $30 billion by 2030, sneakers may become the next mainstay alternative asset class, alongside fine art and vintage wines. As sneakers become more well-documented and as global sneaker data availability increases, we can further build on the existing research and literature to determine if sneakers are worth adding into an investment portfolio.

7. Further Research

Collectible sneakers are still a relatively new alternative asset class and there is not a wide array of existing literature compared to other alternative asset classes. There is also no global marketplace which tracks each sneaker transaction done both offline and online. This means that there are inherently data limitations which can affect our analysis. As the sneaker market grows large, the need for a transparent composite global marketplace for sneakers will be greater than ever. A marketplace which tracks each pair of sneakers that has been manufactured will allow us to reliably perform our analysis with a greater range of products. StockX was unable to provide me with details on each specific transaction and hence the gaps between each data point varied and the method I used could have been improved if there were smaller gaps in the data points, along with an increased data and sample size.

Due to the nature of sneakers having various distinct price ranges as highlighted in the earlier section on the sneaker market, there is a high level of variability in the prices of sneakers. Within these large-scale variabilities, there may also be smaller-scale variabilities that may occur due to measurement errors when currency fluctuations are not accurately accounted for when sales are transacted. Issues that compound the variability errors may also arise because of the platform the sale is transacted on; the system may be prone to software errors that generates incorrect prices especially when simultaneous sales are transacted across a range of difference currencies in various countries.

As mentioned in the sneaker market overview, the transaction costs associated with the sale of a sneaker can also affect the data on our compounded monthly returns. However, we currently do not have a standardized global platform which tracks each transaction. It will be challenging to do so as transactions could occur either offline or online; for instance, a seller could conduct a transaction at a nearby park with cash and without any transaction fees.

Gathering data for each successful sneaker transaction would be difficult unless governments globally convene and begin to enforce laws and restrictions on sneaker-related transactions.

To minimize sampling errors and increase the reliability of the data analysis that I may perform on a larger dataset in the future, I would also want to improve the method of random sampling. The method I used was based on StockX's algorithm that is completely random, but I would try to use a different method in the future to ensure that StockX's algorithm has no biases. StockX currently has cookies embedded within the website which tracks user behavior; by using an alternative randomization method, I can compare the results from both methods and identify if the data collection and the subsequent data analysis I perform is valid.

8. Figures

Figure 1

This figure shows the compounded monthly returns for both the S&P 500 index and the sneaker index which I constructed using data from StockX.

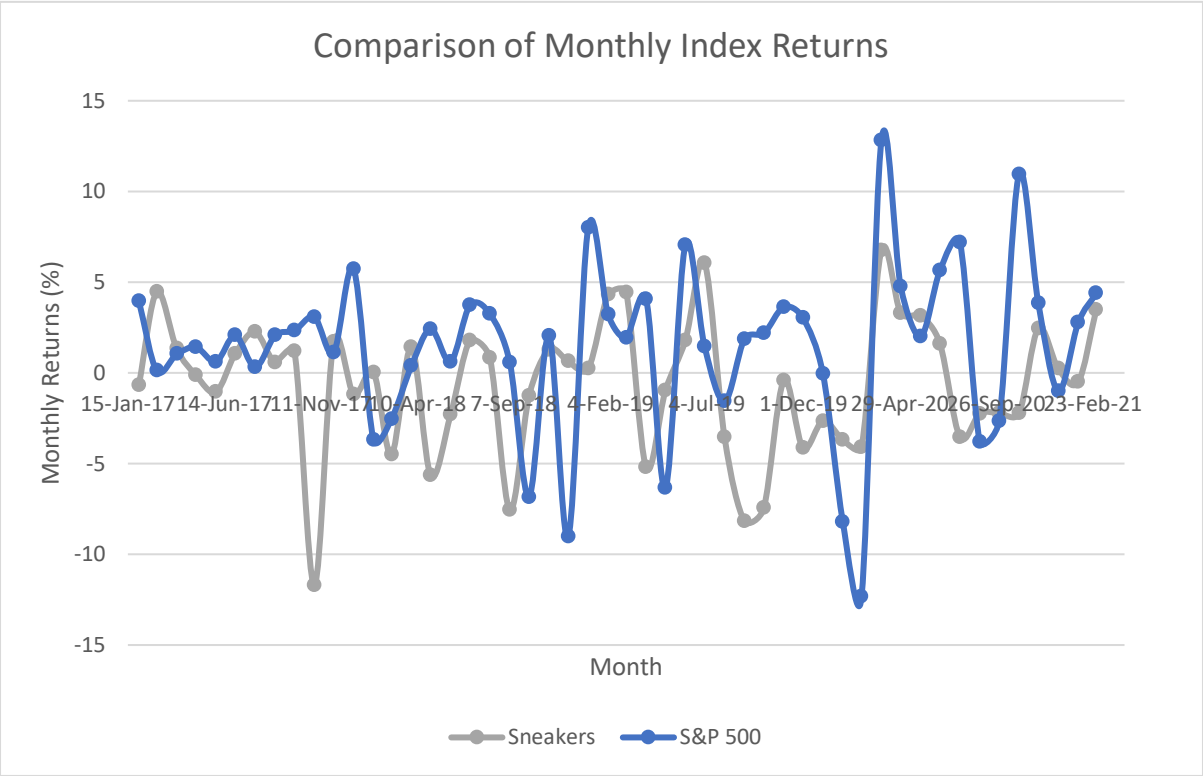


Figure 2

This figure shows the compounded monthly returns for both the S&P 500 index and the sneaker index, which excludes pre-release prices.

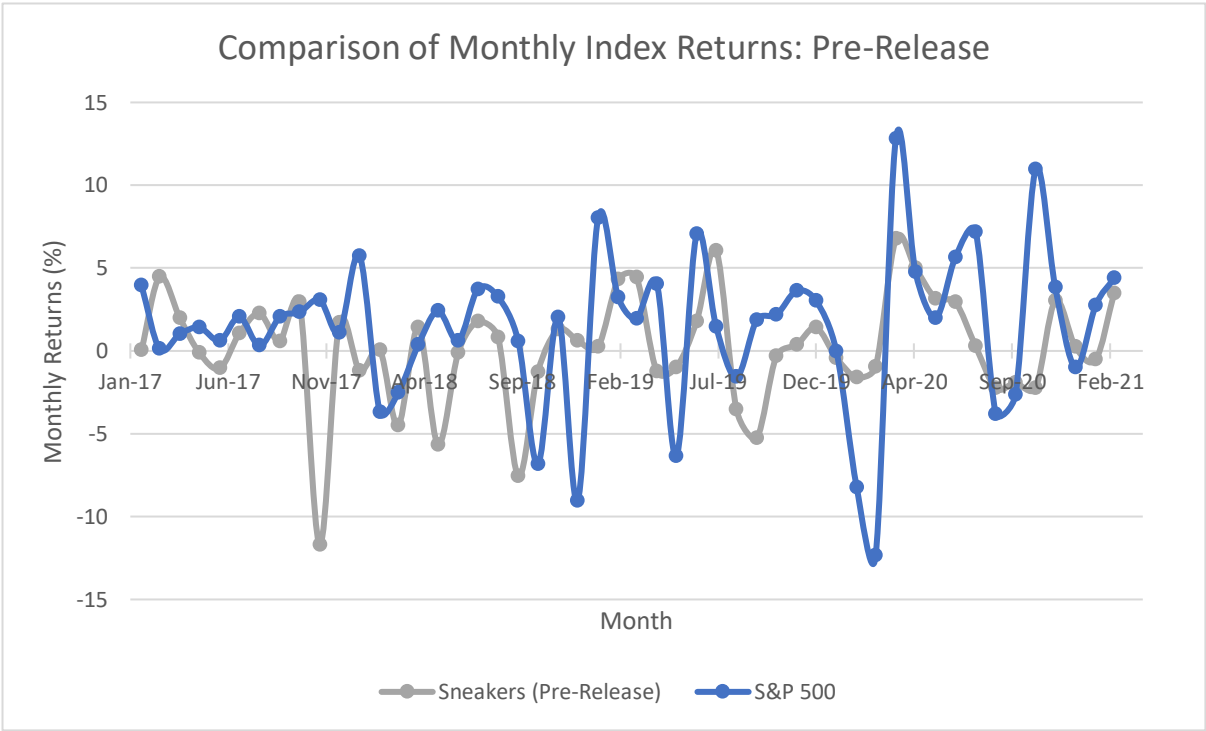


Figure 3

This figure shows the compounded monthly returns for both the S&P 500 index and the sneaker index, excluding pre-release price and restock prices.

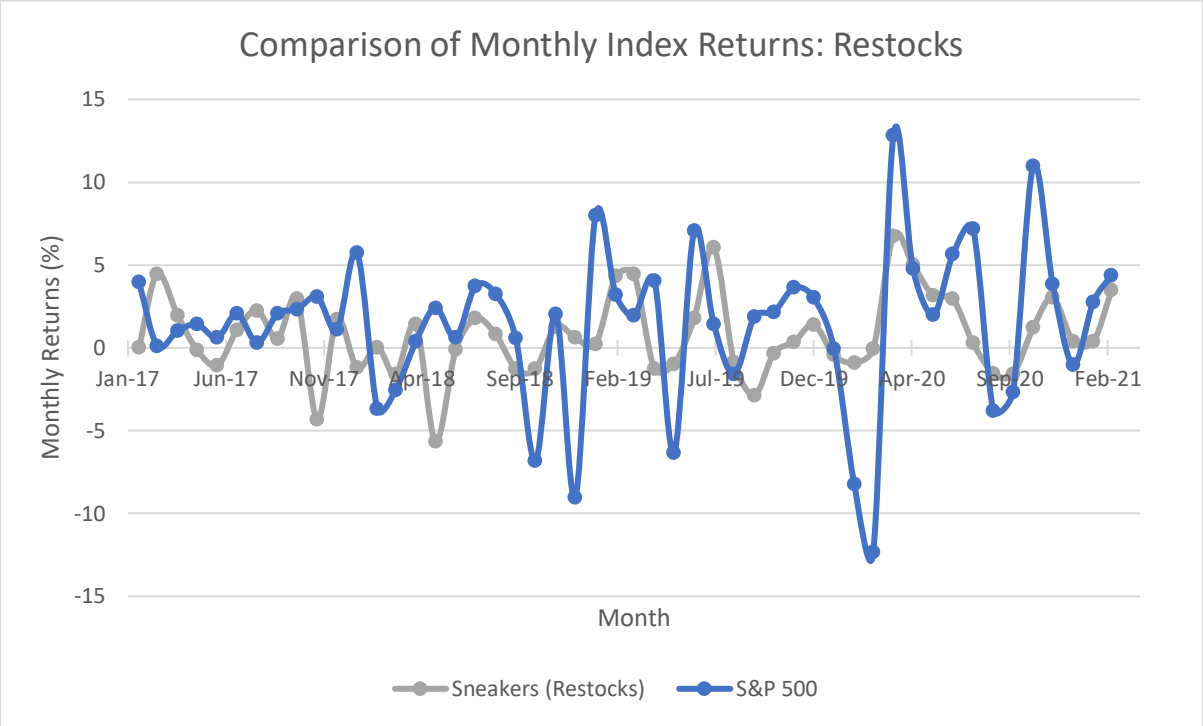


Figure 4
Summary Statistics (95% Significance)

Figure 4: The summary statistics at the 95% significance are shown for the four different indexes in this figure.

S&P 500		*Sneaker Index*		*Sneaker Index: Pre-Release*		*Sneaker Index: Restocks*	
Mean	1.38840	Mean	-0.6176791	Mean	0.19768137	Mean	0.77456382
Standard Error	0.6585261	Standard Error	0.53015395	Standard Error	0.47368374	Standard Error	0.34315769
Median	0.02015	Median	-0.0518811	Median	0.26020824	Median	0.40197604
Mode	#N/A	Mode	#N/A	Mode	#N/A	Mode	#N/A
Standard Deviation	4.6564826	Standard Deviation	3.74875453	Standard Deviation	3.34944988	Standard Deviation	2.4264913
Sample Variance	2.168283	Sample Variance	14.0531605	Sample Variance	11.2188145	Sample Variance	5.88786005
Kurtosis	1.55634233	Kurtosis	0.62819775	Kurtosis	2.57901288	Kurtosis	0.67104609
Skewness	-0.5724596	Skewness	-0.6144904	Skewness	-0.9974344	Skewness	0.15871525
Range	25.17	Range	18.4648831	Range	18.4648831	Range	12.4094332
Minimum	-12.35	Minimum	-11.709268	Minimum	-11.709268	Minimum	-5.653818
Maximum	12.82	Maximum	6.75561519	Maximum	6.75561519	Maximum	6.75561519
Sum	69.42	Sum	-30.883955	Sum	9.88406855	Sum	38.728191
Count	50	Count	50	Count	50	Count	50

Figure 5
Index Correlation

The figure below shows the correlations between each of the four indexes. The S&P 500 index data was obtained from YCharts. The data used to construct the sneaker indexes were taken from StockX.

	S&P 500	Sneakers	Sneakers: Pre-Release	Sneakers: Restocks
S&P 500	1.00	0.2242039	0.24745324	0.33963432
Sneakers	0.2242039	1.00	0.90833776	0.86060665
Sneakers: Pre-Release	0.24745324	0.90833776	1.00	0.90952386
Sneakers: Restocks	0.33963432	0.86060665	0.90952386	1.00

9. Appendix

Appendix A
List of sneakers in Sneakers: Index

Sneaker Name	Style Code
Adidas Yeezy Boost 350 V2 Black Red	CP9652
Adidas Yeezy Boost 350 V2 Cream/Triple White	CP9366
Adidas Ultra Boost 4.0 Running White	BB6168
Adidas Yeezy Boost 700 Wave Runner Solid Grey	B75571
Jordan 11 Retro Win Like 96	378037-623
Adidas Yeezy 500 Utility Black	F36640
Jordan 11 Retro Concord (2018)	378037-100
Nike Blazer Mid 77 Vintage White Black	BQ6806-100
Jordan 11 Retro Playoffs Bred (2019)	378037-061
Jordan 1 Retro High Fearless UNC Chicago	CK5666-100
adidas Yeezy Boost 350 V2 Yecheil (Non-Reflective)	FW5190
Jordan 1 Retro High Shattered Backboard 3.0	555088-028
adidas Yeezy Boost 350 V2 Citrin (Non-Reflective)	FW3042
adidas Yeezy Boost 350 V2 Yeezreel (Non-Reflective)	FW5191
Jordan 4 Retro Bred (2019)	308497-060
Nike Air Force 1 Low Supreme Black	CU9225-001
adidas Yeezy Boost 350 V2 Carbon	FZ5000
Jordan 1 Retro High Tokyo Bio Hack	555088-201
Jordan 12 Retro Black University Gold	130690-070
Jordan 5 Retro Alternate Bel-Air	DB3335-100
Nike Air Max 95 OG Neon (2020)	CT1689-001
Jordan 1 Retro High Pine Green Black	555088-030
Jordan 11 Retro Low Concord Bred	AV2187-160
adidas Yeezy Boost 350 V2 Desert Sage	FX9035
Jordan 3 Retro SE Unite Fire Red	CK5692-600
Jordan 4 Retro SE 95 Neon	CT5342-007
Jordan 1 Retro High Twist (W)	CD0461-007
Jordan 1 Retro High Satin Black Toe (W)	CD0461-016
adidas Yeezy Boost 350 V2 Cloud White (Non-Reflective)	FW3043
Jordan 1 Retro High NC to Chi Leather (W)	CD0461-046

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