

High score or game over? The financial returns of retro video games on the secondhand market

By

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Abstract

Recent high-profile sales of retro video games, including the \$1.5 million sale of *Super Mario 64*, have spurred renewed interest in purchasing retro video games as investments, not merely as collectibles. While existing literature suggests that collecting anything solely as a financial investment is unlikely to result in returns greater than those seen in traditional financial assets, the prominence of video games as one of the dominant forms of entertainment and the utility associated with owning a retro game may make them a more attractive asset. There is a lack of existing research into the secondhand market for retro games or the financial returns of similar pop culture items. This thesis explores that gap and determines if there is a significant financial interest in secondhand retro video games as an investment. eBay sales data from January 2014 to January 2022 were collected for games across ten different consoles and several standardized financial indexes were assembled according to the repeat-sales methodology. For an index consisting of all games for which sales data was obtained, there is an annualized real rate of return of 10.2% and a Sharpe Ratio of 0.73 compared to a 9.8% real return and 0.25 Sharpe Ratio for the S&P 500. Consequently, secondhand retro video games are a compelling alternative investment. Additionally, their low correlation and high risk premium suggest they may be a good investment from a diversification perspective, as risk is lower but returns are similar to those of the stock market. These results break with the established literature on collectibles, which suggests that collectibles are not an efficient or worthwhile investment.

Keywords: retrogaming, collectibles, financial returns, alternative investment, videogaming, repeat-sales methodology

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1.0 Introduction

Video games are powerful cultural artifacts that transport their players back to a nostalgic time when they were younger. This nostalgia is one of the key factors contributing to the recent success of retro games – video games released from the 1970s to the early 2000s (Wulf et al., 2018). Along with the rise in interest in the retro gaming subculture, there is an interest in purchasing games as an alternative investment strategy. The same internet-savvy investors who set their sights on GameStop, AMC, and NFTs view retro video games as another potential market to exploit (Davison, 2021). A pristine copy of the 1996 game, *Super Mario 64*, recently sold for over \$1.5 million, spurring interest in buying and selling retro games for a profit (McGreevy, 2021). While research exists for the financial returns of other collectibles, no such study exists for retro video games.

Retro video games serve as unique pop culture artifacts with a utility that cannot be perfectly replicated. For example, comic books can be accessed on the web with almost no difference to the reading experience, which is not the case for video games. While LEGO sets share some of the same traits as games, recent analysis of LEGO does not use the more robust and comprehensive repeat-sales methodology to calculate returns. This paper bridges that gap by using the repeat-sales methodology to assemble indexes and calculate returns for secondhand retro video games.

While other similar hobbies with collectibles markets are no longer as popular as they once were, video games are a new kind of asset that is growing in popularity. For example, the comic book industry crashed in 1993 and never recovered (Last, 2011). In comparison, Juniper Research values the current global video game market at \$155 billion and predicts that it will eclipse \$268 billion by 2025 (2021). Video games are popular and will remain popular for the

foreseeable future. Perhaps the popularity of video games explains why speculators and investors are not deterred by prior research suggesting that “the majority of collectibles yield lower financial returns than stocks... and embody more risk than most other financial assets” (Burton & Jacobsen, 1999).

Many investors of games physically own what they invest in, but other options exist. The apps Otis and Rally enable customers to fractionally invest in “shares” of many different video games without the need to physically own them (Davison, 2021). Those customers will see a profit once the game is sold at auction or if they choose to sell their share to another user. As the market for physical trading is more mature than that of the digital share market, this physical trading is the focus of this paper. To facilitate the discovery of interesting insights, the main research question guiding this paper is: How do the financial returns of retro video games on the secondhand market compare to those of equities, bonds, gold, and general market inflation in the United States?

To explore this question, this paper utilizes an abductive research philosophy in the same vein as prior research performed regarding collectibles (Burton & Jacobsen, 1999; Dimson & Spaenjers, 2011). Rather than asserting specific hypotheses, this paper follows the guidance of Behfar and Okhuysen and substitutes abductive reasoning in place of a more traditional hypothetico-deductive inquiry (2018). Given the format of prior literature and the relative lack of research on retro video games or similar classes of collectibles, the hypothetico-deductive style of inquiry may limit the scope of potential findings.

I use the repeat-sales index assembly methodology described by Burton and Jacobsen to apply a common scale by which the financial performance of secondhand retro video games can be compared to that of traditional financial assets (1999). The calculation of additional financial

metrics, including the Sharpe Ratio and market risk estimates, will provide insight into the over- or under-performance of these assets and how suitable they are as an investment. Consequently, this thesis is of relevance to investors looking for alternative assets in which to invest.

The subsequent section looks at available literature on the financial returns of collectibles, the motivations behind collecting, and factors influencing the value of collectibles. The third section details my methodology, pre-analysis limitations, and data analysis. The fourth section contains the results of my research. Section five discusses the implications of the results while section six contains a post-hoc analysis of limitations and potential avenues for future research. Finally, the last section lists closing thoughts.

2.0 Literature Review

There is a large body of research into the financial returns of collectibles. Some of the most examined collectibles include art, wine, and stamps, but such research exists even for Beanie Babies and LEGO sets. A broad examination of the returns for collectibles determined that they embody higher levels of risk than other financial assets and yield lower returns than stocks and bonds (Burton & Jacobsen, 1999). The accepted consensus is that one should only collect items if they enjoy doing so, and not as an alternative investment strategy. However, there is little research regarding returns on collectibles with utility except for wine. To get the utility associated with wine – drinking it – one must physically own the bottle. Similarly, one must own the original game and hardware to experience a retro video game as intended. While there exist ways to play retro games on modern gaming consoles, phones, or computers, they use different control input methods or resort to emulation that introduces technical glitches. Items like comic books or art lack utility, as they can be appreciated through other means with relatively little loss in the experience.

Additionally, there is no financial research on retro video games, very little on pop culture associated items in general, and none using a repeat-sales methodology. This paper attempts to bridge the gap in existing research by providing a detailed analysis of the financial returns of such a pop culture item – retro video games. The following section briefly describes the motivations for collecting before a detailed discussion of the hedonic factors that influence the value of a collectible and the investment feasibility of different collectibles.

2.1 Factors motivating interest in collecting and investing in collectibles

Research shows that while there may be financial factors driving the decision to collect, the primary driver is the collector's emotional attachment to his or her purchases. One study examining the motivation behind women who collect dresses found causes as varied as wanting to mimic a celebrity to wanting a collection to pass on to friends and family (Bishop, 2018). A study directed at nonmonetary collectors of art lists several motivations driving their behavior, including the desire to surround oneself with beautiful objects and seeking art as a source of comfort (Baekeland, 1981). Research from Carey found that additional factors that "enhance the ordinary value of a good" can make items more desirable (2008). In the case of retro games, one such factor that increases their value and provides motivation for collectors is their nostalgic nature. Typically, people will not collect something as a hobby without some kind of personal attachment.

However, there is a group of collectors called "investor collectors" who connect their collecting interests to financial motives (Kleine et al., 2020). This group has a different psychological and demographic makeup to regular investors and the general population. Kleine et al. consider this niche to be about 70% male, with above-average education and income (2020). The current set of "investor collectors" is a unique group with their own traits and their own motivations. They are interested in collectibles as both a new experience and something that can offer a potential financial return. This research suggests that while all collectors are motivated by emotional means, some would not collect items if they did not believe they would appreciate.

One study of a niche internet forum for video games found that the desire to be recognized as a pure "true gamer" is a significant motivator behind someone choosing to buy a

physical copy of a retro game (Downing, 2011). However, this group views collectors who own games out of a desire for ownership instead of a desire to play the game the way it was intended as inauthentic (2011). The primary dialectic in the retro video game market is a struggle between those who view retro video games as an art form worth playing and those who view retro video games simply as something to sell for a financial return. Popular gaming press outlets lament the latter group as culpable for a recent perceived increase in the prices of retro games (Devore, 2021).

2.2 Hedonic factors influencing the value of collectibles

There exist several standard characteristics influencing the value of most collectibles. A hedonic analysis of American collectible comics determined that rarity and condition are two of the primary factors influencing a given comic's price (Wyburn & Roach, 2012). All else held equal, the item in better condition will be worth more. Likewise, the rarer item will usually be worth more. Koford and Tschoegl found that rarer coins commanded higher prices but that "rarity in the form of original mintage" was the most valuable (Koford & Tschoegl, 1998). However, an analysis of vinyl records determined that rarity does not necessarily have a premium price (Cameron & Sonnabend, 2020). Just because an item is rare does not mean that collectors are interested.

Cameron and Sonnabend assert that "cultural importance" is the most critical factor driving the price of a vinyl record (2020). A Prince record is likely to be worth more than the record from a small, local band. Even if the local band's record is scarcer than a Prince record, it lacks the same cultural capital. Other goods have similar types of soft factors that influence value. Wyburn and Roach found that the title, content, characters, artists, and media presence of a comic all impacted its value (2012). This research suggests that while an item's purely factual

traits may influence its price, the most crucial factor is whether the collector has an emotional attachment to it. These soft factors determine the strength of an individual's emotional attachment.

Retro video games lack any hedonic analysis determining what factors influence their value the most. There is some research on what traits archivists can use to curate a collection of retro video games. Leblanc mentions completeness, condition, media type, and instruction manual format as some examples (2021). However, this research lacks any analysis on which factors have the most influence on the value of a given video game.

2.3 Investment feasibility for different types of collectibles

Due to the popularity of art, stamps, and other collectibles as an alternative investment, there is a substantial body of research answering the question of whether they are a worthwhile investment. A general census regarding the returns of various collectibles, determined that they are riskier than traditional financial assets and usually carry inferior returns (Burton & Jacobsen, 1999). Burton and Jacobsen state that collectibles are more illiquid than other assets and have significantly higher storage and transaction costs, which drives the actual returns even lower (1999).

Table 1 contains the real returns for various kinds of collectibles explored in prior literature. The research implies that traditional collectibles like fine art and stamps underperform the market. A study from Grable and Chen found that U.S. stamps only performed better than bonds and that only classic stamps were worthwhile from an investment strategy standpoint (2015). A similar study from Dimson and Spaenjers examining British postage stamps came to the same conclusion (2011).

Returns for Other Collectibles		
Paper	Item	Annualized Real Return (%)
Grable & Chen (2015)	U.S. Stamps	2.90%
	<i>Classics (1969-2013)</i>	5.50%
	<i>Modern (1969-2013)</i>	3.29%
	<i>Airmail (1969-2013)</i>	1.60%
Dimson & Spaenjers (2011)	British Postage Stamps	2.70%
Baumol (1985)	Fine Art	0.55%
Burton & Jacobsen (2001)	Wine	7.90%
	<i>1982 Vintage</i>	16.20%
Dobrynskaya & Kishilova (2022)	LEGO sets	8.00%

Table 1: Returns for Other Relevant Collectibles

Even fine art is not necessarily a good investment, with a real rate of return even lower than stamps (Baumol, 1985). Baumol suggests that it is impossible to “beat the game” of art investment (1985). Despite this, Mei and Moses state that many investors pursue the accepted strategy of buying the most expensive piece of art available (2002). However, their study found significant underperformance of these “masterpieces” (2002). Additionally, one 2009 study found that the returns on fine art correlate with stock returns (Hiraki et al., 2009). This suggests that investing in such collectibles is a waste of time as even employing a specific strategy will not reliably beat the market.

However, stamps and art are unlike retro video games. Most significantly, neither asset holds much practical utility beyond its aesthetics. One collectible that does have a utility is wine. To drink a glass of wine, one must own that wine. Therefore, wine is consumable, as once it is drunk, it loses all value. Consequently, “investment-grade” wine appears to have the most significant investment potential of any collectible (Burton & Jacobsen, 2001). Burton and Jacobsen assert that without considering storage and shipping costs, wine is more attractive than

T-Bills and could be an alternative to fixed-income securities (2001). Retro video games have a utility like wine but have a more immature market and are not consumable, so their returns will likely differ and may be higher.

More recent research, focusing on pop culture collectibles associated with Millennials, suggests that investing in such collectibles may be a good idea. Dobrynskaya and Kishilova found that investments in LEGO from 1987 to 2015 outperformed all market benchmarks with an annualized real return of 8% and an annualized Sharpe Ratio of 0.4 (2022). Research from Shanaev et al. reflects this, stating that LEGO carries diversification benefits to a portfolio, making it an attractive investment (2020). Video games are much like LEGO, as both are nostalgia-driven, pop culture items with a utility beyond just the aesthetic. As much of the research on such pop culture items is very new, it is unclear how applicable it is to collectibles overall or why these assets carry greater investment potential.

Research from Choi and Lee may provide one explanation. They assert that the consumer perception of the sneaker resale market is that sneakers are “now recognized as a market with new economic benefits,” (2021). This implies that retail investors now view all collectibles as a potential investment. Additionally, auction websites, online forums, and price tracking websites makes it easy for collectors and investors to buy items and see what those items are worth. A positive feedback loop could occur whereby the price of an item goes up, so investors buy more of such item, and the price continues to rise.

Such a positive feedback loop could lead to potentially catastrophic speculative bubbles. For example, a positive feedback loop was responsible for the bubble in the late 1970s for Dutch collectible postage stamps (Franses and Knecht, 2016). Other research found that sudden rightward shifts in demand are just as likely to bring a sudden leftward shift as speculative

expectations change (Stoller, 1984). While most studies agree that collectibles are not a good long-term investment, except under particular circumstances, the returns could significantly exceed those of other assets during these speculative bubble periods. However, following the bursting of the bubble, asset prices will drop significantly and are unlikely to reach the heights seen during the bubble period again.

In summation, existing research asserts that traditional collectibles are generally not a good investment and that one should only choose to collect these if they enjoy it. The literature on the motivations of collectors suggests that while there is usually a financial component, the primary motivator is emotional. That motivator could be nostalgia or self-satisfaction, but it is usually just as powerful or even more potent than financial motivation. While factors like rarity or condition can drive the price of an item, the emotional interest component seems to be the most significant factor. However, more recent research indicates that pop culture collectibles, such as sneakers and LEGO, not only may have higher investment returns, but also carry diversification benefits.

While there is some research regarding the investment potential of pop cultural collectibles, it is from the last few years and does not cover the same scope of objects as the research regarding traditional collectibles. Additionally, research for these classes of items analyze fewer items and do not use the repeat sales methodology for pricing index assembly. Retro video games represent a unique set of criteria that has yet to be analyzed. Consequently, the following paper bridges the gap of research that excludes analysis of secondhand retro video games, usage of the repeat sales methodology for pop culture collectibles, and items with a practical, non-replicable, non-aesthetic utility. *Table 2* shows how research on retro video games are differentiated from other collectibles.

Comparing Collectibles with Prior Research to Retro Video Games										
		Stamps	Fine Art	Beanie Babies	Wine	Comic Books	Action Figures	LEGO	Sneakers	Retro Video Games
Age and Popularity	Mature Market	Y	Y	Y	Y	Y	N	N	N	N
	Growing Popularity	N	N	N	N	N	N	Y	Y	Y
Cultural Status	"High-Class" Perception	N	Y	N	Y	N	N	N	N	N
	Viewed as Investment	N	Y	N	Y	N	N	Y	Y	N
	Pop Culture Item	N	N	Y	N	Y	Y	Y	Y	Y
Utility	Irreplicable Utility	N	N	N	Y	N	Y	Y	Y	Y
	Consumable	N	N	N	Y	N	N	N	N	N
Costs	High Storage Costs	N	Y	N	Y	N	N	N	Y	N
	High Selling Costs	Y	Y	N	Y	N	N	N	N	N
Common Selling Venue	Auction House	Y	Y	N	Y	Y	N	N	N	N
	Internet Auction	N	N	Y	Y	Y	Y	Y	Y	Y
Speculative History	Bubble Period Experienced	Y	N	Y	N	Y	N	N	N	N
Research Methodology	Existing Repeat-Sales Research	N	Y	N	Y	N	N	N	N	N

Table 2: Comparing Collectibles with Prior Research to Retro Video Games

3.0 Methods

3.1 Datasets

To obtain a dataset of the prices of retro video games on the secondhand market, I scraped data from the website pricecharting.com after receiving their consent. This website provides monthly pricing data from eBay sales dating back to 2008. At the end of each month, pricecharting.com calculates the price of a given game based on the average of what it sold for on eBay. For example, if *Super Mario Bros* sold two copies in January 2022, then the price recorded on pricecharting.com would be the average of the sale value of the two games. The dataset obtained includes a release ID for a given game, the name of the console of release, the name, the level of completeness, the genre, the month of sale, and the average price it sold for that month. Game genres were inconsistently applied depending on the game and the consoles. Consequently, I combined overly specific genres into a smaller set of more general categories. *Table 3* shows these changes.

Bundled Genres	Resulting Genre Categories	Number of Games	Proportion of Total
Baseball, Basketball, Extreme Sports, Football, Golf, Soccer, Wrestling, Sports	Sports	1114	20%
Board & Card, Casino, Compilation, Dance, Educational, Mini-Games, Horror, Light Gun, Music, Party, Trivia, Visual Novel, Other	Other	465	8%
First Person Shooter, Third Person Shooter, Action & Adventure	Action & Adventure	1893	34%
Shoot'em Up, Beat'em Up, Pinball, Arcade	Arcade	397	7%
Fighting	Fighting	280	5%
Platformer	Platformer	336	6%
Puzzle	Puzzle	220	4%
Racing	Racing	496	9%
RPG	RPG	238	4%
Strategy	Strategy	149	3%

Table 3: Genre Bundling

Starting in April 2013, this sales data began to distinguish between whether a sale of a game was loose, complete-in-box, or brand new. Loose describes a sale that consists only of the loose cartridge or disc. Complete-in-box describes a sale including the game, its original box, and any manuals or documentation that was originally included. New describes a sale that is complete-in-box and unopened. To bypass data coverage and accuracy issues regarding the new classification of game sales into different level of completeness, my research covers the period of January 2014 to January 2022. Since this market is in its relative infancy compared to other collectibles, this time period is representative of the kind of returns one can expect when choosing to invest in retro video games.

I only obtained sales data on the games released for popular consoles with high N values to get more precise results. I selected a range of systems using both cartridge and disc formats as well as home console and handheld formats. Additionally, I focused only on systems released by Nintendo, Sega, and Sony. Consequently, all games in the dataset are guaranteed to be licensed and commercially available. I selected systems released prior to the year 2000 to fit the definition of a retro video game and ensure the secondhand market for each console is relatively mature.

See *Table 4* below for a complete list of systems.

Console Name	American Release Year	Media Format	Console Type	Number of Games	Proportion of Total
Nintendo Entertainment System	1985	Cartridge	Home Console	775	14%
Nintendo Game Boy	1989	Cartridge	Handheld	518	9%
Super Nintendo Entertainment System	1991	Cartridge	Home Console	732	13%
Nintendo 64	1996	Cartridge	Home Console	300	5%
Nintendo Game Boy Color	1998	Cartridge	Handheld	452	8%
Sony PlayStation 1	1995	Disc	Home Console	1,330	24%
Sega Genesis	1989	Cartridge	Home Console	727	13%
Sega Game Gear	1991	Cartridge	Handheld	235	4%
Sega Saturn	1995	Disc	Home Console	253	5%
Sega Dreamcast	1999	Disc	Home Console	266	5%

Table 4: Video Game Consoles Included in Dataset

Tables 5 and 6 contain a set of summary statistics describing the dataset at the console level. Table 5 includes summary statistics after excluding null values, but prior to the exclusion of outliers. Table 6 contains the same statistics but after excluding outliers. To exclude extremely high-priced games that are not a feasible purchase for a retail investor, outliers were defined as those entries with sales prices greater than 1.5 times the inter-quartile range. Since the most expensive games are not indicative of what a typical collector might own, they are not relevant to the analysis. This excluded 252,283 transactions from final index assembly. “Transaction” refers to a row containing a monthly price.

Summary Statistics by Console Prior to Filtering for Outliers												
Console	Games		Prices						Transactions			
	of Games	Proportion of Total	Min Price	1st Quartile	Median Price	Mean Price	3rd Quartile	Max Price	Total # of Transactions	CIB Transactions	Loose Transactions	New Transactions
Nintendo Entertainment System	775	14%	\$0.01	\$13.23	\$34.95	\$211.95	\$95.00	\$175,250.00	242,899	80,972	81,891	80,036
Nintendo Game Boy	518	9%	\$0.01	\$9.97	\$26.01	\$74.59	\$70.87	\$8,978.34	155,532	50,972	53,480	51,080
Super Nintendo Entertainment System	732	13%	\$0.01	\$11.99	\$29.99	\$114.59	\$79.99	\$39,999.00	230,760	77,341	77,720	75,699
Nintendo 64	300	5%	\$0.01	\$11.05	\$25.34	\$69.28	\$60.00	\$9,201.00	94,638	31,489	31,714	31,435
Nintendo Game Boy Color	452	8%	\$0.01	\$5.69	\$11.87	\$26.82	\$23.19	\$5,422.00	140,733	45,855	47,616	47,262
Sony PlayStation 1	1,330	24%	\$0.01	\$4.99	\$9.99	\$24.38	\$22.99	\$3,000.00	414,998	138,431	138,464	138,103
Sega Genesis	727	13%	\$0.01	\$8.00	\$17.50	\$48.34	\$40.01	\$21,600.00	225,571	75,398	75,775	74,398
Sega Game Gear	235	4%	\$0.01	\$6.99	\$14.99	\$35.04	\$32.71	\$4,999.99	68,986	22,503	24,330	22,153
Sega Saturn	253	5%	\$0.01	\$11.11	\$22.11	\$48.20	\$47.01	\$1,574.99	79,308	26,450	26,503	26,355
Sega Dreamcast	266	5%	\$0.01	\$8.50	\$15.00	\$27.06	\$30.00	\$964.08	80,699	26,901	26,894	26,904
All Systems	5,588	100%	\$0.01	\$7.95	\$17.99	\$74.56	\$45.90	\$175,250.00	1,734,124	576,312	584,387	573,425

Table 5: Summary Statistics by Console Prior to Filtering for Outliers

Summary Statistics by Console After Filtering for Outliers												
Console	Games		Prices						Transactions			
	Number of Games	Proportion of Total	Min Price	1st Quartile	Median Price	Mean Price	3rd Quartile	Max Price	Total # of Transactions	CIB Transactions	Loose Transactions	New Transactions
Nintendo Entertainment System	775	14%	\$0.01	\$10.00	\$22.48	\$31.07	\$45.93	\$102.82	187,072	69,539	77,034	40,499
Nintendo Game Boy	518	9%	\$0.01	\$8.00	\$19.95	\$28.73	\$41.71	\$102.82	129,511	43,580	52,882	33,049
Super Nintendo Entertainment System	732	13%	\$0.01	\$9.99	\$20.97	\$29.74	\$42.42	\$102.82	185,034	66,052	74,370	44,612
Nintendo 64	300	5%	\$0.01	\$9.99	\$20.49	\$29.08	\$41.00	\$102.81	81,553	28,947	31,054	21,552
Nintendo Game Boy Color	452	8%	\$0.01	\$5.50	\$19.99	\$17.31	\$20.99	\$102.78	135,753	44,692	47,376	43,685
Sony PlayStation 1	1,330	24%	\$0.01	\$4.99	\$9.62	\$16.65	\$20.00	\$102.82	399,851	136,095	137,992	125,764
Sega Genesis	727	13%	\$0.01	\$7.74	\$15.14	\$24.05	\$32.99	\$102.82	208,016	72,461	74,904	60,651
Sega Game Gear	235	4%	\$0.01	\$6.71	\$13.99	\$21.50	\$29.00	\$102.79	65,608	21,655	24,231	19,722
Sega Saturn	253	5%	\$0.01	\$10.00	\$19.95	\$26.91	\$35.99	\$102.81	71,337	23,948	25,578	21,811
Sega Dreamcast	266	5%	\$0.01	\$8.16	\$14.97	\$21.46	\$27.99	\$102.81	77,730	26,280	26,729	24,721
All Sysytem	5,588	100%	\$0.01	\$6.99	\$14.99	\$23.63	\$32.05	\$102.82	1,541,465	533,249	572,150	436,066

Table 6: Summary Statistics by Console After Filtering for Outliers

For equities, I gathered a dataset from DataPlanet tracking the price performance of the S&P 500. The S&P 500 is a standard proxy to measure the performance an individual investor can expect to see. I obtained a dataset tracking the price of gold from the S&P Capital IQ database and an index of U.S. Treasury Bills from S&P Dow Jones Indices. To determine the level of inflation, I sourced Consumer Price Index (CPI) data from the Bureau of Labor Statistics. I converted all data to a monthly basis if required and set the base month for all data to January 2014 by dividing all subsequent entries by the value of the given index in April 2014.

All datasets examine the same period of April 2014 to January 2022. The retro video game price dataset solely includes North American released games as data for other markets is more limited and significantly increases the complexity of the analysis required. Additionally, my analysis excludes variants, non-commercially released games, and unlicensed video games. These types of releases are unrepresentative of the collector's market and are excluded from the analysis. In summation, the dataset's controls ensure that each game only has one ID and is limited to the North American geographical market. *Table 7* provides a detailed list of variables available in the dataset.

Variable	Description
Date	Month and Year of sale
Game ID	The database ID associated with a given release
Name	Name of video game
Price	The average price a game sold for in a given month
Completeness	Loose disc/cartridge, complete-in-box, or new
Genre	The genre of a game. See <i>Table 1</i> for a detailed list
Console	Game system the video game released on
Console Year	The release year of a given console
Console Type	Home or handheld
Console Format	Disc or cartridge

Table 3: Variables Available in the Dataset

3.2 Retro Video Game Price Index Justification

In a detailed analysis of previous studies, Burton and Jacobsen list three methods of calculating returns for assets: market basket analysis, hedonic regression, and repeat sale regression (1999). According to Burton and Jacobsen, none of these approaches “will necessarily understate or overstate returns as compared to the other approaches” (1999). Consequently, we are free to choose the method that best fits the dataset. Market basket is the least sophisticated method of analysis and involves selecting a basket of items and comparing their prices over time. The basket can be chosen at random or hand-picked and can be varying or fixed. A varying basket changes for each year of analysis, while a fixed basket includes the same items over the entire period of analysis. Unlike wine and fine art, which both have well-credentialed experts who could hand-select an adequate portfolio, retro video games lack these experts or research that could inform a typical portfolio strategy. While I could have selected a basket of retro games randomly, it may exclude commonly purchased games that add significant value to a collection.

A hedonic regression involves regressing the price of an item based on certain characteristics. Consequently, one can track the price performance over time while allowing for different levels of quality for different items. However, such a regression is linear, resulting in a constant rate of return that doesn’t allow for detailed analysis or comparison with different assets.

The final method, running a repeat-sales regression, is the most sophisticated method of analysis. This method involves tracking the performance of repeat sales of a given item. Repeat sales refer only to subsequent sales for a given retro video game, not the repeat sale of one individual copy of that game. For each pair of sales, the log-price is calculated and regressed based on a set of dummy variables which are equal to +1 at the time of the sale and -1 at the time

of the prior sale. This method enables the creation of an index for retro video games that accurately captures the price movement of the entire market without limiting the analysis to a constant rate of return. The repeat-sales method is most apt when studying heterogeneous assets and comparing their performance to other asset classes. Consequently, this paper uses the standard repeat-sales methodology put forward by Bailey et al. to create an index for housing prices (1963).

3.3 Repeat-Sale Price Index Assembly

For this paper, I calculated a variety of repeat-sale indexes based on the characteristics available in the dataset. This included one index containing all game sales, three completeness indexes, three console manufacturing company indexes, ten genre indexes, and ten console indexes. The base methodology followed to assemble each index was the same. While they all provide interesting insights, I will primarily focus on the overall index and the three completeness indexes for the subsequent analysis. Doing this enables the development of more useful and specific insights.

To assemble the various indexes, I imported the video game price index into the data analysis tool RStudio. I cleaned the data by filtering out all rows containing null entries and any outliers. Following the exclusion of outliers, I filtered for additional traits depending on the kind of index to be assembled.

To assist with the analysis, I used the R Package “rsmatrix” based on the “rsi” package detailed by Kirby-McGregor and Martin (2019). This statistical package was designed for non-economists to calculate repeat-sales matrix and convert data into a sales pair format. First, I converted the filtered dataset into the sales pair format using the function `rs_pairs`. This function creates columns for the previous date of sale, what it sold for on that previous date, the current

date of sale, and what it currently sold for. Secondly, I used the function `rs_matrix` to assemble the dummy variable matrix using January 2014 as the base year. Each sale was given a dummy variable of +1 for the date of sale and -1 for the date of the prior sale. All other dates were assigned a value of 0.

After assembling of the dummy variable matrix, I calculated the geometric repeat sales (GRS) index based on the methodology in Bailey et al. (1963). This consisted of solving a system of equations where the cross products of the dummy variable matrix are on the left-hand side and the cross products of the dummy variable matrix and the log prices are on the right-hand side. Then the exponentials of the calculated values were multiplied by 100 to generate the final pricing index. The resulting price index starts at a value of 100 in the base month of January 2014.

3.4 Additional Data Analysis Methods

To provide useful insights for investors, I calculated several other financial metrics for each index to compare to those of more traditional assets. These included the annualized rate of return, real rate of return, monthly return rates for each asset, and the standard deviation of returns. The methodology for these are described in *Appendix 1*. Additionally, I calculated the Sharpe Ratio, alpha and beta estimates, and the correlations of each index against the others.

Sharpe Ratio

The Sharpe Ratio is a measure that represents how well an asset performs compared to a risk-free rate given the asset's level of risk. This measure was calculated on a monthly basis unless otherwise specified. The risk-free rate provided by the data library of Kenneth R. French is derived from the one-month Treasury bill rate. The following formula was used to calculate

the Sharpe Ratio for each index: $\frac{R_{a-rf}}{\sigma_a}$, where:

R_{a-rf} = Average of monthly excess returns, calculated by subtracting the risk-free rate from the monthly rate of return and

σ_a = Standard deviation of the asset.

Alpha and Beta Estimates

Alpha and beta estimates measure the relative over- or under-performance of a given index based on its level of risk. Estimates were calculated for the all games, loose, complete-in-box, and new indexes based on the CAPM and Fama and French Three-factor and Five-factor Models. These models attempt to find the factors that influence the returns of a given portfolio. Therefore, using these models enables us to determine if there are any existing factors that explain the over- or under-performance of retro video games. All values for the CAPM and Fama and French Models were obtained from Kenneth R. French's data library. For each index a regression was performed on each of the following formulas to calculate the Alpha and Beta estimates:

$$\text{CAPM: } R_a - R_{rf} = \alpha + \beta_1 * (Mkt - RF),$$

$$\text{Three-factor: } R_a - R_{rf} = \alpha + \beta_1 * (Mkt - RF) + \beta_2 * (SMB) + \beta_3 * (HML), \text{ and}$$

$$\text{Five-factor: } R_a - R_{rf} = \alpha + \beta_1 * (Mkt - RF) + \beta_2 * (SMB) + \beta_3 * (HML) + \beta_4 * (RMW) + \beta_5 * (CMA), \text{ where:}$$

R_a = Rate of return for a given month,

R_{rf} = Risk-free rate of return for a given month,

α = Alpha value, and

β_x = Beta value for a given factor.

Correlation

A correlation matrix was calculated based on Pearson coefficients. All assets and indexes were included in the assembly of the matrix.

3.5 Assumptions, Limitations, and Strengths

The primary assumption required for this analysis is that the dataset obtained is representative of the secondhand market for games. Since the data is from a commercial platform that sells access to stores, we can assume it is representative of the value of these games. Additionally, pricecharting.com has been gathering such sales data since 2008, a much larger time window than any other competing service. Consequently, the dataset contains the price of every eBay sale for every official, North American-released, commercially available video game sold for all game consoles analyzed over that time period. As eBay is the dominant internet auction site in the world and the small physical dimensions of most games makes the online listing and shipping of them simple, it is safe to assume that sales on eBay capture a representative sample of the market.

However, eBay sales do not capture the entirety of the retro video game market and exclude the most high-value sales seen at auctions. For example, the copy of *Super Mario 64* that sold for over \$1 million sold at auction, not on eBay (McGreevy, 2021). While the following analysis is consciously aimed at the average individual collectible investor and not wealthy collectors or institutional investors, it does mean the analysis excludes the retro games likely to have the greatest return. Also excluded are those sales at specialist stores or video game conventions. As these transactions are conducted in-person, there is no way to gather a representative sample of historical sales. However, given that many vendors base their pricing on prices listed by platforms like pricecharting.com, the exclusion of these sales is inconsequential.

Another limitation is the relative immaturity of the retro video game secondhand market. Current conclusions based on this data could be inaccurate in only a few years. The Dutch stamp bubble of the 1970s was indicative of such a relationship. This bubble spanned several years and

gave a false impression as to the value and financial return potential of the asset (Franses and Knecht, 2016). Therefore, it is possible that retro video games are in a bubble period or that they have yet to reach their market potential. In the event the retro video game market is in a bubble period, the long-term investment potential is likely very low.

4.0 Results

This section outlines the results from the data analysis, including all relevant graphs and tables. Some graphs created are excluded from the results section, such as for the index values for the genre indexes. When this occurred, it was because the graph was deemed to not show any additional, new, worthwhile insights. Section 4.1 shows the financial returns for each index and a graphic representation of the monthly index value over the period. Section 4.2 looks at the Alpha and Beta values estimated by the CAPM and Fama and French 3-factor and 5-factor models. Section 4.3 contains a correlation matrix to determine how the video game indexes compare to traditional financial assets.

4.1 Pricing Index Returns and Graphs

Table 9 shows the nominal returns, real returns, standard deviation of returns, and Sharpe Ratio for the traditional financial assets and the video game price indexes representing all games and each level of completeness. Of the four video game indexes, the new games index saw the highest real return of 12.2%, while the index containing all games carried the most favorable Sharpe Ratio of 0.73. *Table 10* shows the same information but only for the additional indexes that are not the focus of the primary analysis. The highest values for these indexes are summarized in *Table 8* below. *Figures 1-3* show the index values for each month for the various indexes from January 2014 to January 2022. These graphs show a steady rise in index value along with fairly low variation. This is especially true for *Figure 1*, which shows similar growth alongside market benchmarks, with less significant drops in value.

Highest Values for Additional Indexes		
	Highest Real Return	Highest Monthly Sharpe Ratio
Company	Nintendo (10.77%)	Sega (0.70)
Console	Nintendo 64 (14.10%)	Nintendo 64 (0.64)
Genre	Strategy (11.46%)	Platformer (0.78)

Table 8: Highest Values for Additional Indexes

Game and Traditional Investment Asset Returns and Measures					
	Index Name	Annualized Nominal Return (%)	Annualized Real Return (%)	Annualized SD (%)	Monthly Sharpe Ratio ¹
Traditional Assets/Measures	CPI	2.3%		1.16%	0.41
	T-Bills	0.8%	-1.5%	0.08%	
	S&P 500	12.3%	9.8%	13.93%	0.25
	Gold	4.5%	2.1%	13.28%	0.10
Completion and Overall	All Games	12.7%	10.2%	4.52%	0.73
	Loose	11.5%	9.0%	5.21%	0.58
	CIB	11.5%	8.9%	5.03%	0.59
	New	14.9%	12.2%	6.78%	0.57

Table 9: Game and Traditional Investment Asset Returns and Financial Measures

Additional Game Index Returns and Measures						
	Index Name	Nominal Return (%)	Real Return (%)	Annualized SD (%)	Monthly Sharpe Ratio	Number of Games
Company	Sega	13.09%	10.52%	4.86%	0.70	1,481
	Nintendo	13.35%	10.77%	5.18%	0.67	2,777
	Sony	10.77%	8.25%	4.54%	0.62	1,330
Console	Genesis	12.40%	9.84%	5.50%	0.59	727
	Game Gear	15.55%	12.92%	8.66%	0.47	235
	Saturn	12.86%	10.29%	6.17%	0.55	253
	Dreamcast	12.55%	10.00%	6.13%	0.54	266
	NES	12.73%	10.17%	5.38%	0.62	775
	Game Boy	11.29%	8.76%	7.06%	0.42	518
	SNES	14.64%	12.03%	6.28%	0.61	732
	Nintendo 64	16.75%	14.10%	6.78%	0.64	300
	Game Boy Color	12.07%	9.52%	6.15%	0.51	452
	PlayStation	10.77%	8.25%	4.54%	0.62	1,330
Genre	Act. & Ad.	12.44%	9.88%	5.11%	0.63	1,893
	Arcade	13.00%	10.43%	6.40%	0.53	397
	Fighting	11.42%	8.88%	5.32%	0.56	280
	Other	13.27%	10.69%	5.39%	0.64	465
	Platform.	13.09%	10.52%	4.39%	0.78	336
	Puzzle	13.90%	11.31%	5.31%	0.68	220
	Racing	11.20%	8.67%	6.07%	0.48	496
	RPG	8.17%	5.71%	5.13%	0.41	238
	Sports	10.61%	8.09%	5.43%	0.51	1,114
	Strategy	14.05%	11.46%	5.42%	0.68	149

Table 10: All Additional Index Returns and Measures

Video Game Indexes and Traditional Investment Assets (Jan 2014 - Jan 2022)

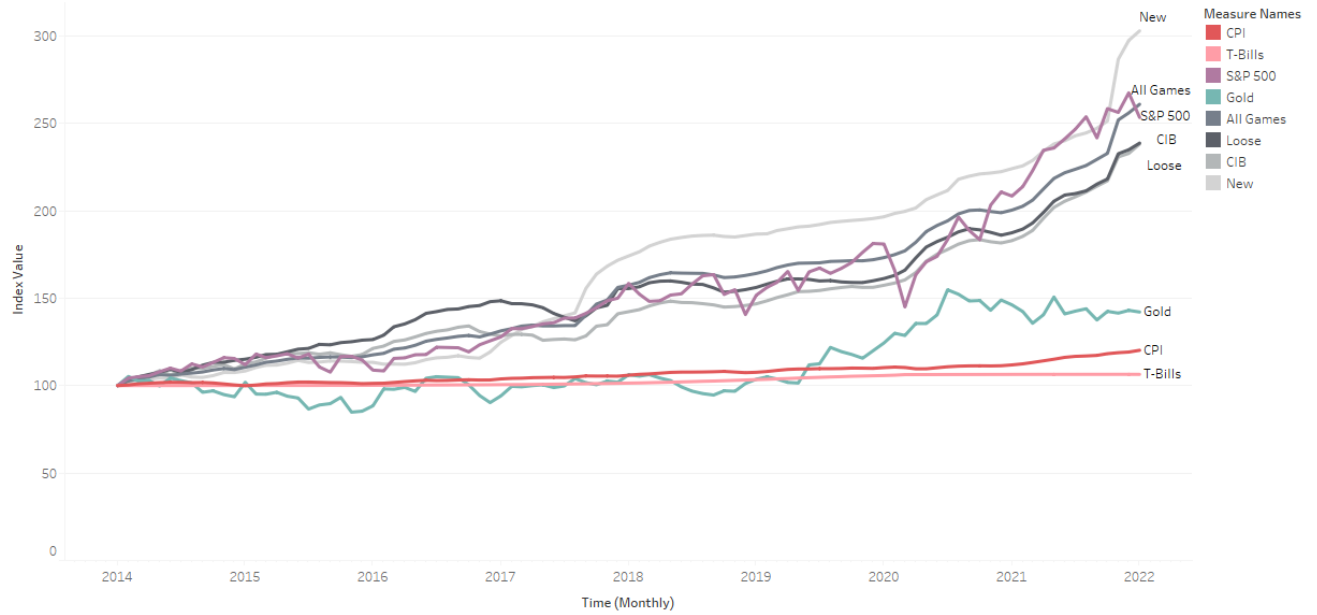


Figure 1: Primary Game Indexes and Traditional Investment Asset Values

Console Indexes (Jan 2014 - Jan 2022)

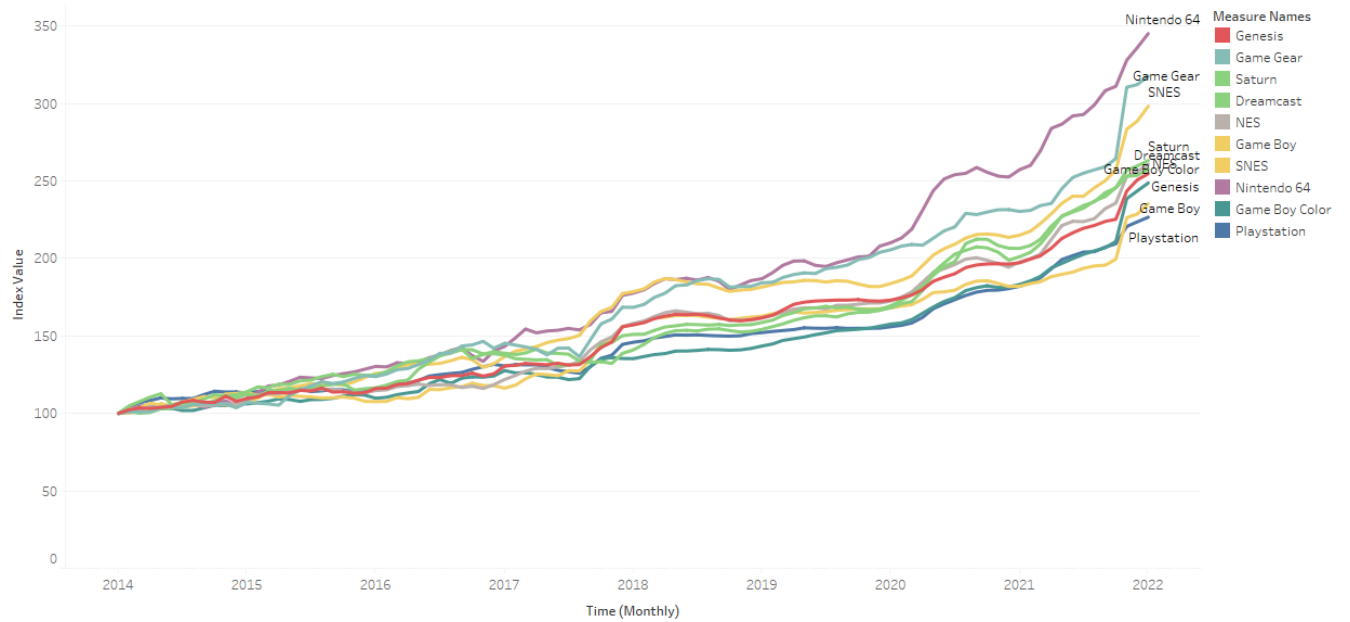


Figure 2: Console Index Values

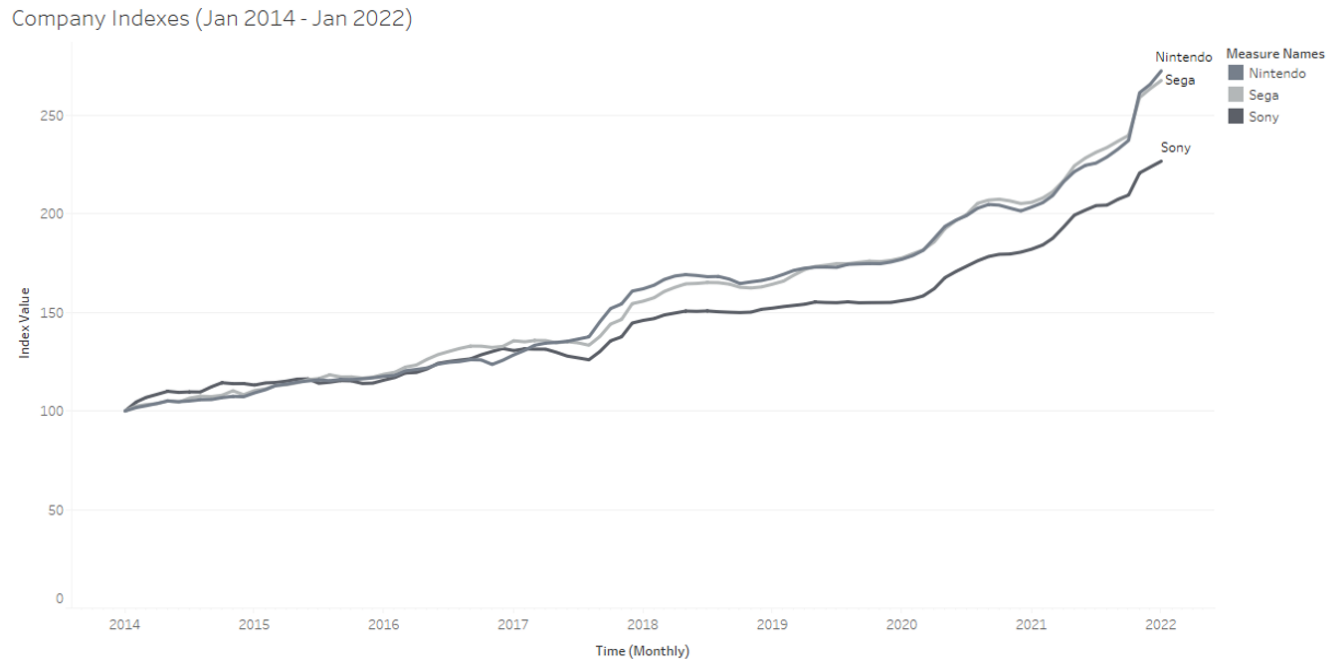


Figure 3: Company Index Values

4.2 Financial Metrics – CAPM and Fama and French Models

Table 11 shows all Alpha and Beta estimates for the index including all games and the completeness indexes. These values were derived from the linear regression methodology previously mentioned. In the event that a value for a given model is statistically significant, that model can explain the excess returns of the asset and to what degree. The relatively low R-squared values suggest that none of these models adequately explain the returns seen for the game indexes. All alpha measures are statistically significant at a level of $p < 0.01$. The only factor with a P-value lower than 0.01 is the RMW (Robust Minus Weak) factor. Also known as the profitability factor, this takes the average return of two robust operating profitability portfolios and subtracts the average return of two weak operating profitability portfolios. The RMW Beta value for the index containing all games is 0.32, meaning such a portfolio would have lower exposure than the American Stock Market, which has a Beta value of 1. *Table 12*

shows only the R-squared, alpha value, standard error, t-stat, and P-value for each Alpha estimated.

		Alpha and Beta Estimates Based on CAPM and Fama and French 3-Factor and 5-Factor Models ¹											
		All Game			Loose			CIB			New		
		CAPM	3-fac	5-fac	CAPM	3-fac	5-fac	CAPM	3-fac	5-fac	CAPM	3-fac	5-fac
Betas	R-Squared	0.4%	1.1%	17.0%	1.0%	1.1%	12.6%	0%	3.8%	12.3%	0.1%	0.2%	15.5%
	Alpha	0.0099***	0.0097***	0.0090***	0.0088***	0.0088***	0.0081***	0.0091***	0.0087***	0.0081***	0.0116***	0.0115***	0.0105***
	Mkt-RF	0.0196	0.0296	-0.0058	0.0347	0.0355	0.0071	0.0023	0.0285	-0.0014	0.0158	0.0197	-0.0315
	SMB		-0.0425	0.0782		-0.0063	0.1089		-0.1082*	-0.0105		-0.0184	0.1584*
	HML		0.0136	-0.0422		0.0149	-0.0510		0.0183	-0.0237		0.0136	-0.0693
	RMW			0.3163***			0.2981***			0.2568***			0.4629***
	CMA			0.0141			0.0530			0.0016			0.0247

Note: * denotes $p < 0.10$, ** denotes $p < 0.05$, *** denotes $p < 0.01$

Table 11: Alpha and Beta Estimates Based on CAPM and Fama and French 3-Factor and 5-Factor Models

		Alpha Estimates and Hypothesis Tests Based on CAPM and Fama and French 3-Factor and 5-Factor Models ¹											
		All Game			Loose			CIB			New		
		CAPM	3-factor	5-factor	CAPM	3-factor	5-factor	CAPM	3-factor	5-factor	CAPM	3-factor	5-factor
R-Squared	0.4%	1.1%	17.0%	1.0%	1.1%	12.6%	0%	3.8%	12.3%	0.1%	0.2%	15.5%	
Alpha	0.009896	0.0097	0.009	0.0088	0.0088	0.0081163	0.0091506	0.0087074	0.0081624	0.0116076	0.0115607	0.0105445	
Std. Error	0.0014	0.0014	0.0013	0.0016	0.0016	0.0015	0.0015	0.0015	0.0015	0.0021	0.0021	0.0020	
t-Stat	7.2360	6.9744	6.9325	5.6331	5.5071	5.2649	5.9902	5.6692	5.4435	5.6032	5.4478	5.2789	
P-value	1.24E-10	5E-10	6E-10	2E-07	3E-07	9.468E-07	3.824E-08	1.638E-07	4.478E-07	2.089E-07	4.23E-07	8.93E-07	

Table 12: Alpha Estimates and Hypothesis Tests Based on CAPM and Fama and French 3-Factor and 5-Factor Models

4.3 Correlation Matrix

Figure 4 shows a correlation matrix for all traditional assets, the comprehensive index including all games, and each completeness index. Each game index has a high correlation with all other game indexes, with the exception of the new index, which has a lower correlation with the loose and complete-in-box indexes. All game indexes have low positive correlation with inflation, although this correlation is higher than that seen from the S&P 500. They also have

negative correlation with T-Bills and low positive correlation with both the S&P 500 and gold.

For convenience of viewing, asset returns are included alongside the matrix.

Game and Traditional Investment Asset Return and Correlation Data													
						Correlations							
						Traditional Assets/Measures				Completion and Overall			
	Index Name	Nominal Return (%)	Real Return (%)	Annualized SD (%)	Monthly Sharpe Ratio ¹	CPI	T-Bills	S&P 500	Gold	All Games	Loose	CIB	New
Traditional Assets/Measures	CPI	2.3%		1.2%	0.41	100%							
	T-Bills	0.8%	-1.5%	0.1%		-11%	100%						
	S&P 500	12.3%	9.8%	13.9%	0.25	7%	-21%	100%					
	Gold	4.5%	2.1%	13.3%	0.10	-2%	14%	3%	100%				
Completion and Overall	All Games	12.7%	10.2%	4.5%	0.73	29%	-20%	8%	6%	100%			
	Loose	11.5%	9.0%	5.2%	0.58	17%	-27%	10%	5%	82%	100%		
	CIB	11.5%	8.9%	5.0%	0.59	28%	-17%	3%	13%	84%	67%	100%	
	New	14.9%	12.2%	6.8%	0.57	26%	-13%	5%	-2%	79%	40%	46%	100%

Figure 4: Correlation Matrix and Asset Returns for Video Game Indexes and Traditional Assets

5.0 Discussion

5.1 The Performance of Secondhand Retro Video Games as an Investment Asset

Based on the results of the data analysis, secondhand retro video games are a reasonable investment and perform better than more traditional investment assets. In particular, an investment strategy based on having an equal mix of games of all different completeness levels and from different systems would represent the greatest opportunity. The index containing all games reflects this strategy. This is evidenced by both the real return of 12.7%, which is slightly higher than the S&P 500's value of 12.3%, and significantly lower variation. Additionally, the Sharpe Ratio of 0.73 is almost three times greater than that of the S&P 500. This finding breaks with prior literature examining the returns of collectibles. Secondhand retro video games could not be more different from collectibles analyzed in prior research, as they are less risky than stocks and provide comparable returns. Even if storage and transaction costs for the games were factored into this analysis, they would still prove an attractive asset for potential investors. This relationship holds for the other three indexes as well. However, they are not as attractive as simply choosing to hold a general portfolio of games as they have a lower Sharpe Ratio and only new games result in a greater real rate of return.

The index including all games is moderately positively correlated with inflation, only slightly positively correlated with the S&P 500 and gold, and negatively correlated with T-Bills. These results hold for the three completeness indexes. These findings suggest that while video games may not be much of an effective hedge against anything but T-Bills, they could be a better store of value than the both the American Stock Market and gold. Additionally, the low correlation and high risk premium associated with them suggests that retro games are a good investment from a diversification perspective since they could reduce the risk of a portfolio

without reducing the returns. Due to the low standard deviation of 4.5% for the index containing all games, secondhand retro video games are an increasingly attractive investment for retail investors who want something a bit more interesting than stocks or commodities. In fact, video games compare favorably to more traditional collectible investments such as wine as well.

Burton and Jacobsen's study of the rate of return on wine found that wine typically sees about an 8% annual return, with some vintages seeing returns as high as over 16% (2001). However, wine requires high storage and shipping costs, making their investment potential debatable. Such high costs are not found with video games.

Additionally, the comprehensive game index and the three individual completeness indexes all have a statistically significant alpha of about 0.009-0.012 on a per-month basis according to the CAPM and Fama and French 3-factor and 5-factor models. This suggests that, in all cases, a typical basket of retro video games will outperform the market with significant excess returns over the risk-free rate and the excess returns of the market. However, these models all fail to adequately explain the price performance of secondhand retro video games as an investment asset. Therefore, we can assume there are additional factors explaining the price performance. The RMW beta value of 0.32 for the comprehensive index including all games suggests that this index has lower exposure compared to the market average, which has an RMW beta of 1. Thereby, diversifying one's portfolio with retro games presents benefits even if there may be other risks. This reflects positively on the investment potential of secondhand retro video games.

While not the focus of this analysis, the additional indexes created for the console development companies, each individual console, and each genre do present some interesting insights. Firstly, Sega appears to be the console manufacturer with the highest investment

potential at a Sharpe Ratio of 0.70 and only marginally lower returns than games released for Nintendo consoles. However, this Sharpe Ratio is still lower than that of an index containing all games. Therefore, it is not a good idea for an investor to choose to invest solely in games for one company's consoles.

Secondly, while Sega is the best company overall, games for the Nintendo 64 have the highest investment potential for a single console. The high real return rate of 14.1% combined with a Sharpe Ratio of 0.64 sets it above all other systems analyzed. However, much like for the index of games released for Sega consoles, the Sharpe Ratio is lower than that of an index including all games. So, while the role of set completion may play a factor influencing the prices of games, it is not a good idea for an investor to attempt to contrive this by obtaining all games for a one system (Carey, 2008).

Finally, platformer genre video games represent the highest valued opportunity for any genre. While the real rate of return of 13.09% is not quite as high as strategy or puzzle games, the Sharpe Ratio of 0.78 is significantly greater. This relationship is potentially explained by the genre including some of the most iconic retro games ever, like *Super Mario World* and *Sonic the Hedgehog 2*. However, answering this question would require an additional analysis and is outside the scope of this paper.

5.2 Graphic Trend Analysis

When examining *Figure 1*, one sees the stability of the video game indexes compared to the stock market. While the S&P 500 does occasionally outperform the index including all games, it has significantly higher variability. For example, in early 2020 there was a significant drop in value on the S&P 500 in the wake of the Coronavirus. However, the prices of

secondhand retro video games were unaffected by this and appreciated over the same period. The only game index that saw a significant decrease in value over any period was the steady decline for loose games over 2017. However, this index rebounded and continued to grow alongside complete-in-box and new games.

Unsurprisingly, new games are worth the most, with steady returns consistently outpacing those of all other financial assets examined. There was a significant increase in index value at the end of both 2017 and 2021. The other indexes saw a similar leap over the same period in 2021, suggesting the sales at auction of rare games may have had a trickle-down impact on the prices of games on eBay. The outperformance of the stock market in the same year could be indicative of a potential bubble period for games. However, for the time being, prices for games continue to rise and it appears as if secondhand retro video games both offer short-term and long-term returns and relative stability for investors interested in alternative investments.

In summation, secondhand retro video games are an attractive asset for any investor interested in assets other than stocks, bonds, and commodities. They provide comparable, often greater, returns to the S&P 500 and are much less risky, with a lower level of volatility. This contradicts almost all prior research regarding the investment potential of collectibles. Returns are greater than those calculated by Dimson and Spaenjers and Baumol for British postage stamps and fine art, respectively. However, given the fact that fine art and postage stamps are more mature assets, it is possible that the remarkable returns and low volatility seen for secondhand retro video games will not continue in the long-term.

6.0 Post-Hoc Analysis

The results of the data analysis are interesting for retail investors, large investment firms, and alternative investment platforms. Retail investors looking for a unique alternative to the stock market or inflation hedges like gold and silver are likely to be attracted by the lower volatility, high returns, and personal interest. Large investment firms and alternative investment platforms may want to offer a fund composed of retro video games. Even retro gaming specialist stores may find some benefit to offering curated packs of games that offer good returns at an affordable price.

The analysis performed is by no means comprehensive. It only focuses on a limited number of consoles and ignores home computers with large gaming libraries, such as the Commodore 64, and any systems released prior to the Nintendo Entertainment System, such as the Atari 2600. Additionally, focusing solely on retro games means we exclude games for any console released after the year 2000. Games released for newer systems are still collectible and have appreciated in value over the same time period. Since many of these consoles will be considered retro in a few years, they potentially have the most interesting games from a growth perspective. As the future of gaming seems to be focused on digital downloads on home consoles, computers, and mobile phones, it is unclear how large a time period physical retro games will eventually encompass. It could be strictly limited to the period analyzed in this paper, as more modern releases forgo physical releases altogether. Finally, the dataset utilized lacks many interesting factors that could influence the value of a game. For example, knowing the publisher and developer of a given game would generate more interesting insights. However, while these limitations are present, it provides several interesting directions for future research to take.

One simple path for future research is to provide a more comprehensive analysis including more consoles and more geographic markets. Additionally, choosing to focus on another geographic market altogether could be worthwhile. One potential market could be Japan, which has a strong retro gaming specialty store culture and prefers Yahoo! Auctions to eBay. Additionally, they have different cultural tastes when compared to America. These differences may make data gathering and analysis difficult but could provide an interesting insight into foreign collectors' markets now that there is an American benchmark.

Another potential area of research are game auctions selling high-value games. While this selling channel has recently been mired in controversy over accusations of fraud, it is still a worthwhile target of research due to the substantial difference in sale prices and quality (Kamen, 2021). In many ways, they are almost a completely different category of item in the way original fine art is distinct from a print. Future research could simply examine the returns on these games and how they differ.

However, the most interesting direction for future research would be to determine the best investment strategy for retro games. A hedonic analysis will show what factors have the greatest impact on the price of a game and, therefore, what the best strategy for investment is. The research of Cameron and Sonnabend and Wyburn and Roach provide satisfactory models for performing such an analysis (2020; 2012). Due to the limited scope of this paper and dataset, questions like these are best left for future research papers to analyze.

7.0 Conclusion

The goal of this thesis was to assemble a set of secondhand retro video game indexes, estimate their returns, and compare their performance to more traditional financial assets. To accomplish this, I gathered a robust dataset and performed a data analysis based on methods explored in the existing literature. The results showed that a typical portfolio of secondhand retro video games offers significant, superior returns and Sharpe Ratios to those of traditional financial assets. Particularly when compared to the S&P 500, video games offer comparable returns and lower volatility with an annualized real rate of return of 10.2% and a Sharpe Ratio of 0.73. These findings break with established literature on collectibles, which suggests that collectibles are not an efficient or worthwhile investment. The insights derived from this research are relevant for retail investors, investment firms, and alternative investment platforms looking for potential competitive advantage in a sea of similar offerings.

However, the data I gathered and the analysis I performed are not comprehensive nor do they identify an ideal strategy for potential investors to follow. If future research were to determine what factors most influence the value of secondhand games and create a tailored index to reflect their findings, it may offer a foundation upon which firms could create funds and retail investors could build portfolios. There are still plenty of questions left unanswered that provide exciting avenues for future literature to explore. The results of my research imply that retro video games are not just entertainment anymore – there is serious money to be earned.

Appendix 1: Methodology for Rates of Return and Standard Deviation

Annualized Nominal Rate of Return

The following formula was used to calculate the annualized nominal rate of return for

each index: $\left(\frac{X_f - (X_f - X_i)}{X_i}\right)^{\frac{1}{T}}$, where:

X_i = Initial index value,

X_f = Final index value, and

T = Number of years.

Real Rate of Return

The real rate of return was calculated based on the annualized rate of inflation from the CPI Inflation Index. The following formula was used to calculate the annual real rate of return of

each index: $\left(\frac{(1+R_a)}{(1+R_i)}\right) - 1$, where:

R_a = Annualized nominal rate of return for a given asset/index and

R_i = Annualized rate of inflation.

Monthly Return Rates

Monthly return rates for each index were calculated beginning in the February 2014. The following formula was used each month to calculate the rate of return: $\frac{(X_t - X_{t-1})}{(X_{t-1})}$, where:

X_t = The index value for a given month and

X_{t-1} = The index value for the month prior.

Standard Deviation of Returns

The standard deviation of returns was calculated the sample standard deviation of the returns for a given index. The following formula was used: $\sqrt{\frac{\sum(x - \bar{x})^2}{(n-1)}}$, where:

x = Sample mean and

n = Sample size.

(1) Kenneth R. French - Data Library; data accessed at http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html

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