

Louvain School of Management

Creation of a Classic Car Index: investment considerations,
opportunities and challenges

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Abstract

This thesis investigates the viability of classic cars as an alternative investment. It is the first study to question the well-known index and reference in the field created by The Historic Automobile Group International. We first review past work on the financial analysis of paintings and fine wines. We then address the classic car World as well as a methodical comparison of the hedonic and repeat sales regression. Based on 46.000 auction sales we built our own Classic Car Index with a hedonic regression method. Through this method, we determined the principle price constituents of historic cars.

Our index performed at an average annual real rate of 6.03% for the period between 1980 and 2017. We reported a low beta estimate and low correlations with other asset classes.

The thesis includes numerous other financial analyses and ratios which demonstrate the opportunities classic cars could offer. Especially, we show the advantages of the asset in comparison to other alternative investments such as gold, real estate, paintings and fine wines.

Finally, we investigate the feasibility and considerations at stake of a hedge fund specialised in classic cars.

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List of abbreviations

CAPM	Capital Asset Pricing Model
CPI	Consumer Price Index
FIA	Fédération Internationale de l'Automobile
HAGI	The Historic Automobile Group International
HNWI	High Net Worth Individual
OLS	Ordinary Least Square
PF	Portfolio
RSR	Repeat Sales Regression
T-Bills	Treasury Bills

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Chapter 0. Introduction

Our economy today is characterized by crisis. During the 20th Century and up until now, crisis has followed crisis; the 1929 crash, the oil crisis in 1973, the dot com bubble in 2001, the 2008 subprime crisis, and more recently the sovereign debts crisis amongst others (The economist, 2017). Whilst some of those market downturns were similar, some were completely different and unique. The only sure thing is that they will continue to occur.

We are still recovering slowly from the 2008 crisis. The past years have been marked by aggressive monetary policies characterized by historically low interest rates in order to re-launch inflation and stimulate the economy. During this period of crisis and low interest rates over the past five years there has been an increase in alternative investments (Liu et al., 2017). Alternative investments as opposed to equity, bonds and classic assets in general cover a wide range of subjects such as real estate, private equity, art, wine, collectibles, etc.

Over the years it seems that more and more people are considering classic cars as well. Which is not surprising, since despite the global markets plunging over 30% in 2008, a 1961 Ferrari 250 GT Spyder, was still able to command a price of over \$10 million. Indeed, press releases and the internet are full of articles that promote classic cars as an alternative investment.

“467% returns over 10 years for investing in classic cars” from the Financial Times (Greenhalgh, 2016).

“Forget stocks and shares, the FT and the London Stock Exchange: the truly savvy investor is buying up classic cars” from The Guardian (Macalister, 2013).

“Classic Cars: The Best ‘Alternative Investment’ of All” from Yahoo Finance (Korn, 2013).

The articles above, and hundreds of others have two points in common. The first point, is that they claim good returns. The second, is that they lack actual data and research to demonstrate and prove those assertions. The fact, that an asset attracts so much attention and shows so little methodical analysis compared to the other alternative investments, is the first motivation for this study. One of the reasons could be the difficulty of assessing such a market.

The second motivation is more personal. I worked for a classic car dealer and realised that at a certain point, people were no longer asking for “a black Aston Martin” with dreamy eyes, but rather sought a car whose value might increase over the coming years. I realised that these people were not collectors anymore, but rather investors. Being passionate about the financial markets, as well as classic car history, the idea of combining both appealed to me strongly and grew in my thoughts.

Thanks to a hedonic regression method, this thesis introduces a classic car index. The method has been extensively used to evaluate the painting market. Based on more than 46.000 auction sales, we will methodically analyse the classic car market. This study will be the first to evaluate the whole market. The work will also include two interviews of specialists in this field; a classic car expert consultant for Artcurial, one of the biggest auction houses, and the head of portfolio and funds management at Deutsche Bank. Finally, we will address a more concrete matter; the feasibility of a hedge fund specialized in classic cars including its opportunities and challenges.

The aim of this study is to determine whether classic cars should be taken seriously as an alternative investment.

The thesis will have a methodical approach to the subject. As outlined above, literature on this subject is sparse. So, in point 1.1, we will begin by investigating the painting market which as we will see, has a certain number of related characteristics. Then, as a step closer to the car market, we will review different aspects of the fine wine market. Point 1.2 will present fewer figures and will address the history, attributes, market players and previous financial analysis of the classic car World. Point 1.3 will detail the various methods available to create indices commonly used in literature. We will then detail the aim of the study and methodology, ending with results, discussion and conclusions.

Chapter 1. Literature review

1.1 Collectible assets

1.1.1 Definition and characteristics

This chapter addresses what defines collectibles and makes them eligible to be taken into consideration as alternative investments. A certain number of studies have been published in previous years to investigate the viability of such investments as a portfolio diversification tool. They are summarized below.

According to the Oxford dictionary, a collectible is: “an item valued and sought by collectors” (Oxford Dictionaries, n.d.). In Investopedia, we read that a collectible is an item that is worth more than its intrinsic value. The value is explained by the rarity of the item and a general demand higher than the offer (Investopedia, n.d.).

The approach we will use here, will give emphasis to the attributes that characterise a collectible rather than simply by a definition. Hopefully, these traits will allow us to understand better the potential and limits of this type of asset.

- Tangible assets

A collectible is a tangible asset, which exists in a physical form. It can be touched and evaluated. This is the opposite of intangible assets, such as goodwill patents for example (Accounting Capital, n.d.).

- Illiquid assets

Collectibles can be categorized as illiquid assets. Liquidity assesses the rapidity at which an asset can be traded on the market. More precisely, the time needed to transform an asset into cash without drastically decreasing its price. The more liquid assets consist of cash, T-Bills, equity stocks, and commodities amongst others (Investopedia, n.d.). Collectibles and artworks are typically illiquid due to the time needed to find the right buyer at the right price.

- Inelastic supply

One of the principle aspects of collectibles and which is probably one of the main reasons for their price appreciation over time, is an almost completely inelastic supply. This is defined as a

zero-percentage variation in the quantity offered and a vertical supply curve (Mankiw and Taylor, 2011). Indeed, the very basis of collectibles is their rarity and limited production. When fraud is excluded, the supply cannot increase but only decrease due to loss and ageing, deterioration (physical damage) such as going “over the hill” for wine or being removed from the market by museums. We can add that every piece of art undergoing an increase in value is in short supply. Shortage occurs when the demand for a commodity or item outnumbers the supply (Mankiw and Taylor, 2011).

- Behaviour

The last feature studied here, which constitutes a direct link between collectibles and art, is the part played by consumer sentiment during the purchase of those goods. Ian Robertson (2013), head of art business studies at Sotheby’s Institute of Art said: “Art is a consumer good and a potential investment, but essentially it is a passion investment.”. According to him, the acquisition of artworks is a relationship between intuition, sentiment and analytical responses to prices and others.

Behavioural finance is not a unified theory, but rather a group of studies which aim to verify how psychological traits and bias can influence market prices. Those analyses surged when traditional finance models were unable to explain decision and market situations (Joo and Durri, 2015).

Traditional finance models reside in the modern portfolio theory and the efficient market hypothesis. The gap between the theoretical explanation and actual situation is explained by the irrationality of consumers (Virigineni and Rao, 2017). We expect to find this irrationality particularly among market players in the collectible and art field. In the article “Buying Beauty: On Prices and Returns in the Art Market”, Renneboog and Spaenjers (2013) demonstrate, thanks to a hedonic regression based on over a million auctions of paintings and works on paper, the role of consumer sentiment on art prices. Indeed, they found a correlation between consumer sentiment and art prices. The study reinforces the importance of passion and behaviour when it comes to art and collectibles and will be reported in depth in the point 1.3.

- Collectibles and art

We used interchangeable notions for artworks and collectibles in the last two pages, this should be clarified. Art indeed presents every single property discussed above. However, what is the bridge to be drawn that will allow us to define a collectible as art?

There is neither universal definition nor a structured concept for art. Marcel Duchamp (citation du jour, 2017) defined it as follows: "Je crois que l'art est la seule forme d'activité par laquelle l'homme en tant que tel se manifeste comme véritable individu. Par elle seule, il peut dépasser le stade animal, parce que l'art est un débouché sur des régions où ne domine ni le temps, ni l'espace". A more practical definition would be from Satchell (2009): "any object that is judged to have substantial artistic merit by the community of interest that participates in the study, display, and collecting of objects of the same category".

It remains a personal point of view linked to emotion. We will therefore leave to the discretion of the reader to decide whether classic cars should be considered as art. It is important to keep in mind that for the purpose of this analysis, it is the characteristics above which will be used throughout this thesis.

1.1.2 Types of collectible assets

Literature covering financial markets analysis and classic cars is scarce, although, historic cars themselves are well documented. We will come back to those studies in point 1.2.

For now, despite the few market analyses on cars, we notice many publications on asset classes presenting the same characteristics as discussed above which deserve some attention. This information will give us a strong base for comparison and a path to follow during our own analysis.

We count as collectibles; old coins, stamps, books, antiques, artworks and many other objects. Art can be split by type and period, it is distinguished between fine art and applied art (Jureviciene and Savicenko, 2012). We will start by reviewing studies on fine art and more specifically drawings and paintings. Indeed, paintings were the centre of extensive literature over the recent years.

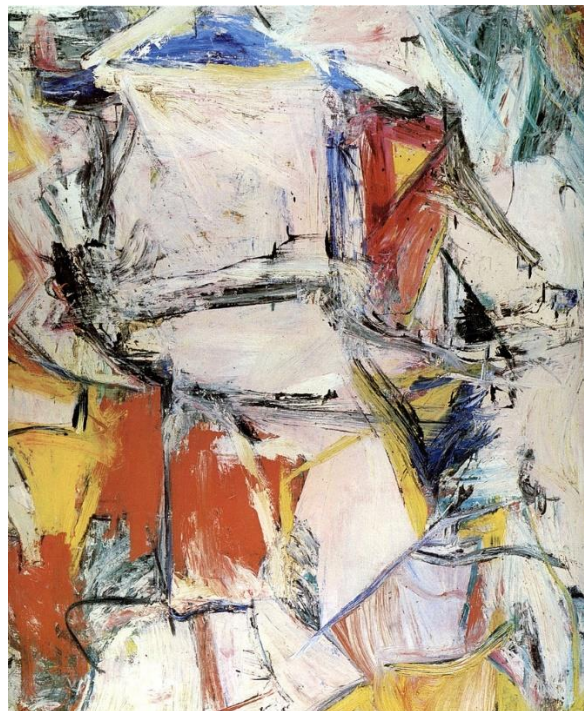
We will then go a step further and analyse wine. Cars and wine present a major difference in comparison to paintings in that they are created to serve a specific purpose and display an intrinsic value when produced, before changing into a collectible or even an art form for some

people. Art in general and paintings have very little intrinsic value and are created without any purpose other than decoration, prestige or emotional need.

- Paintings

The most expensive painting was sold for about \$300 million. “Interchange” by Willem de Kooning is the current auction record achieved in the art World (*figure 1*). The auction took place in 2015 (Barcio, n.d.).

Figure 1: Interchange by Willem de Kooning.



Source: Cho, A. (2014). *Interchange (de Kooning)*. Retrieved June 17, 2017, from Wikipedia:

https://en.wikipedia.org/wiki/File:Photo_of_Interchanged_by_Willem_de_Kooning.jpg

The market size of fine art is difficult to assess. Although auction houses keep a good track of the different sales, the art market presents numbers of private deals due to high transaction costs and people wanting to keep private the change of property. A first good approximation can be found by the sales through Sotheby's and Christie's the two biggest auction houses. An allocation of 75% of their annual sales of \$12 billion has been estimated for fine arts. The yearly fine art turnover in dollars in 2007 amounted to above 12 billion (Kinsella, 2008).

According to the yearly review from art index auction houses, turnover in 2015 in fine art was estimated around \$16 billion, again excluding private deals (Artprice.com, 2015).

Paintings and their value can be defined and explained by a number of attributes. Here are the main ones that were tested by Goetzman, Renneboog and Spaenjers (2011) thanks to a hedonic regression. First, the name of the artist and the fact that he is alive or deceased defined a painting. Second, the period and region are important. Other secondary criteria such as size or colour will also be considered (Satchell, 2009).

The first study was made by Anderson (1974). Thereafter, more than 20 studies followed, using several different indices.

- Wine

Moving a step closer to the classic car asset class, we will study the fine wine market. Wine is actively traded on the primary and secondary market and up to 4.000 different fine wines were traded in 2016 according to Liv-ex (Liv-ex, n.d.). We will define here the different characteristics of the fine wine market and the factors to consider when measuring wine as an investment asset. First, as for cars, wine when produced, comes in a series and is therefore not unique. Moreover, when produced, the bottles have a value and a utility purpose. These two aspects make the wine industry fundamentally different from the painting market. If the wine is not destroyed, drunk or corked, it can be held as a collectible. It will then hopefully increase in value. Let us nevertheless bear in mind that like cars and real estate, wines even if kept as an investment and no matter how the market is going, will maintain an intrinsic value and can still be drunk and appreciated. Wine is considered as a luxury good; its price being explained by its increasing rarity. Good wines can remain suitable for consumption up to an age of 80 years and can achieve remarkable prices (Satchell, 2009). As Satchell (2009) reported: “For example, a single case of Cheval Blanc 1947 was sold at Christie’s in 2007, 60 years on, for £75.000.”

The value is of course driven by demand and consumption. However, other traits determine the value and need to be considered. The first ones, described above, namely; utility, rarity, luxury consumption goods and expiration date were provided to us by Satchel (2009). He informed us with a last one, which is consequent fees and commission linked to the holding and selling of wine. The commissions are generally between 10-15% on top of which fees need to be added such as storage, insurance and others (Satchell, 2009).

The other factors to consider for the value of a bottle are provided by Ashenfelter, Ashmore and Lalonde (2009) in their work entitled “Bordeaux Wine Vintage Quality and the Weather”. They demonstrate in their work, that the later price in the secondary market of a good vintage

is strongly related to a small number of characteristics. Firstly, attributes directly linked to the quality of the wine are fundamental. Starting with the location of the vineyard, which in Europe needs to be near good sources of water, on South facing slopes and with good soil drainage. The weather during the growing season is also a significant factor. It needs to be dry during September and August and the period following needs to be warm. The winter preceding the growth season should be wet. Last but not least, the quality of the grape itself will affect the quality. On the matter of price, we will note that the age of the bottle when sold and the name of the wine estate play a significant role (Ashenfelter, Ashmore, and Lalonde, 2009).

1.1.3 Financial analysis

This part will review past work on comparative collectibles. It will be structured as follows: first we will give our attention to the results of the art market over the last century, then we will review the correlation of those artworks with the market and their diversification opportunities. Moreover, still monitoring correlation, some authors have studied the link between the increase of wealth and the appreciation of prices. Finally, we will address the matter of the masterpiece performance which has been questioned during recent years.

The first notable study was carried out by Anderson (1974). An index was created and regressions were done to determine the price appreciation factor of art. Since then, numerous studies have been published on fine art, mainly paintings and prints. Researchers have created different types of indices to monitor and assess art as a financial asset. In the following part, we will summarize the principal works and especially the ones relevant with what we want to demonstrate in this analysis. We will see that many of the publications present bias and rather heterogeneous results, when it comes to evaluating art. It is difficult to define which work is the more accurate. Therefore, we will attempt to capture and create some trends from the different results.

To measure art performance, two types of index creation methods are mainly used; a Repeat Sales Regression (RSR) and a hedonic regression. These types of indices will be extensively analysed in point 1.3. But for now, let us just note that for a RSR, the piece of art needs to pass through the market at least twice to be taken into account. This limit can be countered with the hedonic regression.

Authors who used those indices and who will be reported in the next pages are the following: Anderson (1974), Stein (1977), Baumol (1986), Pesando (1993), Goetzman (1993), Pesando

and Shum (1999), Mei and Moses (2002), Ashenfelter and Graddy (2003), Ginsburgh et al., (2005), Campbell (2008), Goetzman, Renneboog and Spaenjers (2011), Renneboog and Spaenjers (2013). These studies give us insights on the art market such as; results, volatility, and correlation with other asset classes.

These indices are usually based on public traceable auction prices due to the difficulty of ascertaining data on private deals. Some of these indices go back 300 years, for which auction records were the only available traces. The article “Auctions and the price of art” by Ashenfelter and Graddy (2003) gives us a good understanding of the way auction houses work. Before the sale, an initial reserve price is determined by the seller. It represents the utility of the seller between selling immediately or waiting for the next sale which is usually around 80% of his lowest estimation. Bids start low and buyers offer increasing bids. When the biddings stop rising, the item is “hammered down”. Not all pieces of art that are presented at the auction or hammered down are sold. Due to the reserve price which is kept secret, some items will return to the seller. The auctioneer will bid on the behalf of the seller to start the auction but will always stop before attaining the reserve price. It is important to stress that auction houses are entitled to heavy commissions of up to 30 % of the total of the sale figure. These commissions and fees are supported by both the sellers and buyers (Ashenfelter and Graddy, 2003). Please refer to the appendix (appendix 1) for typical rules and regulations of an auction, in this case a Bonhams classic car sale.

According to Goetzman (1993), the allocation of sales could amount to as much as 50-50 and up to 70-30 for private deals and auction sales respectively Furthermore, Ginsburgh and co-workers (2005) estimated this distribution to be even more unequal, of up to 80-20. However, auction prices should be representative of the market and can be used as a benchmark (Renneboog and Spaenjers, 2013). That is our first source of bias and cause of differences between the actual market and most of the indices. We will see throughout the analysis other bias specific for the market and indices.

- Returns

Once an index is established, it is possible to compute an annualized return for the market. These returns need to be adapted and linked to inflation. This is generally achieved through the deduction of the Consumer Price Index (CPI) or another factor that can be used to measure the

inflation. The prices are converted according to records of currency rates when a painting is sold abroad. The real returns of the most significant studies are reported in table 1.

Table 1: Summary of fine art returns						
Author	Year	Sample	Period	Type of index	Nominal return	Real return
Anderson	1974	Paintings	1780-1960	hedonic regression	3,30%	2,60%
			1780-1970	repeat sales regression	3,70%	3,00%
Stein	1977	American paintings	1946-1968	average prices	10,50%	
Baumol	1986	Paintings	1652-1961	repeat sales regression		0,60%
Pesando	1993	Prints	1977-1991	repeat sales regression		1,50%
Pesando and Shum	1996	Picasso prints	1977-1991	repeat sales regression		2,10%
Goetzman	1993	Paintings	1716-1986	repeat sales regression	3,20%	2,00%
Mei and Moses	2002	American, impressionist and old masters	1875-2000	repeat sales regression	12,81%	4,90%
Ashenfelter and Graddy	2003	Modern and impressionist	1980-1991	hedonic regression		4,00%
		Modern and Impressionist	1980-1991	repeat sales regression		9,00%
Campbell	2008	Old masters, European impressionist, modern and contemporary	1980-2006	repeat sales regression		6,50%
Goetzman et al.	2011	Paintings	1830-2007	repeat sales regression		2,97%
Renneboog and Spaenjers	2013	Paintings and works on paper	1957-2007	hedonic regression		3,97%

As discussed previously, most of the prices were taken from auctions. The differences between calculated real returns will be explained by the data used, the period, the bias and the type of index.

The first study by Anderson (1974) was deducted from the transaction of more than 1.500 paintings between the years, 1780 and 1970. Using both a hedonic regression and a RSR, he found respectively a 3% and 2,6 % real annualized return. Anderson states that the low results might be explained by the wide range of the period studied, which wrote off the recent rise in the value of art. Price determinant factors were covered as well. Anderson's study states a statistical significance to the price contribution, of the size, the year of sale and of the artist's merit. Other factors such as the age of the artist, whether he is still living or deceased, or the

name of the auction house were not significant. Another interesting fact is the small difference between his two indices (Anderson, 1974) that supports the findings of Olivier Chanel, Louis-Andre Gerard-Varet and Victor Ginsburgh (1996), which over the long term showed a strong coherence between the results from hedonic regression and RSR. Like Anderson (1974), Baumol (1986) based his work on the Reitlinger book which gathered all the public auctions data since the 17th Century. The book entitled “the economy of taste” in three volumes, reported auction prices on artworks chosen subjectively by Reitlinger, who assessed which artist was either fashionable or classical. It is not stressed where the early sales came from, but probably from sellers reports which could be a source of mistakes (Renneboog and Spaenjers, 2013). The prices are expressed in British pounds. Other authors such as Goetzman, Renneboog and Spaenjers (2011) used this book also as a basis for their work.

Baumol (1986) through 640 pairs of transactions during the period 1652 to 1961 assessed an annualized return of 0,6%.

Goetzman (1993) who used the same data source expanded it by adding information from Enrique Mayer and his book: “International Auction Records”. He obtained a real return of 2% between 1716 and 1986. This author acknowledged a selection bias since only pairs were taken into account. This bias will be analysed in point 1.3. Another bias is due to the illiquidity of the market. The number of transactions is already low and we can speculate that in a context of rising prices, owners will tend to hold on to their possessions. Moreover, on the contrary, some masterpieces are bought by museums or collectors to be kept and never put on the market again. Their possible increase in value will therefore not be considered.

The work of Pesando (1993) was carried out with the idea to counter those limits. Instead of using paintings which are each unique, he used modern prints in limited editions. That allowed him to have 50 to 100 items for a single artwork. The market was more active and it encountered the challenge to find pairs of transactions. Between 1977 and 1992, the results were computed on 27.961 repeat sales from 28 artists, in comparison to 640 scarce transactions over a 300-year period for Baumol (1986). A mean annualized return of 1,51 % was found for his prints portfolio (Pesando 1993) and 2,1 % for his Picasso portfolio (Pesando and Schum 1999).

On the matter of paintings, “Art as an Investment and the underperformance of masterpieces” is a key study in the literature (Mei and Moses, 2002). The authors used art price records from the New York library and the Watson library at the metropolitan museum to succeed in composing a database of 4.896 prices between the years 1875 and 2000. The indices and plotted

results are still in use today and acknowledged by other authors as one of the most accurate indices like the “Art Market Research Indice” (Campbell, 2008).

Mei and Moses (2002) created three sub-indices split by movements; American, impressionist and old masters. Their results were plotted above the existing works with a real annualized average return of 4,9%. They split their study by period also and noticed a strong rise in art prices approaching the 1980s, as predicted by Anderson (1974).

Campbell (2008) based his analysis on the art market index, which allowed him to derive monthly data during the period 1980-2006. His field of study was also divided by style of art. The lowest annual real return was for the old masters with 5,5%, and 7,5% for modern art which was in pole position.

The last study we will review is the article “Buying beauty: On prices and Returns in the Art Market” from Renneboog and Spaenjers (2013). Thanks to the art sales index online database, and the sales reported in the Reitlinger book, they put together a total of 1.088.709 sales between 1957 and 2007. They arrived thanks to their hedonic regression at a real annualized rate of 3,97%.

Most of the returns plotted above are what we could have expected from corporate bonds and T-Bills over the last years, estimated at 2,2% and 1,9% respectively of annual return by Mei and Moses (2002).

However, we need to categorize and compare this asset class by considering its risk. Moreover, as we stated before, transaction costs which are consequent and up to 25%, were not considered (Ashenfelter and Graddy, 2003). In the next point, we will take the volatility into account and use the Capital Asset Pricing Model (CAPM) to give a complete review of the investment class.

- Market Correlation

The volatility captured by the standard deviation of different indices has been monitored through the different works. Starting with Anderson (1974) and a standard deviation at 56%, this would set art as a very risky asset and a poor investment considering his plotted results. Other authors went further in their analysis and estimated a CAPM as we will review in a subsequent analysis.

Since Anderson (1974), Pesando (1993) with his analysis of modern prints got a 19,94% standard deviation for his prints portfolio and 23,38% for his Picasso portfolio (Pesando and Shum, 1999). The lower volatility was explained by the size of the sample, allowing a better diversification.

Campbell (2008) obtained for the different movements, more reasonable results, with a minimum of 7% for old masters and the more volatile “European impressionists” at 15% (Campbell, 2008). Renneboog and Spaenjers (2013) with their million sales reinforced those results, obtaining 15% standard deviation as well. They explained the differences by an increase in the quality and quantity of the sample as well as an improved selection of artwork, demonstrating better diversification.

Goetzman (1993) did not test a CAPM but introduced the idea in the field. He stated:” While impressive, this growth in art prices was accompanied by high volatility, and there were strong positive correlations to other assets, especially stocks”. Stein (1977) was the first to conduct a CAPM. His tests on the European market were not conclusive, but his analysis on the US market was statistically significant. Using the Fisher Index, which included every single stock traded on the New York exchange as the market, he found a beta of 0,82. This confirms the assertion by Anderson (1974), that the stock would evolve in the same way as art prices. Although, we can note that it represents a slightly lower systemic risk than the market (Stein, 1977). The next study in line was from Pesando (1993). He found a lower systemic risk for modern print portfolios at 0,315 and 0,430 respectively for modern prints and Picasso (Pesando and Shum, 1999). He based his CAPM on the Standard and Poor’s 500 Index. Mei and Moses (2002) used the S&P500 as well and assessed a 0,718 beta, statistically significant. These studies corroborate the fact that art prices move in the same way as stocks but with less systemic risk than the market. However, it is not all black and white. Other studies did not show an impact of stocks on art prices. Using the Vector Auto regressive model, Ginsburgh and Jeanfils (1995) suggested no influence of the stocks on art prices in the long run, but noticed an influence in the short term. These results are put into perspective by the study of Chanel (1995), as well as the one from Worthington and Higgs (2003), using the same method and showing an impact with a time lag.

In summary, the results are generally plotted slightly above corporate bonds and T-Bills with a volatility which is what we could expect from stock equity. Please refer to tables 3 and 4, at the end of point 1.2, for a global overview of the data including wine and classic car analyses.

The correlation between art and other asset classes was intensively investigated to possibly demonstrate a portfolio diversification tool. Campbell (2008) found that within corporate bonds, equity bonds, real estate, stocks and commodities, there was a small correlation in general. A maximum of 9% was found concerning the monthly correlation with future commodities. This small correlation supports art in a portfolio to achieve a better diversification.

On a matter external to the market, numerous articles have investigated the link between luxury goods and art. Their hypothesis was that more than being dictated by stock markets, art prices would be driven by consumption and demand. We will review three studies by Aït-Sahalia and colleagues (2004), Hiraki and colleagues (2009) and Mandel (2014). This will provide us with an introduction to our next point which will be a review of the impact of the increasing wealth on the art market. The first study demonstrated an important link between luxury consumption and the stock market (Aït-Sahalia et al., 2004). Moreover, the second study enlightened us to the fact that this previous hypothesis holds and is valid for the art market (Hiraki, et al., 2009). Finally, the last study, reinforced the idea by saying that art is a luxury consumption item and consumption is the principal influence of a purchase decision (Mandel, 2014).

Although stock and art have been intensively studied, the relationship between the increase in wealth and the demand for art has not. In a recent publication, Goetzman, Renneboog and Spaenjers (2011) addressed this issue. They first constructed a long-term index based on their previous work in 2009 and on the Reitlinger book to plot art prices. On the wealth side, they created a model to determine the increase in capital and income over time. Their purpose was twofold, first to show the relationship between income and prices of artwork; secondly, to capture the link with inequality. This study differs from the others, due to the assumption that collectors buy artworks out of their income and not from capital. Results showed a strong impact on art prices, explained by the increase in the stock market which was used to monitor wealth. The results held when the period 1830-2007 was split. Then, evidence was found of an impact of inequality for the period pre-second World War but not statistically significant for the second period. They concluded by emphasising that evidence actually shows that it is wealth that drives the art market (Goetzman, Renneboog, and Spaenjers, 2011).

- Masterpiece effect

Finally, the last aspect of the relevant artwork to be reviewed is the so-called masterpiece effect. Starting from this famous quote from Edward Merrin (1988): “It’s always better to buy one \$10.000 object than ten \$1.000 objects, or one \$100.000, object if that is what you can afford than ten \$10.000 ones”. This would follow the logic of the article by Rosen in 1981 ((Rosen, 1981) quoted in (Renneboog and Spaenjers, 2013)):

“a small number of superstars earn large amounts of money, and increases in demand make the earnings distribution ever more skewed. A condition is that there is “imperfect substitution among quality differentiated goods”. This is certainly the case in the art market: “ten mediocre works do not add up to a single masterpiece””.

In short, it should be more rewarding to invest in the very best artworks, which are characterised by the most expensive ones, to achieve better results with less risk. The statement implied an over performance of the so-called “masterpieces” or “superstar” assets.

We will focus on the works of Pesando (1993), Goetzman (1993), Ginsburgh and Jeanfils (1995), Mei and Moses (2002), Ashenfelter and Graddy (2003) and Renneboog and Spaenjers (2013). As seen before their studies varied in terms of periods and samples. The methodology remains quite similar amongst those authors. Portfolios are split in parts based on the prices of the different artworks. We then evaluate the two extremes, the highest and the lowest. The first following studies found no underperformance evidence due to the masterpiece effect during their period, or at least not statistically significant. Ginsburgh and Jeanfils (1995) during the period 1962-1991, found no effects with their sample split by painting movements. These results were confirmed by Ashenfelter and Graddy (2003) for a comparable period; 1980-1991, but only for the impressionist movement. Goetzman (1993) who studied paintings in general during a longer time frame (1897-1987), showed no effect either. Finally, Renneboog and Spaenjers (2013) obtained a return slightly higher for the masterpieces though not statically significant. On the other hand, authors have proved a significant underperformance by masterpieces. Pesando (1993) with his modern prints, found an average of 11% lower returns. For a similar period, between 1982 and 1994, Ashenfelter and Graddy (2003) found an even lower return, down to 50% less for masterpieces compared to contemporary art. Finally, Mei and Moses (2002) came to the conclusion that during the period 1875-2000, the more expensive a painting, the lower return it would offer. A 10% increase in price would be translated by a 1% lower return.

Here below in table 2, we can see a summary of the masterpiece effect.

Table 2: Summary of the masterpiece effect				
Author	Year	Sample	Period	Masterpiece effect
Goetzman	1993	Paintings	1897-1987	No effect
Pesando	1993	Prints	1977-1991	Underperformance
Ginsburgh and Jeanfils	1995	Paintings	1962-1991	No effect
Mei and Moses	2002	American, impressionist and old masters	1875-2000	Underperformance
Ashenfelter and Graddy	2003	Impressionist	1980-1991	No effect
Ashenfelter and Graddy	2003	Contemporary	1980-1991	Underperformance
Goetzman et al.	2013	Paintings	1830-2007	Slight effect, not significant

- Wine

Although the literature on the fine wine market is less extensive than the one for paintings, some authors have shown interests in measuring the attributes of such an investment. Briefly, we can observe that the studies shifted from a general fine wine analysis, to Bordeaux wine related works. Indeed, the Bordeaux' market share is clearly the principle one in the industry, and since these wines definitively need more time to mature, it makes them ideal candidates for investment (Krasker, 1979).

We will start by reviewing the works of authors on results and volatility. Then, taking a step further, we will summarize the advantages of wine in a portfolio for diversification, notably using the CAPM. Finally, a few studies took an interest in diversification within the wine market itself.

The first to monitor the return on wine was Krasker (1979), using data from the annual Heublein wine auction. He succeeded in collecting 140 observations during the period 1973-1979. He focused on Bordeaux and California Cabernet Sauvignon, and found annual nominal returns below what we could have expected from investment in Treasury Bills. The study was rapidly followed by Jaeger's one (1981), where a comparable method on the same sample was used, but with an expanded time frame and number of observations. For the period between 1969 and 1977, he had 190 observations. His results showed differences when plotting returns above the ones for Treasury Bills.

From there on, studies started to use more extensive samples. Ashenfelter et al., (2009) obtained a real return of 2,4%. They started using a RSR, comparable to the one shown in the previous point on paintings and they increased the time frame. Burton and Jacobsen (2001) between 1986 and 1996, found a 3,1% real return on red Bordeaux, not far from the rate found by Ashenfelter

and colleagues (2009). They used the wine price file of William Edgerton, who collected extensive data from major auction houses throughout the World. The annual average rate of Treasury Bills during the same period was 5,8%. The standard deviation of 13,3% for wine was above the Dow Jones and Treasury Bills at respectively 7,9% and 0,8%.

Devine and Lucey (2015) analysed returns based on the database of the Chicago wine company of 335.000 auction sales and obtained a 5,2% annualized return with a 9,1% standard deviation.

The following studies, explore the diversification of the wine market using amongst others the CAPM. Sanning and Shaffer (2008), for the period between 1996-2003, recorded 13.662 wine asset returns. They acknowledged the fact that the period is relatively short to compute correlations with stocks, and showed that standard pricing models are not sufficient to explain the prices of wine. They split wine by type and age, and found returns between 6,2% and 11,1% with a beta around 0.

Similar to the study by Devine and Lucey (2015), Masset and Weisskopf (2010) used the Chicago Wine company database, and confirmed the previous study with a low beta related to the Russell 3.000 Index for the period 1996-2009. Moreover, they assessed the diversification benefits of the assets by computing volatility tests on portfolios with some including wine and others excluding them. However, their beta results were not confirmed over an extended period. They explained this by the fact that the stock market could after all affect the wine market but with a time lag. Finally, they determined a high heterogeneity within the market. This heterogeneity was corroborated by Kourtis et al., (2012). They demonstrated within a portfolio of wines, the advantages in diversifying between countries, and especially Italy, Australia and Portugal.

The results reviewed above are summarized in tables 3 and 4 at the end of point 1.2.

1.2 Classic cars

1.2.1 Introduction

Since the first steam engine automobile that was drivable by people in 1769, a passionate and rich history has evolved. An entire book dedicated to the subject would be required to cover its rich history, particularities and subtleties

It is a long story for over slightly more than a Century. In fact, this period is marked by an impressive evolution with many stepping stones and achievements along the way.

This was made possible by the contribution of various countries, famous car makes both current and no longer made, research teams, entrepreneurs, businessmen, engineers, and many more.

Cars were usually associated with wealth and reserved for the upper class at the beginning of the 20th Century. Since the manufacture of the modern car, either being Karl Benz's patent in 1886 or the earlier steam road model in 1873, designed for passenger' transportation by a French man, the field has been the centre of attention and has never lacked funding.

Interestingly, and one of the rare peculiarities of this industry, is that since its beginning it has always reflected the progress of society. This progress is observed in various fields. When telling the automobile story, we must include these discoveries.

In science for example, the invention of the combustion engine happened in 1859, and the steam engine invented in 1968 by Thomas Savery. Also, the invention by François Isaac de Rivaz in 1807, of an engine working by burning fuel inspired the invention of the petrol engines we use today. Of course, one cannot leave out electrical cars which are becoming more popular nowadays. The first electrical powered automobile goes back to 1828, and became quite a success in the late 19th Century. The concept of a mini-nuclear reactor to power a car was even considered at one time. In 1908, Henry Ford pioneered mass production assembly lines in the car industry and influenced modern manufacturing and the indexation of wages and salaries. This model later inspired the Keynes' economic policies and became known as Keynesian economics. The evolution of technology always been a large part of the automobile World. The best example demonstrating this point is to look at the actual market and where it is heading. The car as we know it today is highly likely going to change dramatically over the next 50 years. Artificial intelligence even at its beginning is being used, and other sectors are evolving to build self-driving cars (Gao, Hensley, and Zielke, 2014). To address environmental

challenges, the ownership and use of cars is being rattled as well. Soon, multi-ownership cars and “pay-to-use” models, will progressively gain ground and become the norm.

The first automobile race took place in the United States of America. There were two participants and the winner of the 323-kilometres race, made it in 33,27 hours. Since then, the competition has been fierce, on race tracks, in car factories, and for car market shares.

Today the classic car market is more active than ever. Financially speaking, the size of the market is difficult to estimate. The first difficulty is due to the limits of the market and what makes a car eligible as a classic. Secondly, as covered above for the art market in general, many sales are done privately due to high transaction costs and the wish of owners for discretion. Despite these difficulties, the “Federation International des Voitures Anciennes” (FIVA) estimated an annual 16-billion Euro turnover, for the classic car industry in 2015. The Historic Automobile Group International (HAGI) research group, made estimations using two different methods of extrapolation. Starting from a small portfolio and number of sales, they expanded their results to a World level, and estimated for 2013 an annual sale of \$2,9 billion. The number of events related to the classic car World has skyrocketed over the last two decades. We can count numerous historic races re-created, massive auction events, exhibitions and car rallies.

We discussed above the difficulties in setting the limits of the classic car market and in deciding which cars are eligible.

Regulations often define antique and classic cars simply by the age of the car. For example, in the USA, even though it is a state level decision, on average a car can apply for antique status if it was produced more than 25 years ago. This is from a legal point of view and for tax purposes. One must understand that when a classic car is bought, we are not only buying four wheels and an engine. We have noted above that the value of a car is influenced by its provenance and history. However, there are many more aspects to be considered in understanding these assets.

In this part, we will first attempt to define what makes an old car a classic car. Then we will analyse the market environment including the different market players. Finally, we will review the different financial analysis done on the subject.

Several books and references inspired the introduction above and were used to write the next section, we count the FIVA (FIVA, n.d.), the books; “The life of the Automobile: The Complete History of the Motor Car Hardcover” (Parissien, 2014), “The Classic Car Book: The Definitive

Visual History” (Gurdon, Long, Noakes, and Quiller-Rees, 2016), “Better than gold investing in historic cars” (Hatlapa, 2014), “Ces voitures qui font rêver” (Nichols, 1987).

1.2.2 Classification and characteristics

Cars demonstrate the same characteristics as other general collectibles which were discussed in the point 1.1. Here, we will develop some of those attributes and complete the analysis in point 1.1 by adding some specific ones to the classic car market. We will differentiate characteristics that allow us to categorize the different cars and the ones that will play a role in deciding whether the car enters the category of classical and iconic cars.

Indeed, as we saw in the previous point, historic cars are defined by the age of the car. But for this study we will pay explore other attributes in order to qualify as a collectible, and as an investment.

Our first and last point of this review is to acknowledge that we can analyse every part of a car; the engine, the clutch, the body etc. But in the end, it remains a matter of personal taste and choice: “There is not a car here that someone, somewhere, would not want to own and drive, or simply to possess, perhaps restore, and feel proud of its historical significance” (Gurdon, Long, Noakes, and Quiller-Rees, 2016).

Following the logic of most countries and regulators, the first two categories that enable us to classify cars are geography and period of manufacture.

- Geography

Today, most countries possess or had at a certain point their own car makes even though the industry is currently characterized by huge conglomerates. However, in the field of classic cars, we can easily show that only very few regions in the World have been key players.

Western Europe, including Germany, Italy, England and France amongst others, has been the principle place for car manufacturing. The United States, and later Japan can be included.

- Period

To enter the classic car category, the period is commonly used around the world. In the United States, for example, the Classic Car Club of America, defined eligible classic cars as “distinctive” or “fine” cars produced between 1915 and 1948 (Classic Car Club Of America,

n.d.). In the United Kingdom, the Royal Automobile Club, has its own distinctive categories; Veteran cars before 1903, Edwardian cars between 1904 and 1914, Vintage cars between 1919 and 1930 and Post-Vintage between 1931 and 1939 (Royal Automobile Club, n.d.).

Nevertheless, some of these rules were created years ago, which means that new cars should now be considered in new categories. For this study, we will segment the market per decade as follows: 1900s, 1910s, 1920s, 1930s, 1940s, 1950s, 1960s, 1970s, 1980s and 1990s. We will base the appellation “classic cars” for every car that will generate either an interest to be collected or invested in. Once the country and period of the cars have been assessed, the type of car deserves some attention.

- Type of car and purpose

As we saw in point 1.1 for wine, a car is not initially a collectible asset or an investment since it was built with a purpose. Cars were built as a means of transport or for racing. We can thus distinguish; sports cars, racing cars, road cars, luxury cars and prototypes.

- Makes

The make of the car is one if not the main determination of the attributes of car. Today, if we look at the collector’s market, 80% of the market value is represented by 20 different makes that share the market (Hatlapa, 2014).

The importance of a make is dictated mostly by its history and racing pedigree over the years, as we will detail below, as well as the dynamism of today’s brands with a steady flow of new models. The main car makes are opening museums, clubs and even attraction parks, such as the “Volkswagen Autostadt” (Autostadt, n.d.) to sustain interest.

Two of the most iconic makes acknowledged for classic cars are Ferrari and Porsche. Both demonstrated a strong and on-going “palmares” in the racing world.

Probably one of the key factors that drove prices of these makes today is that Porsche and Ferrari were experts at producing an extensive number of limited editions. This is a major factor in the appreciation in value, sometimes soon after production. This aspect leads to our next point. Now that the cars can be correctly characterized, the following criteria are directly linked to what makes a specific car a collectible item.

- Production

Like other collectibles, the first way to monitor price valuation and determine where a car stands is to look at the number of cars for a specific model. Indeed, even if the demand grows exponentially for a specific model, if the car was mass-produced the chance of a big increase in value is small.

Production and so supply are limited; the supply is almost completely inelastic. Thus, the market is only driven by demand. However, one trait very specific to cars is that sometimes there are more products than the actual production number. Indeed, sometimes car parts are used to build a new car, claiming that it is original; this is fraudulent.

A key factor related to supply, is the survivorship of cars. As for wine, cars have an expiry date. In exchange for large amounts of time and money, cars can be restored back to good condition and kept alive. However, an authentic and correct restoration should not give a result better or different than when the car was released from the factory, which requires precise research. Moreover, the car needs to follow the current safety regulations. When one considers these different factors, an amateur must show a considerable personal interest, or be expecting a serious increase in value, to justify the costs in money and time. Many cars will just be left to rust or be forgotten. Fraud as we saw above, and occasional barn findings are the only way the supply can increase. Most of the time the supply decreases, either by cars being destroyed or being definitively removed from the market by museums for example. This creates a rarity subject to value increase.

The categories used in the industry are the following: mass market production with one million or more produced, high production with more than 10.000, low production with fewer than 10.000 and small production with less than a thousand. Then, we have the rare cases, with less than a hundred, super rare, with less than 30, and finally ultra-rare, with only a few units.

For example, as of today, Ferrari has made more than 300 different limited series models since 1940.

The next points also give a strong explanation of what makes cars desirable as collectibles. First the importance of the history. We saw in the introduction, the strong history that classic cars carry with them. A second key factor is of course the racing World. Finally, events today are equally shaping the market.

- History

When a classic car is bought, it carries with it a time and a lifestyle. We have already detailed its history in general, but we will assess relevant details of history which can influence the market today. Classic cars have always been an exclusive item reserved for the wealthy. People who purchase them now, are simply pursuing a long-time youth dream or travelling in time to this period. Being exclusive items, those cars were often driven by celebrities of the moment. Models of cars which were driven in famous movies, or by celebrities, were often most wanted. Sometimes, a precise car was owned by a celebrity, increasing its value. Documents and proof of ownership are therefore highly valuable in this specific World.

- Sports

There was initially no distinction between road cars and racing cars. People wanted to buy cars that were performing well on tracks. The car races were actual exhibitions of the latest evolution and were popular events at that time. The success of brands during those races was strongly linked to the popularity of the brand. Today F1 and racing cars are so different from road cars that the impact is much smaller.

As discussed, the history linked to classic cars is marked by numbers of races which define today's most iconic makes. At the time, some regulations and norms for the cars were in function. Some of those races are still re-created today with their own rules, which are for most of them determined by the Fédération Internationale de l'Automobile (FIA). This creates another way to classify vehicles. The easiest way to differentiate categories is by engine type and power. Historically, three categories were used: Grand touring, Sports cars and Grand prix.

- Lifestyle and events

The numbers of events today have exploded. The FIVA estimated the number of events across the World at 265.000. Just in Europe, we can count more than 2.000 clubs. When it comes to inscriptions, many of them are prestigious, very expensive, as well as elitist. The ownership of a specific historical car can often be an entry ticket to a club or event. We can differentiate two types of events. First, we find the same historic events that were pursued or recreated. Second, we stress the apparition of new events to gather classic car enthusiasts. In the events we count: racing, concours, rally, sales auction, shows, exhibitions, fairs and parades. Amongst the most famous events we count: Amelia Island, Retromobile, Monterey, Palm Springs, Pebble Beach,

Goodwood, Artcurial Paris, Greenwich, Bonhams Paris, Spa Classic, Knokke Heist et Les Grandes Marques à Monaco (F. Tasiaux, interview, July 26th, 2017) (appendix 3.1), a more detailed list can be seen in the appendix (appendix 4.7).

As we stated, classic cars share numbers of characteristics with fine wines, we detailed the fundamentals of such items already. Both are characterized by an intrinsic value and immediate value when produced due to their utility purpose, before any price appreciation.

- Intrinsic value

Advanced technology comes with a price. Before Henry Ford, every single car was reserved for the well-off. Even after Fordism, the classic cars as known today, were still expensive. Contrary to paintings, for which the intrinsic value is more or less equal to the frame of the painting. Moreover, for limited editions it was not rare that those models were handcrafted and that the materials used were some of the finest of the market. Artists were often summoned to design the body and the interior. Even if the car did not increase in value, most of them would still have an intrinsic value today for the chosen materials. Some car constructors maintain this idea, even if most of the work is industrialized. Each Aston Martin for example, is signed by the engineer in charge of the final inspection on a plate which is attached to the car.

- Personal perception

The two definitions given in point 1.1 for collectibles shed light over two aspects. First, a collectible by definition is an item collected and sought by collectors. Second, the item is more valuable than its intrinsic value. Which in fact can depend on a single individual.

We quote here of one of the dealers in Belgium; Gerard Dulait (British and Sportscars) when asked if there was a real market for a specific model that he was selling. At the time, he replied: “we do not need a market, we just need one buyer”.

To fulfil this definition, we only need one person to enjoy, buy or collect a car. The emotion of an enthusiast could be triggered by various factors including the year, a colour, or the noise of the engine, which would be enough to guarantee a sale. We can set categories and criteria to help us identify what will make a classic car a collectible. Not every car will be able to apply as a classic car. However, it remains a personal and subjective matter, and it is in the end, the amateur who will define the cars value.

Thanks to these various criteria, a clearer image of what defines a classic car is now available. The attributes listed above are not guaranteed to be influential factors and price determinants but there is a high chance that they will. In any case, they will be useful to sort different cars.

1.2.3 Market players

The first two categories consist of car owners namely, the collectors and the speculators. Nevertheless, it is not rare that a collector has also some financial interests, or that a speculator simply enjoys cars.

- Collectors

The first big collector group is the museum. The FIVA estimated that there were 700 transport museums in Europe alone. Another major group is the private collectors. This group is mostly related to the speculator's category. Finally, we can count all the individual owners. A collector that is not only driven by financial means is usually characterized by a collection with a theme or purpose. We can spot collections that trace the history of a single model or brand, or only cars from a specific period.

- Speculators

On the other side, a purely speculative collection is usually characterized by a portfolio. A more strategic collection with completely different models that differs in brands, year and type as a diversification purpose. Moreover, pure speculators usually do not share a passion for classic cars. Typically, they will not drive the cars to avoid insurance for accidents. The number of speculators generally increases during periods of price appreciation.

- Dealers

Auction houses are key players in the market, the principal ones being; Bonhams, Artcurial, RM Sotheby's, Coys, Barons and Silverstone (F. Tasiaux, interview, July 26th, 2017) (appendix 3.1). We also count private dealers for whom transactions with private owners are direct. These market participants will be detailed and differentiated in our point transactions.

- Experts and market makers

The existing literature, biographies, videos are sometimes the only way to assess the exact way a classic car should look like. That is the fruit of extensive research, so when there is a sale or restoration, we saw the rise of the importance of expert's specific or general car knowledge. These experts as well as the clubs, regulators and event organizers, can have a strong impact on the price markets, which through their insights can be market shifters. Finally, makes today and their dynamism can be important market players too.

- Outside activities

The market is colossal and has increased over the years. This leaves place for some side activities and business. A secondary market benefits greatly from this expansion, such as external parts reseller, restoration experts, and events related business, insurance and financing, books, videos, related items such as helmets, clothing and race trophies...

1.2.4 Transactions

- Auction houses

Auction houses are often present at famous events or the auction itself, sometimes represents the event. Each auction house has its own rules, fees and commission system. In the appendix (appendix 1), the Bonhams sale general information is supplied as an example. As we can see, in *figure 2* below, information is given before the sale; pictures, description and price estimations. First, auction houses do not always guarantee what is written in the description and often the script is provided by the seller itself. The responsibility depends on the country's regulations. The price estimation neither constitutes the reserve price which was explained in point 1.1, nor a price which includes fees and the buyer premium. The auction house collects a seller fixed fee which will vary in function of auction houses and events. A buyer's premium will also be collected, which will be added to the total price. In our example, the buyer's premium amounted 25%. This can lead to confusion in the reported prices. Let us note, that the Hammer price is free of fees and taxes. Once the buyer's premium, as well as the VAT and other side fees are added, we obtain the total price.

Figure 2: Illustration of a Bonhams sale.



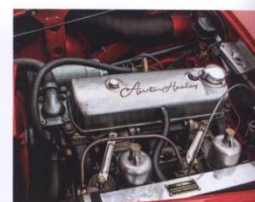
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1955 AUSTIN-HEALEY 100M BN2 ROADSTER

Registration no. 609 APF

Chassis no. BN2/229013

Engine no. 1B/229013



Donald Healey's stylish Austin-Healey 100 caused a sensation when it debuted at the 1952 London Motor Show. Intended as a low-cost, high-performance, limited production sports car and aimed at the US market, which took almost 100% of production initially, the Austin-Healey 100 sourced its major components from the Austin Atlantic saloon. In fact, the car first appeared at Earls Court badged as a 'Healey Hundred' and was re-badged 'Austin-Healey' while still on its stand after Austin boss Leonard Lord bought the rights to the design. It was just as well that he did, for Healey would take over 3,000 orders during the Show yet his company had never made more than 200 cars in a single year!

Following the Austin-Healey 100's sensational debut in 1952, the works had entered two mildly modified cars in the 1953 Le Mans 24-Hour Race, which finishing in 12th and 14th places, a highly praiseworthy achievement for what were recognisably production sports cars.

Accordingly, the name 'Le Mans' was chosen for a bolt-on tuning kit offered through Austin-Healey dealers, by means of which private owners could bring their cars up to a specification approaching that of the works entries. The kit included a pair of 1¾" SU HD6 carburettors plus special inlet manifold and cold air box, high-lift camshaft, stronger valve springs and distributor with alternative ignition advance curve. With the kit installed power increased from the standard 90 to 100bhp.

From October 1955 the conversion was available factory-fitted on the successor BN2 model in the form of the 100M. In addition to the Le Mans kit, the latter boasted high-compression pistons, stiffer front anti-roll bar, special Armstrong front dampers and a louvred bonnet. Power increased to 110bhp and top speed, with windscreen folded flat, to within a whisker of 120mph. The number of BN1s converted by their owners is unknown, but 1,159 cars, mostly BN2s, were built or subsequently modified to 100M specification between 1955 and 1956. Of these, approximately 640 were completed at the factory, some 544 of which were exported to the USA.

A BN2 model fitted with the 100M 'Le Mans' tuning kit, chassis number '229013' is one of only 165 cars supplied in right-hand drive form to the UK market. The car was completed in October 1955 and supplied new via Wimbledon Motors. We are advised that it has had relatively few owners and in 1998 underwent a full 'ground upwards' restoration at leading marque specialists JME (full documentation available). Since then the Healey has formed part of a large private collection in Northamptonshire and has covered approximately 550 miles only since restoration. Described as in generally excellent condition, '609 APF' is said to drive, feel, handle and looks just like a brand new car. Accompanying paperwork consists of the aforementioned restoration records, old-style logbook, current MoT/tax, V5 registration document and an interesting letter from Healey 'guru' John Wheatley.

£50,000 - 60,000

€62,000 - 74,000

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Source: Bonhams. (2014). *Goodwood Festival of Speed Sale*. London: Bonhams

- Private deals

The private deals are very unlikely to be publicly observable, which makes them difficult to monitor. Indeed, like art, classic car ownership is often related to a social prestige, some owners are reluctant to let the market know that they are selling. Furthermore, most sales represent huge amounts of money. For paintings, reviewed estimations of the distribution of private deals-auctions are the following: 50-50, 70-30 and up to 80-20. Usually, prices through private dealers will be higher than the auction prices. Indeed, these dealers tend to buy at auctions and sell the car with a premium, or restore it first to achieve a margin (Hatlapa, 2014). They will typically not include commissions and fees, unless an owner used a private dealer to sell his car.

1.2.5 Financial analysis

Despite the expansion of the classic car market and the fact that the news report huge amounts of money spent for a car at an auction, actual financial research on the subject remains succinct today. In comparison, paintings display way more research, with over 20 studies based on their indices allowing monitoring the prices and other financial indicators. The classical car literature is characterized by marginal references. The only valuable research on the financial aspect of the classic car World was performed by Dietrich Hatlapa (Hatlapa, 2014). With his team, they published a book entitled: “Better than gold investing in historic cars” and maintain the website Hagerty. They created a financial index; “the HAGI index” and keep it up to date monthly.

Other articles, blogs and news used the data provided by the HAGI index as a starting point. Therefore, we will summarize here the findings and methodology used by the HAGI team.

HAGI created two different indices. The first one covered the period between 1980 and 2008 and used an equally weighted method. It included a portfolio of 38 cars which were selected in 2008 then back-tested to 1980. The second one was computed monthly and covers the period from 2009 onwards. It uses a “survivor weighted method” and is based on 50 different cars. The survivor weighted method captures the fact that only a part of the car production is still on the market. Therefore, it allocates more weight to cars which demonstrate a higher number of cars still “alive”. This could result in a first bias. Indeed, we could argue that by giving more weight to cars which are less rare, we reduce the returns given by the rare cars.

Both indices are based on the HAGI database which gives information on both auctions and private deals. The number of transactions and provenance are unknown. Both car portfolios have been selected based on a diversification by age, type of car and geography.

Based on their index from 1980 to 2008, they assessed a nominal annual return of 12,6%. They adjusted it with inflation using the CPI, which gave them a real annual return of 11,7%.

Their indices were compared with the SP&500 and the MSCI World indices, both plotted results under the classic cars indices. Other alternative asset classes, namely; wine, paintings and real estate, were used as comparison. Lastly, gold performance has been evaluated for the period with an average annual nominal return of 2,17%.

Moreover, they computed the correlation between their indices and currencies appreciation on a 30-year basis and smaller period, but no significant correlation was found.

The link between wealth, luxury and art consumption has been established above. HAGI used the number of billionaires in comparison to their indices and concluded that wealth had an impact on car prices. However, the theory did not hold over time. They stressed periods of strong correlation such as 1980, and periods with no correlation.

Tables 3 and 4 present summaries of alternative investment returns.

Table 3: Summary of alternative investment returns

Author	Year	Sample	Period	Type of index	Real return	Std Deviation	Beta
Anderson	1974	Paintings	1780-1960	hedonic regression	2,60%		
			1780-1970	repeat sales regression	3,00%		
Stein	1977	American paintings	1946-1968	average prices			0,82
Baumol	1986	Paintings	1652-1961	repeat sales regression	0,60%		
Pesando	1993	Prints	1977-1991	repeat sales regression	1,50%	19,94%	0,315
Pesando and Shum	1996	Picasso prints	1977-1991	repeat sales regression	2,10%	23,38%	0,43
Goetzman	1993	Paintings	1716-1986	repeat sales regression	2,00%		
Mei and Moses	2002	American, impressionist and old masters	1875-2000	repeat sales regression	4,90%		0,718
Ashenfelter and Graddy	2003	Modern and impressionist	1980-1991	hedonic regression	4,00%		
		Modern and impressionist	1980-1991	repeat sales regression	9,00%		
Campbell	2008	Old masters, European impressionist, modern and contemporary	1980-2006	repeat sales regression	6,50%	7%-15%	
Goetzman et al.	2011	Paintings	1830-2007	repeat sales regression	2,97%	10,92%	
Renneboog and Spaenjers	2013	Paintings and works on paper	1957-2007	hedonic regression	3,97%	15%	
Burton and Jacobsen	2001	Fine wine	1986-1996	repeat sales regression	3,10%		
Lucey and Devine	2015	Fine wine	1996-2007	repeat sales regression	5,20%	0,091	About 0
Sanning et al	2008	Fine wine	1996-2003	repeat sales regression	6,2%-11,1%	6%	About 0
HAGI	2015	Classic cars top 38	1980-2008	/	11,70%		

Table 4: Summary of alternative investment returns with a corresponding period

Author	Year	Sample	Period	Type of index	Real return	Std Deviation	Beta
Pesando	1993	Prints	1977-1991	repeat sales regression	1,50%	19,94%	0,315
Pesando and Shum	1996	Picasso prints	1977-1991	repeat sales regression	2,10%	23,38%	0,43
Mei and Moses	2002	American, impressionist and old masters	1875-2000	repeat sales regression	4,90%		0,718
Ashenfelter and Graddy	2003	Modern and impressionist	1980-1991	hedonic regression	4,00%		
		Modern and impressionist	1980-1991	repeat sales regression	9,00%		
Campbell	2008	Old masters, European impressionist, modern and contemporary	1980-2006	repeat sales regression	6,50%	7%-15%	
Renneboog and Spaenjers	2013	Paintings and works on paper	1957-2007	hedonic regression	3,97%	15%	
Burton and Jacobsen	2001	Fine wine	1986-1996	repeat sales regression	3,10%		
Lucey and Devine	2015	Fine wine	1996-2007	repeat sales regression	5,20%	9,10%	About 0
Sanning et al	2008	Fine wine	1996-2003	repeat sales regression	6,2%-11,1%	6%	About 0
HAGI	2015	Classic cars top 38	1980-2008	/	11,70%		

1.3 Type of index

1.3.1 Repeat Sales Regression and hedonic regression

Indices are very popular today. There are hundreds of them showing numerous asset types; commodities, equity, artworks... They have various uses. For example, they allow us to estimate certain market trends and to determine correlations between different industries. They give us information on valuation and can serve as benchmarks for fund managers amongst many other utilities. When it comes to art investments, usually the investment is characterized by the absence of dividends. A price index instead of a return index is then used. Over the last 50 years of research in the field, two principal estimation methods transpired. The first, the hedonic regression, was introduced by Court (1939). He used the automobile industry as an example to demonstrate the method ((Court, 1939) quoted by (Ginsburgh, Mei, and Moses, 2005)). The second method is the RSR. It was first used by Bailey, and co-authors (1963) to observe the real estate market. Within these two methods, a certain number of variants exist, some which were created to counter the different bias that will be assessed below. However, for the benefit of this study we will only detail the variant for the hedonic regression in the methodology. Let us acknowledge the existence of two extra basic estimation methods: the geometric mean and the average prices (Campbell, 2008).

This section addresses both principal methods with their limits and bias as well as their advantages, by summarizing different studies on the subject. Thereafter, a comparison of the results obtained by both methods will be discussed. Finally, we will review the different weighting possibilities for indices.

Before describing in detail each method, Ginsburgh, Mei, and Michael Moses (2005) defined the following rules that should be followed to construct a precise index. On the one hand, the data should be publicly available and large enough to avoid sample selection bias. On the second hand, the index should focus on a specific art category to be fully accurate and the estimation method should be easily verifiable.

1.3.2 Repeat Sales Regression

A RSR is an estimation based on the sale of a same item at multiple time points. It will reflect the price appreciation/depreciation over time. The item needs to be the same or a copy presenting the same attributes and being in a relatively comparable state.

This method is particularly interesting for monitoring artworks or real estates. The assets remaining the same over time, the method often uses auction prices.

Concerning the painting studies reviewed in point 1.1, the RSR has been used to capture the appreciation of art prices by several authors: Anderson (1974), Baumol (1986), Goetzman (1993), Pesando (1993), Ginsburgh, Mei and Moses (2005), Campbell (2008) and Goetzman, Renneboog and Spaenjers (2011) amongst others. However, we notice the use of such a method in the wine analysis too. Authors such as Burton and Jacobsen (2001), Ashenfelter and Grady (2003), Sanning and Shaffer (2008) and Devine and Lucey (2015).

- Limits and bias

Despite the simplicity and transparency of the estimation method which gives clean results, the RSR comes with its limits and bias which will be reviewed here below.

The first notable limit which has been addressed by most of the authors reported above, but especially by Ginsburgh and colleagues (2005) with their article: “On the computation of price indices” as well as by Ashenfelter and Grady (2003), resides in the fact that to use a RSR, you need at least a pair of sales for the same item. Indeed, the fundamental principle of a RSR is based on the sales of a same item. If a masterpiece is sold once and then held over a long period, it will not be considered. The same goes for an item that with time has been heavily deteriorated. There is no way for a RSR to capture the change in quality, which restricts the data used. Therefore, two issues arise; first, the difficulty to obtain enough data, and second, the waste of valid data for which no pairs can be found. The study of Pesando (1993) in point 1.1 addresses these issues by analysing the market of modern prints instead of paintings. The limited edition of those prints demonstrated a market more active. This allowed him to collect 27.961 sales over only a 15-year period. In comparison, Baumol (1986) managed to collect only 640 transactions over a 300-year period. Moreover, one of the most accurate estimated studies: “Art as an investment and the underperformance of masterpieces” by Mei and Moses (2002), obtained 4.896 pairs of sales between 1875 and 2000. Ashenfelter and Graddy, (2003) constructed an index using both estimation methods based on the same data. They could use 474 sales with the RSR compared to 8.792 with the hedonic.

A limit directly linked with the previous point, and acknowledged by Ginsburgh et al., (2005) is the period studied. The time frame needs to be long enough to optimize the chance of seeing

a same item returning to the market. They concluded with the fact that a RSR should not be used for a period below 20 years.

Due to the small eligible data, a first bias can be demonstrated. The selection bias or sample bias has been acknowledged as a possible source of mistakes by all the listed above authors who used the RSR for art. The bias was vastly investigated by Gatzlaff and Haurin (1997) and quoted in the article by Ginsburgh and colleagues (2005). They showed, that due to the lack of available data for a sample, it could not always be representative of the market. This is especially true for the goods for which we cannot find any pair of sales. Meaning, they might present a lack of interest and in turn a poor return on investment. In this case, these goods would not be considered and would increase the return of the market. The index will then be too optimistic. This bias is corroborated by Meese and Wallace (1997), who demonstrated the fact that RSR are under a selection bias and that the indices will be extremely sensitive to the observation retained in the sample.

Another bias briefly assessed above, is the specification bias. The bias is more important for the hedonic regression. However, it is noticeable with the RSR. The bias is defined as the inability of the RSR to capture any changes in the object such as quality deterioration, age of an estate amongst others (Ginsburgh, Mei, and Moses, 2005).

1.3.3 Hedonic regression

A hedonic regression is an estimation that attempts to explain a price by a series of calculable factors. The residual of the regression, which represents the price of the object excluding all the measurable attributes such as age, name of the artist, size amongst others, can then be used to build an index and assess the evolution of the market. This method was intensively employed to study industrial products, which are explained by attributes, especially automobiles or computers. The price of new vehicles could be explained by the engine power, the number of doors, the make amongst others and was the beginning of the hedonic regression. We count several authors: Court (1939), Griliches (1961), Triplet (1969) and Berry (1995) who used such a method to capture the evolution of prices for new models of cars. This method counters one of the principal challenges issued by the RSR which is the requirement of a minimum of two sales of the same object. Indeed, each object is first “cleaned” from its differences with others before being considered. Therefore, even if there is a change in the quality or another aspect of an asset, we will still be able to include it in the regression. The hedonic estimation method was

used to analyse the painting market by several authors: Anderson (1974), Chanel and co-authors (1996) and lately by Renneboog and Spaenjers (2013).

- Limits and bias

For a complete approach and review of the hedonic regression, Triplet (2006) dedicated a whole book to the matter. Each author listed above, who used such a regression to evaluate art prices, gave insights on bias and possible limits. Some aspects were briefly covered in point 1.1, to discuss differences in results. Ginsburgh, Mei and Moses (2005), as well as Ashenfelter and Graddy (2003), addressed this subject in detail. Their findings will be summarized in the point here below.

The first limit in agreement for all the studies, is that the accuracy of the index depends entirely on the capacity to assess and find the characteristics that contribute to the price of an object. It is called “the specification bias” by Ginsburgh et al., (2005) and means that the wrong factors are considered, or the form of the regression is not suited. In the art World, most of the data comes from auction houses. It is unfortunately not always possible to gain access to all the characteristics needed to complete the regression. Moreover, the coefficient allocated to factors is constant over time. However, preferences of people can evolve over time and certain specificities can be more or less appreciated. For example, Anderson (1974) found that large paintings were more successful over the years. This fact is not accounted for in a hedonic regression. To counter this issue, the idea to split the period and reaggregate after each adjacent period was found by Triplet (2006), who demonstrated that the results would be better plotted if the number of observations is big enough.

The second bias: “multi-collinearity” which was studied by Pakes (2003), is that for industrial products, the characteristics are often highly correlated. He used the computer market to demonstrate his point. In the art market, the problem does not apply according to him.

Silver and Heravi (2004) as well as Triplet (2006) discussed another issue which does not concern artworks, but rather industrial goods or modern prints for example. The hedonic regression does not consider the number of assets in the market. The rarity, or the size of the production is not captured, and therefore neither the size of the market. We will see in the point “weighting” that we can adapt the price through a coefficient linked to the “market capitalization” of the asset and bypass this limit.

Melser (2005) investigated the fact that a hedonic regression does not support the monotonicity property of an index. The monotonicity property is as follows: “the price index which compares two periods, must increase if the prices of the later period increase, maintaining other factors fixed. The second version states that the price index should decrease if the prices of the earlier period are increased, maintaining other factors fixed”. Melser (2005) found that it does not hold due to the quality factor, but argues that for an economic application, the quality variable should be fixed when we test the monotonicity, which provides us with good results.

1.3.4 Comparison

Authors have carried the research further to compare actual returns and correlation for both methods, using the same data. The general trends and results should be highly correlated and give comparable returns. We will review six articles starting from 1974 with Anderson who created his indices using both methods.

Anderson (1974), who studied over 1.500 painting prices during the period 1780-1970, does not give us much information concerning the differences between both indices, but plotted a real return of 3% for the hedonic regression and 2.6% for the RSR. These results confirm a relatively similar trend for the whole period.

Goetzman (1992) made some comparisons between different types of RSR. He demonstrated that the RSR, no matter which method is employed, is accurate if one can collect enough data.

Chanel, Gérard-Varet and Ginsburgh (1996) addressed the matter in a more systematic way, using both methods. We quote their results: “the results are of the same order of magnitude and there is little reason to believe that the quality of resales is different from the quality of “all” sales”. Where resales discuss the RSR and “all sales” is for hedonic. Meese and Wallace (1997), by reporting the bias of RSR, which is the sample bias analysed above, argue that the RSR depends too much on the size of the sample which is therefore in favour of the hedonic method.

Ashenfelter and Graddy (2003) in their article: “Auctions and the price of Art”, attempted to demonstrate whether both methods give the same results. Using the same period and database, 474 observations were collected for the RSR method and 8.792 for the hedonic one. They found a correlation of 0,9559 between the two indices. Although, the returns obtained were surprisingly different; 4% for the hedonic and 9% for the RSR. They explained this difference, either by the fact that for the RSR some data was missing or alternatively, by a high increase of

the price at the end of the period, which the hedonic regression failed to capture due to quality factors.

Finally, Ginsburgh et al., (2005) conducted a systematic approach to assess differences between the two. First, they reviewed the different bias in their article: “On the computation of Prices Indices” by running a battery of statistical analyses to examine the accuracy of the methods.

They observed that tracking errors and standard deviation were much lower for the hedonic regression, though by increasing the quantity of data, both methods got much closer. They also demonstrated results of the same magnitude with estimations. They conclude that hedonic regression performs better than RSR for small samples and that RSR should not be considered for a period below 20 years.

In conclusion, some important facts clearly transpire. First, RSR should only be seriously considered as an accurate method if enough data can be found and therefore the period is long enough. Furthermore, if enough data can be collected, the RSR will be the more accurate method, allowing overcoming the difficulty to correctly determine the factors in the hedonic regression. Secondly, there is no evidence of fundamental mismatches between both methods in the plotted results. Finally, there is no “best” method and to decide which one is the most suitable will depend on the type of asset and available data.

1.3.5 Weighting

Most of the indices today are not built by those methods. To understand how they work, one should determine how each asset will contribute to the index. Indeed, numerous types of weighting exist and have an impact on the available indices. In this part, we will review the principle used in today’s market as well as their advantages.

- Equally weighted

As is stated in the name, an equally weighted index allows the same impact for each stock or asset included. Each item will have the same weight as a fixed percentage and will influence as much as the others the trend. One possible downside of such an index is that it could fail to demonstrate the market properly. For example, let us imagine that 98% of a market is dictated by ten firms, an equally weighted index composed of 20 firms would not really be representative of the market. Indeed, too much emphasis would be given to the ten other firms. On the other

hand, in the art market for example, it allows the possibility to view the general market even if one or two masterpieces are traded far above the others. Hence, the utility of an equally weighted index to capture those movements too. An example of an equally weighted index would be the Guggenheim S&P500 equal weighted (Guggenheim, n.d.).

- Price weighted

The second method is a price weighted index, which allows weight based on the price of the stock or asset per share. It allows capturing most of the “blue chip” or best assets in class. One of the most popular price weighted indices would be the Dow Jones Industrial Average (Bloomberg, n.d.).

- Market capitalization weighted

The Market capitalization weighted index gives an impact to each stock in proportion to their market capitalization, which is the price per share times the number of shares. In the art market, it would be the price of an artwork multiplied by the number of available items of artwork. This method measures the size of the market dictated by any asset, and therefore gives an accurate estimation of the total market. Most of the indices today are market capitalization weighted such as the S&P 500 for example (Bloomberg, n.d.).

- Floating market capitalization

The floating market capitalization index works on the same principle as the one addressed above. However, the number of shares used to compute the market capitalization are the ones available to trade on the market, excluding locked up shares amongst others. In the art World, we should possibly consider assets that have been taken out of the market by museums or by destruction for example as locked assets. This approach captures more effectively the active market instead of the total market.

- Other specificities and methods

One of the last points which needs to be addressed is the “re-balancing”. When an index is created it is usually set at a value of 100 or 1.000. From there on, the value will fluctuate to show trends based on each stock or asset. No matter which weighted method is used, the weight

will move due to the fluctuation of the different parts. One must decide if he allows those to continue to fluctuate, or do a re-balancing every period to continue to maintain the method.

Finally, other specificities can be used such as a cap. Indeed, a market capitalization weighted index can be the chosen method, but with a cap that will not allow to give more than 10% of the weight for example. The same goes for re-balancing, one can choose to let the asset fluctuate and evolve with a special cap.

Chapter 2. Aim of the study

By creating a new classic car index that will enlighten the period from 1980 to today, we will investigate in this study the following question: is it currently efficient to integrate classic cars as an investment in a portfolio?

Contrary to the Hagerty index, which focused on 38 selected cars knowing the past and their evolution, we will monitor the classic car market as a whole, using a hedonic regression. Since the HAGI index, this study is the largest to date.

If the results are promising, we will address in a second part, the viability and challenges faced by a novel hedge fund specialized in classic cars investments. The opportunities and weaknesses of such a management fund will be investigated.

To answer this question, the following hypotheses will drive and structure our analysis. The indicators will provide the necessary information to validate or dismiss the hypothesis.

H1: The price of a car can be explained by characteristics related to the car.

Indicator 1: The hypothesis concerning the chosen variables will be detailed in the methodology.

H2: Alternative investment in classic cars offers a combination of return and volatility which makes it an efficient investment compared to others.

Indicator 1: Annualized real return.

Indicator 2: Volatility.

H3: Classic cars is a more attractive alternative investment than its pairs.

Indicator 1: Comparison of returns, volatility and beta with fine wines and paintings.

Indicator 2: Comparison with gold and real estate.

H4: Investing in classic cars is a valid tool of diversification in a standard portfolio.

Indicator 1: Correlation with other indices and assets.

Indicator 2: Correlation with other alternative investments.

Indicator 3: CAPM, beta estimate.

Indicator 4: Numbers of financial ratios that will be detailed later.

H5: Portfolios including classic cars are better off.

Indicator 1: Analysis of a standard portfolio before and after including classic cars.

Indicator 2: Comparison of 1.000 random portfolios with and without classic cars.

Chapter 3. Methodology

In this chapter, we will detail the hedonic method used to create a financial index that monitors the classic car market from 1980 to 2017. First, the model will be explained, then we will address the variables and data used. Finally, we will outline how we proceeded to compare other asset classes to classic cars and to answer the hypotheses cited above.

3.1 Model

- Hedonic function

Considering the different bias and limits viewed in point 1.3 and the type of assets we wish to study, the hedonic method is more suitable. Indeed, cars, even if produced in series will generally demonstrate quality differences and other characteristics from one to another. The chosen method allows us to control these differences and to expand the number of auctions used by avoiding the pairs of sales required for a RSR. Before discussing the hedonic price index, one should pay attention to the hedonic function. An example of such is as follows:

$$PRICE_k = \alpha_0 + \alpha_1 YEARPROD_k + \alpha_2 HORSEPOWER_k + \varepsilon_k$$

The function above will explain the price (P) of a car (k) by a number of attributes (Triplet, 2006). Here, the year of production and the horsepower were used. In our example, we could predict a positive coefficient for the horsepower variable and a negative one for the year of production. With a hedonic function, we assume that the price of the car can be explained by those parameters. The success of such a method will depend entirely on our capacity to determine the variables. The function includes an intercept term as well (α_0) which represents the constant. Finally, we can see the regression residual (ε_k) which shows how far the car (k) stands from the regression line. Of course, in our study the number of variables used to assess the price of a car will be much bigger. In our case, most of the variables will be dummy variables. A dummy variable only takes the value “0” or “1”. For example, an automatic black Ferrari will take the values: “1” for the FERRARI variable, “0” for the TRANSMISSION variable since automatic is the constant and “1” for the COLOUR_BLACK variable.

The coefficient will be estimated using the Ordinary Least Square method (OLS). The regression will plot a line that minimizes the square of the different residuals. The square is used to avoid that negative values absorb the positive ones (Bereau, Hafner, Petitjean, and Van

Bellegem, 2016). It is important to stress that the OLS estimates a coefficient by maintaining all the other variables fixed.

- Semi-log form

According to Triplet (2006), there are three main forms used for the hedonic function. The linear form, where the explained variable and the explanatory ones use their native value and no logarithm is used. The log-log form, which uses as indicated by its name, a logarithmic form on both sides. Finally, a semi-log form, where only the left part is expressed in a log form. The major part of hedonic function was used to estimate the price of computers and the double log form was the most conventional method. However, for different markets such as the car market for example, the semi-log form was more often used. When dummy variables are used or that the explanatory variables are a short range of numbers, the semi-log form is used. Therefore, in our case the semi-log form will be employed, our variables being almost entirely dummy variables. The preceding example evolves into the following formula:

$$\ln(PRICE_k) = \alpha_0 + \alpha_1 YEARPROD_k + \alpha_2 HORSEPOWER_k + \varepsilon_k$$

- The hedonic price index

Within the hedonic method, we count four different variants to estimate a price index. First of all, what we call the direct method includes the characteristics and time dummy variables. The direct nomination refers to the fact that the price index is derived directly from the hedonic function. The indirect method often called the imputation method, includes the quality adjustment calculation. This method uses external price information to plot the index and only uses the hedonic function to adjust for quality (Triplet, 2006). In our case, all the information can be found in the hedonic function. The time dummy variable will then be used to build our price index. In the preceding example, we now add a time dummy variable that will take the value “1” if the sale occurred in that year and “0” otherwise. Here, the function considers two years. The first year is represented in the constant and the variable (D_{t+1}) is for the second year. The variable will take the value “1” for each model (k) of a car which was sold in the second year.

$$\ln(PRICE_k) = \alpha_0 + \alpha_1 YEARPROD_k + \alpha_2 HORSEPOWER_k + \gamma_1(D_{t+1}) + \varepsilon_k$$

Where (γ_1) represents the coefficient that explains the price appreciation due to a sale in the second year. Adding all the characteristics and the time dummy variables we obtain the following form:

$$\ln(PRICE_k) = \alpha_0 + \sum_{j=1}^J \alpha_j X_{jk} + \sum_{t=1}^T \gamma_t D_{kt} + \varepsilon_k$$

Where, (X_{jk}) is a characteristic of the car (k), and (D_{kt}) is a year of sale.

Thanks to this method we will derive a coefficient for each year of sales while other characteristics remain fixed. Those coefficients therefore reflect the price impact explained by the year, all the other characteristics being controlled for. From those coefficients, we can find the value for each year compared to the reference one and then the appreciation from one year to another.

The following formula gives us a geometric mean of the value for year (t) relative to the base year (Renneboog and Spaenjers, 2013). One should not forget that due to the use of a semi-log form, the value will be given by the exponential of the coefficient.

$$V_t = \exp(\hat{\gamma}_t) * 100$$

To compute the rate of increase between two years, we can use the following form:

$$r_t = \frac{V_t}{V_{t-1}} - 1$$

While using the same method, we can compute the price percentage influence of a coefficient:

$$Price\ impact\ (\%) = \exp(\hat{\alpha}_j) - 1$$

One of the issues with the time dummy variable method that was acknowledged in point 1.3 is that the characteristics are fixed for the entire period failing to allow for the possible evolution of tastes. Triplet (2006) investigated the use of several hedonic regressions of adjacent periods to increase the accuracy of the model. The technique was used here as well as a global regression, and indeed, our adjusted R^2 was higher when using a period split in four. Several test regressions were done by changing the variables, adding and deleting some to create for each period the most accurate possible model. For each regression, we proceeded by deleting the less significant variable and starting the regression again until only significant or marginally

significant variables were included. Unless we knew for sure that a variable was important and needed to be included in the model.

3.2 Variables

In point 1.3, we saw that the hedonic regression can be a very powerful tool and gives accurate results if the characteristics can be determined. The specification bias is the most important one concerning the hedonic function. Over the years, before being used to evaluate artworks, hedonic regression was used to evaluate industrial products which can be fully explained by their attributes. Computers and cars are good examples. Indeed, more ram, a better processor, more horsepower, will be reflected by a higher price. The main difference with collectibles is the low intrinsic value; most of the prices can be explained by intangible traits. In this point, we will demonstrate how we faced this challenge.

It is impossible with a hedonic regression to include all the variables. It remains a theoretical model attempting to explain reality which it will not reflect perfectly. According to Triplet (2006), there are two possible scenarios of omitted variables. The missing variables can either be correlated with the existing ones, or uncorrelated. If the variables are correlated, the coefficient of the present variables will be biased, since they would take into account the explanation of the missing ones. If the variables are uncorrelated, the coefficient will not be biased, however the model will fail to fully adjust for quality. In conclusion, in both situations there will be a bias that is unavoidable. It is common with hedonic models to miss some variables. For example, the biggest study made on artworks by Renneboog and Spaenjers (2013) using more than a million sales had a R^2 of 0,6411.

Our variables were based on what was reviewed in point 1.2 with the help of François Tasiaux consultant for Artcurial (F. Tasiaux, interview, July 26th, 2017) (appendix 3.1). To create these variables, some clusters were needed due to a high quantity of data and will be fully investigated in the point data. A detailed list of the variables can be found in the appendix (section 4).

- Car related

First, several dummy variables were allocated for the car itself and were inspired from the characteristics outlined in point 1.2. To avoid perfect multi-collinearity, one of the variables of each category is left out. The first category includes 100 different car makes with Buick being

left out. The second category monitored the type of engine such as: V6, V8, in line 8... The body of the car created an additional nine variables, the body sedan being reflected in the constant. Moreover, we added the transmission in our model with a value of 1 corresponding to manual and the constant representing automatic. Finally, 13 colours were added with the constant being blue. These variables can be viewed in detail in the appendix (appendices 4.1, 4.2, 4.3 and 4.4).

Still related to the car itself, two other variables were employed. First, the number of models produced which will demonstrate the rarity characteristic of the car. Secondly, the date of production was also considered and was organized in decades, 1900-1910 being left out.

To assess the state of the car, we referred to the Worldwide system in use. This system attributes a number from one to six, six being a car that is only good for parts and one for a car with a concours state level. Five more dummies were added, condition 1 being used as the constant.

- Auction related

Auction houses are key players in the car market. They can have an influence on the price of cars sold. The following auction houses are the most important ones, their impact will be monitored by including them in the model: Bonhams, Artcurial, RM Sotheby's, Coy, and Barons. The month of sale will be checked as well, adding 11 variables in the function. Finally, we created a list of the most famous sales, believing that an important sale could attract wealthier customers and higher prices. The lists are detailed in the appendix (appendices 4.5, 4.6 and 4.7).

- Time

We built an index showing results over a period of 37 years from 1980 to 2017. However, the market was struck by the bursting of the speculation bubble in the late 80's from 1987 to 1990 and no sales were reported. To consider the downfall of prices, the year 1986 and 1990 were valued, then a geometric interpolation was made to fill the missing years. For this purpose, 33 dummy variables were added to the model to allow for the appreciation of each of those years, 1980 being the constant.

- Sentiment

As stated in point 1.2, an important part in the acquisition of classic cars is the sentiment of buyers. It is not possible to monitor the sentiment on a personal level. However, some trends and generalities can be determined. To do so, we have created lists of possible effects on the behaviour of collectors. The first list, the “Bullitt effect”, includes cars driven in famous movies. On top of that, a list of the most iconic classic cars per decade according to “supercars.net” (n.d.) and a list of the cars with the most amazing designs were also added to the variables. Those three lists can be found in detail in the appendix (appendices 4.8, 4.9 and 4.10). Once these lists were created, they needed to be matched with the auctions in the database.

- What is missing?

The online database as well as some external research allowed us to collect information for a good number of variables. However, some data that we believe to be fundamental in the car market are still missing from the function. First, concerning the condition of the car, the matching of engine and chassis numbers were not reported for the individual sales, nor was the number of kilometres of the car. However, those variables would be partly reflected in the condition variable. Secondly, we discussed the importance of history in point 1.2. The previous owners were not collected in our database, neither was the quality of documentation and the history of the cars. Finally, some minor external factors could influence a small number of cases but should be of little significance.

3.3 Data

For this study, we purchased and employed the most complete online database available, which is the one kept up to date by the website: “Sports Car Market” (Sports Car Market, n.d.). The database holds 272.740 auction records, with the first one dated back to 1962. Most of the auction houses sales are recorded in the database on a worldwide level. Therefore, we should not be affected by a non-representative sample bias. We assumed that if a car aroused enough interest to be bought at an auction, it should and will be considered as a classic car in this thesis. Therefore, the car will be included in our analysis and index.

The online database is not user friendly and requires manually clicking on each individual auction to collect the information. Therefore, for the years after 1997, only the auctions with pictures were filtered. This allowed the number of auctions used to be reduced and guaranteed

that the auctions present a good number of details. The years before 1997 were less detailed, so all the auctions were considered, the ones displaying pictures being too scarce. The second filter applied was to show only the cars sold which were the relevant ones. Despite those filters, we were still able to collect a total of 46.494 auctions for the period between 1980 and 2017, which is clearly a first in the field. As discussed previously, the online database required to click manually on each auction, therefore a first program was created to make the data extraction possible.

Moreover, in view of the size of the sample, the database was cleaned and some limits were set during the process. Numerous programs and codes had to be created to allow handling of the data. We kept only the 100 most representative car makes which covered 90% of the total sample. We verified that these makes were present for each year and that they displayed correctly the different variables. For example, the make Jaguar was present each year with at least one record per year showing all the characteristic's included in the model. The second limit was for the transmission. To keep the number of variables the lowest possible, we excluded the numbers of gears and kept only the manual or automatic string. Thirdly, cars are well-known for the high variety and imagination when discussing colours. For example, Rosso Corsa, aquamarine amongst others are adjectives describing the colour. We decided to convert those colours into 13 basic different colours. For this purpose, a code searched for keywords and formatted the colours. The list of 13 colours and the related keywords are described in the appendix (appendix 4.4). It is common use in the classic car market to assess the condition or the state of the car by a number from one to six, one being a national concours state, and six being good only for parts. To be more precise a "plus" or a "minus" sign is usually added. For this thesis, we will only keep the number.

The same technique used for colour sorting was applied for sorting the various car bodies. Some clusters were made and keywords were used to allocate the different types. Indeed, depending on the country, different appellations are in use which left us with more than 300 different body styles. The list of clusters can be found in the appendix (appendix 4.3).

The last clusters were created for the engine types, the list can be found in the appendix (appendix 4.2).

All those clusters were established under the supervision of François Tasiaux, (Interview F. Tasiaux, July 26th, 2017) (appendix 3.1) Moreover, some additional external sources were required to complete the information missing from the database. For example, the numbers of

produced units of each car model were found on [supercars.net](#) (Supercars.net, n.d.), [conceptcarz](#) (Conceptcarz, 2017), [wikipedia](#) (Wikipedia, n.d.) and the constructor's website. The production number was one of the biggest challenges encountered. Indeed, there are almost as many models as observations in the sample, and the production number needed to be researched, then manually matched and encoded in the database. A script was not possible here due to the differences between the model appellation from our database and the different websites.

As discussed above, in the point model, the model was split. The first reason for this is allowing the factors to evolve over time. The second reason is that depending on the year of sale, some auctions had more or less details. For example, for the period 1980-1991, the colour of the car was not reported and so not reflected in the regression, contrary to the other periods.

As reviewed in the first part of this study, the classic car market was affected by a speculative bubble which burst in the late 80's. The bubble was reflected in the database by an absence of sales. Therefore, there were no data between the years 1986 and 1990. We used geometric interpolation to show the evolution of prices during those years, picking up in 1990.

After cleaning the database and setting the limits, we obtained a total of 33.193 auction records.

Finally, all the prices recorded in "Sports Car Market" (n.d.) were in dollars, which spared us the work of translating them using currency rates. However, the CPI All Urban Consumers was used to adapt those prices to inflation and convert them in real prices for January 2017 (appendix 5) (Bureau of Labor Statistics, n.d.).

The most expensive of our observations was for a 1962 Ferrari 250 GTO sold by Bonhams for the real price of \$38.891 million in 2014. A photograph of this famous car is shown in the appendix (appendix 6). This price is closely followed by a Ferrari 355 s racer, sold by Artcurial for \$36.798 million. Those numbers were far from the mean and median of respectively \$191.995 and \$51.472 of the total sample.

3.4 Analysing the asset

To compare the asset classes, we based our selection of investments on the standard portfolio described by El-Erian (2008), but we adapted it to reflect how a European investor would behave. We based our methods on an interview with Youssef Uriagli, head of portfolio and fund manager at Deutsche Bank (Interview Y. Uriagli, July 27th, 2017) (appendix 3.2). He

assisted us for the portfolios creation. The transcript of the part of the interview dedicated to the type of assets can be found in the appendix (appendix 3.2). We assumed as well that we were a long-term investor.

The following indices were selected for comparison and analyses: Gold spot (Bloomberg, n.d.), Bloomberg Barclays US Agg Total (global US Bonds Index) (Bloomberg, n.d.), Deutsche Boerse AG German Stock (DAX index) (Bloomberg, n.d.), Real home prices Index (real estate) (Shiller, 2009), S&P500 (Yahoo Finance, 2017).

These indices covered the period from 1980 to 2017 and were selected, since they were representative of the general market to avoid the bias of indices already diversified. To perform our analysis, we created a standard portfolio with various weights (Table 5).

Table 5: Weights of standard portfolio.						
	S&P500	DAX	US Global Bonds	Real Estate	Classic Car	Gold
PF1	25%	20%	25%	10%	0%	20%

*PF: Portfolio

We then made modifications which are reported in table 6.

Table 6: Weights of portfolios.						
	S&P500	DAX	US Global Bonds	Real Estate	Classic Car	Gold
PF1	25%	20%	25%	10%	0%	20%
PF2	24%	19%	24%	9%	5%	19%
PF3	23%	18%	23%	8%	10%	18%
PF4	22%	17%	22%	7%	15%	17%
PF5	21%	16%	21%	6%	20%	16%
PF6	20%	15%	20%	5%	25%	15%
PF7	25%	20%	25%	5%	10%	15%
PF8	25%	20%	25%	0%	10%	20%

*PF: Portfolio. Figures in bold show the replacement of gold and real estate.

The modifications consisted in gradually increasing the weight of classic cars by removing an equal weight from the other investments. PF7 and PF8 were built in order to investigate the benefits of classic cars in replacement of gold and real estate.

We created a code that built 1.000 possibilities of efficient portfolios according to Markowitz, by varying the weights of the different assets. The constraints for the 1.000 portfolios were that the maximum weight on an asset class would be 25% to guarantee diversification and a

minimum of 0% excluding short selling. Half of those portfolios were imposed a 0% weight in the asset classic car. This was done to illustrate the possibilities that this new asset class could offer. When that many portfolios are created in order to find the best possible solutions, there is a probability that these solutions might be the result of luck. The bias is known under the name of data snooping or data mining, both being interchangeably used in finance. Data mining can have an important impact on the different statistical tests (Harvey and Liu, 2016). Therefore, we will not use the portfolios created by the code for other purposes than to illustrate graphically the possibilities that this new asset class could offer. For our performance analyses, we will, as described above, start from a random standard portfolio and gradually increase the weights of classic cars.

Chapter 4. Results

We begin the presentation of the results with a review of the various hedonic regressions followed by the financial index and then the analysis of assets and portfolios.

4.1 Hedonic Regression

To build the financial index, four hedonic regressions were made, each one representing a separate period. Initially, we performed a global regression for the period 1980-2017. However, the results of the model were not as good with an adjusted R^2 of 0,53 (data not shown), as when we used adjacent periods. For the adjacent periods, our adjusted R^2 was between 0,608 and 0,712. For the largest period (1996-2017), we obtained an adjusted R^2 of 0,636, meaning that our model succeeded in explaining 63,6% of the variability of our price data around its mean.

The first aim of this study was to determine which factors would influence and determine the price of a classic car. Each variable detailed in the methodology constitutes a hypothesis. Our null hypothesis is that a variable will not have any impact on the price of a car. For the analysis of the following results, the p-value will represent the percentage of cases for which the null hypothesis will not be rejected. We will consider a p-value of 0,05 as statistically significant to validate the price impact hypothesis and to reject the null hypothesis. A p-value of less than 0,1 will be considered as a trend and will be shown in bold.

The estimators that were obtained for each variable can be expressed as a percentage impact on the price of a car. The last column of each of the tables 7-11 gives us the percentage change which is the exponential of the estimate minus one. Normally, this would represent the price impact for one additional unit of the explanatory variable. However, in our case all the variables are dummy variables except for the production number. Therefore, the price impact is directly related to the variable and fixed. It is important to stress that not all the price determinants were found, which was to be expected. Some of the estimators might be correlated with the missing variables and include a part of their effect. Let us not forget that these estimators are relative to the categories that were left out. In the beginning, the variables left out were the following: Buick (make), automatic (transmission), other (engine), blue (colour), concours (condition), 1900-1910 (decade of production), January (month of sale) and sedan (body type). Depending on the period, some variables were not significant, nor primordial in explaining the price and were eliminated, so the base category evolved to include the variables left out. The following

tables (7-11) show the results of our hedonic regression for the main period; 1996-2017. For the sake of clarity, out of a total of 142 variables, only the extreme values for each category are represented for the period. Moreover, the results of the model were split in different tables. The tables 7-11 present estimates, standard errors, t-values, p-values and price impacts. The dependent variable is the logarithm of real prices. We also report the number of observations and R^2 .

The full table as well as the results for the three other periods can be found in the appendix (appendices 7.1, 7.2, 7.3 and 7.4).

First, we will show the results that directly concern the car. In table 7, we report the variables related to the make of the car. We can see that Duesenberg accounted for the higher prices with a price impact of 913% and a p-value of 0. The opposite, the make accounting for the lowest prices is the BSA, selling for -62,62% than the constant, with a p-value of 0,0005.

Table 7: hedonic regression results (variable: make).					
Dependent variable: natural log of prices.					
1996-2017	Estimate	Std. Error	t value	Pr(> t)	Price Impact
(Intercept)	11,012	0,127	86,458	0	exp(estimate)-1
Make					
Duesenberg	2,316	0,090	25,615	0,000%	913,33%
hispano_suiza	1,770	0,167	10,593	0,000%	486,97%
Bugatti	1,747	0,070	24,843	0,000%	473,86%
Ferrari	1,707	0,032	53,681	0,000%	450,98%
aston_martin	1,517	0,037	40,687	0,000%	355,98%
Delahaye	1,502	0,099	15,116	0,000%	349,23%
Shelby	1,378	0,042	33,159	0,000%	296,63%
Bentley	1,339	0,040	33,214	0,000%	281,58%
talbot_lago	1,262	0,091	13,803	0,000%	253,34%
Lamborghini	1,220	0,065	18,790	0,000%	238,80%
Maserati	1,135	0,048	23,510	0,000%	211,18%
Audi	1,092	0,171	6,374	0,000%	197,87%
rolls_royce	1,069	0,037	29,026	0,000%	191,28%
Facel	1,031	0,126	8,175	0,000%	180,26%
Delage	0,961	0,137	7,010	0,000%	161,39%
Lagonda	0,882	0,074	11,897	0,000%	141,64%
Porsche	0,864	0,036	23,977	0,000%	137,22%
International	-0,436	0,178	-2,458	1,400%	-35,36%
Nash	-0,473	0,092	-5,143	0,000%	-37,68%
Singer	-0,503	0,212	-2,369	1,785%	-39,51%
Messerschmitt	-0,558	0,177	-3,142	0,168%	-42,74%
Datsun	-0,625	0,094	-6,634	0,000%	-46,46%
Crosley	-0,839	0,141	-5,957	0,000%	-56,78%
BSA	-0,984	0,282	-3,488	0,049%	-62,62%
R²= 0,638				N= 29081	
Adjusted R²= 0,636					

*Only extreme price impact percentage variables are represented in this table, intermediate values are detailed in the appendix (appendix 7.4). Only the period 1996-2017 is represented in this table, refer to the appendix for the other periods (appendices 7.1, 7.2, 7.3). Values in bold represent results that are marginally significant.

Table 8 shows various characteristics directly related to the car. A manual car, will sell at 37% more than an automatic, with a p-value of 0. The racing cars are the most expensive with an estimate of 1.807, thus 508,94% more expensive with a 0 p-value. Concerning the car colours, orange are the ones selling at higher prices which is also the case for V16 engines, both being statistically significant. Finally, a replica of a car will sell at -32,07% with a p-value of 0.

Table 8: hedonic regression results (car related variables).					
Dependent variable: natural log of prices.					
1996-2017	Estimate	Std. Error	t value	Pr(> t)	Price Impact exp(estimate)-1
(Intercept)	11,012	0,127	86,458	0,000%	
Transmission					
MANUAL	0,318	0,013	25,405	0,000%	37,39%
Body of the car					
racer	1,807	0,042	43,295	0,000%	508,94%
sports_car	1,249	0,125	9,979	0,000%	248,75%
convertible	0,797	0,017	45,782	0,000%	121,95%
beachcar	0,780	0,124	6,273	0,000%	118,15%
coupe	0,675	0,019	35,992	0,000%	96,48%
drophead	0,623	0,067	9,369	0,000%	86,50%
wagon	0,574	0,038	15,032	0,000%	77,55%
Color					
orange	0,111	0,038	2,947	0,321%	11,73%
white	0,033	0,015	2,136	3,269%	3,33%
green	-0,048	0,018	-2,697	0,699%	-4,69%
brown	-0,083	0,026	-3,198	0,138%	-8,00%
yellow	-0,091	0,025	-3,709	0,021%	-8,69%
other	-0,115	0,026	-4,464	0,001%	-10,83%
beige	-0,134	0,035	-3,803	0,014%	-12,53%
Engine					
V16	0,961	0,106	9,055	0,000%	161,40%
V10	0,800	0,153	5,212	0,000%	122,50%
V12	0,599	0,034	17,818	0,000%	82,03%
I8	0,411	0,042	9,859	0,000%	50,76%
V8	0,242	0,025	9,540	0,000%	27,32%
I4	-0,192	0,026	-7,290	0,000%	-17,45%
V4	-0,410	0,128	-3,202	0,137%	-33,62%
cyl_2	-0,550	0,228	-2,411	1,593%	-42,33%
Replica					
REPLICA	-0,387	0,039	-9,816	0,000%	-32,07%
R²= 0,638				N= 29081	
Adjusted R²= 0.636					

*Only extreme price impact percentage variables are represented in this table, intermediate values are detailed in the appendix (appendix 7.4).

Only the period 1996-2017 is represented in this table, refer to the appendix for the other periods (appendices 7.1, 7.2, 7.3). Values in bold represent results that are marginally significant.

In table 9, we addressed the condition and the production decade of the car. The coefficient for the condition of the car decreases when the condition number increases. One should not forget that the constant includes cars of condition 1 which are concours state. All the p-values for the condition variables are equal to 0. The same goes for the decade of production, the coefficient usually decreases when we consider more recent decades, all of them being statistically significant. This means, that the smaller the condition number, or the earlier the production decade, the more the car will be worth.

Table 9: hedonic regression results (variables: condition and production decade).					
Dependent variable: natural log of prices.					
1996-2017	Estimate	Std. Error	t value	Pr(> t)	Price Impact exp(estimate)-1
(Intercept)	11,012	0,127	86,458	0,000%	
Condition					
COND_2	-0,472	0,014	-32,751	0,000%	-37,61%
COND_3	-0,974	0,015	-64,541	0,000%	-62,23%
COND_4	-1,465	0,023	-65,037	0,000%	-76,90%
COND_5	-2,234	0,044	-51,336	0,000%	-89,29%
COND_6	-3,952	0,103	-38,447	0,000%	-98,08%
Production decade					
DEC_1910	-0,422	0,132	-3,210	0,133%	-34,46%
DEC_1930	-0,545	0,116	-4,708	0,000%	-42,01%
DEC_1920	-0,823	0,118	-6,966	0,000%	-56,10%
DEC_1950	-0,883	0,115	-7,678	0,000%	-58,64%
DEC_1940	-0,917	0,117	-7,840	0,000%	-60,02%
DEC_1960	-1,202	0,115	-10,457	0,000%	-69,94%
DEC_1970	-1,575	0,116	-13,624	0,000%	-79,31%
DEC_1990	-1,846	0,118	-15,679	0,000%	-84,21%
DEC_1980	-2,040	0,117	-17,473	0,000%	-86,99%
R²= 0,638				N= 29081	
Adjusted R²=0,636					

*Only extreme price impact percentage variables are represented in this table, intermediate values are detailed in the appendix (appendix 7.4). Only the period 1996-2017 is represented in this table, refer to the appendix for the other periods (appendices 7.1, 7.2, 7.3). Values in bold represent results that are marginally significant.

The data from table 10 show that variables related to the sale itself and the auction houses have a significant impact on prices as well. Indeed, the price impact of RM Sotheby's is 101,38% with a 0 p-value. For auctions at Barons on the other hand, there is a trend towards less expensive cars (-29,81%). However, since the p-value is 0,051 we cannot statistically prove that the Barons variable has indeed an impact. January would be the month of the year for which the prices are higher, all the estimators of the month of sale variable being negative with a 0 p-value. The sales that take place in Villa Erba show a strong coefficient of 1,109 with a p-value of 0.

Table 10: hedonic regression results (auction related variables).					
Dependent variable: natural log of prices.					
1996-2017	Estimate	Std. Error	t value	Pr(> t)	Price Impact exp(estimate)-1
(Intercept)	11,012	0,127	86,458	0,000%	
Auction house					
RM_sothebys	0,700	0,049	14,172	0,000%	101,38%
Artcurial	0,476	0,036	13,108	0,000%	60,92%
Silverstone	0,331	0,043	7,694	0,000%	39,27%
Bonhams	0,171	0,016	10,614	0,000%	18,63%
Barons	-0,354	0,181	-1,954	5,069%	-29,81%
Auction sale					
RM_Villa_Erba	1,109	0,227	4,887	0,000%	203,03%
Pebble_Beach	0,584	0,052	11,287	0,000%	79,36%
Retromobile	0,580	0,068	8,527	0,000%	78,58%
Monterey	0,328	0,048	6,861	0,000%	38,86%
Bonhams_Paris	0,317	0,144	2,197	2,799%	37,36%
Amelia_Island	0,235	0,051	4,632	0,000%	26,46%
Greenwich	-0,145	0,064	-2,256	2,407%	-13,47%
Palm_Springs	-0,582	0,074	-7,883	0,000%	-44,14%
Month of sale					
MARCH	-0,140	0,021	-6,757	0,000%	-13,05%
MAY	-0,288	0,020	-14,481	0,000%	-25,06%
FEBRUARY	-0,355	0,023	-15,642	0,000%	-29,85%
OCTOBER	-0,355	0,021	-16,650	0,000%	-29,86%
NOVEMBER	-0,361	0,024	-14,830	0,000%	-30,28%
JUNE	-0,380	0,019	-19,685	0,000%	-31,59%
SEPTEMBER	-0,395	0,022	-17,789	0,000%	-32,65%
JULY	-0,399	0,027	-14,513	0,000%	-32,89%
APRIL	-0,432	0,018	-23,648	0,000%	-35,07%
DECEMBER	-0,433	0,028	-15,460	0,000%	-35,15%
R²= 0,638				N= 29081	
Adjusted R²= 0,636					

*Only extreme price impact percentage variables are represented in this table, intermediate values are detailed in the appendix (appendix 7.4).

Only the period 1996-2017 is represented in this table, refer to the appendix for the other periods (appendices 7.1, 7.2, 7.3). Values in bold represent results that are marginally significant.

Finally, we discussed the possibility that sentiment might play an important role and was characterised in our model by “effect list”. The results are reported in table 11. It appears that cars that were seen in famous movies would command a price 21,66% higher with a strongly significant variable.

Table 11: hedonic regression results (sentiment related variables).					
Dependent variable: natural log of prices.					
1996-2017	Estimate	Std. Error	t value	Pr(> t)	Price Impact exp(estimate)-1
(Intercept)	11,012	0,127	86,458	0,000%	
Effect list					
LIST_ICONIC	0,595	0,031	19,231	0,000%	81,27%
LIST_MOVIE	0,196	0,044	4,421	0,001%	21,66%
LIST_DESIGN	1,212	0,083	14,533	0,000%	235,93%
R²= 0,638				N= 29081	
Adjusted R²=0,636					

*Only extreme price impact percentage variables are represented in this table, intermediate values are detailed in the appendix (appendix 7.4). Only the period 1996-2017 is represented in this table, refer to the appendix for the other periods (appendices 7.1, 7.2, 7.3). Values in bold represent results that are marginally significant.

The easiest way to review the results of our regressions is to consult the complete tables for all periods in the appendix (appendix section 7).

4.2 Classic Car Index

In our four hedonic regressions, time dummy variables were included as well, with their own estimators. As detailed in the methodology, we can adapt those coefficients to reflect a value compared to the value “100” of the base year which is left out of the variables. Then a rate can be computed between those values, and finally an index can be created. The four periods are the following: 1980-1991 (1980 left out), 1991-1993 (1991 left out), 1993-1996 (1993 left out) and 1996-2017(1996 left out). The table 12 details the estimators and the results as well as the creation of the Classic Car Index.

First, we observe the absence of estimators between 1987 and 1989, which is due to the speculative bubble. The market was waiting and no sales were reported in the database. Therefore, 1986 and 1990 were considered as adjacent periods and the rate was split by geometric interpolation to fill in the missing years. Our index was based on a value of 100 in 1980 and ended with the value of 345,76 for the on-going year 2017. Its annual arithmetic mean of real return is 6,03%. These results, the ratios and other indicators, will be fully detailed in the asset analysis section.

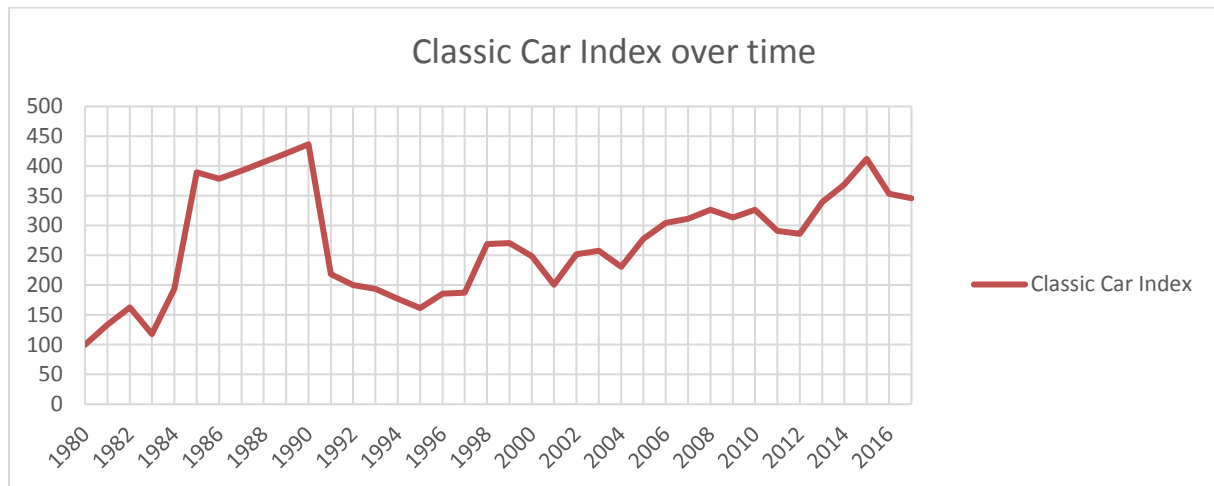
Table 12: Time dummy variables and Classic Car Index.

Dependent variable: natural log of prices.

	Year	Estimate	Std. Error	Value	Rate	Index
Base	1980			100		100,00
	YEAR_1981	0,288	0,201	133,43	33,43%	133,43
	YEAR_1982	0,485	0,195	162,45	21,75%	162,45
	YEAR_1983	0,165	0,181	117,93	-27,41%	117,93
	YEAR_1984	0,660	0,177	193,56	64,14%	193,56
	YEAR_1985	1,359	0,184	389,35	101,15%	389,35
	YEAR_1986	1,331	0,186	378,52	-2,78%	378,52
	1987	-	-	-	3,62%	392,23
	1988	-	-	-	3,62%	406,45
	1989	-	-	-	3,62%	421,18
	YEAR_1990	1,473	0,287	436,44	3,62%	436,44
	YEAR_1991	0,781	0,172	218,36	-49,97%	218,36
Base	1991			100		
	YEAR_1992	-0,087	0,036	91,64	-8,36%	200,11
	YEAR_1993	-0,121	0,041	88,61	-3,31%	193,49
Base	1993			100		
	1994	-	-	-	-8,63%	176,79
	YEAR_1995	-0,180	0,108	83,49	-8,63%	161,54
	YEAR_1996	-0,041	0,068	95,99	14,97%	185,73
Base	1996			100		
	YEAR_1997	0,008	0,067	100,76	0,76%	187,15
	YEAR_1998	0,370	0,062	144,71	43,62%	268,78
	YEAR_1999	0,377	0,065	145,80	0,75%	270,78
	YEAR_2000	0,291	0,058	133,80	-8,23%	248,50
	YEAR_2001	0,078	0,059	108,11	-19,20%	200,80
	YEAR_2002	0,303	0,057	135,46	25,29%	251,58
	YEAR_2003	0,327	0,056	138,64	2,35%	257,50
	YEAR_2004	0,217	0,057	124,21	-10,41%	230,69
	YEAR_2005	0,401	0,058	149,39	20,28%	277,46
	YEAR_2006	0,494	0,058	163,81	9,65%	304,24
	YEAR_2007	0,517	0,057	167,71	2,38%	311,49
	YEAR_2008	0,564	0,057	175,84	4,84%	326,58
	YEAR_2009	0,523	0,059	168,71	-4,05%	313,34
	YEAR_2010	0,564	0,058	175,75	4,17%	326,41
	YEAR_2011	0,448	0,058	156,56	-10,92%	290,78
	YEAR_2012	0,432	0,057	154,08	-1,59%	286,17
	YEAR_2013	0,603	0,058	182,69	18,57%	339,32
	YEAR_2014	0,686	0,058	198,56	8,68%	368,78
	YEAR_2015	0,797	0,059	221,87	11,74%	412,08
	YEAR_2016	0,643	0,059	190,17	-14,29%	353,19
	YEAR_2017	0,621	0,063	186,16	-2,11%	345,76

Figure 3 displays the evolution of our new index over time. The market skyrocketed quite early, starting in 1983 at 117,93 and finishing its ascendance in 1990 at 436,44. The market then plunged to 161,54 in 1995 which was the lowest value for the following years. Indeed, the index has steadily risen since then to attain a new peak in 2015 with some minor market dips every now and then. The last two years are marked by a downturn of 14% for 2016 and 2% for the on-going year.

Figure 3: Classic Car Index over time.



4.3 Asset analysis

For the following analysis, in order to lighten the structure, some extra analyses will only be reported in the appendix (appendix 8). We report here the more pertinent measurements.

Table 13 shows the different annual average returns as well as the volatility of the new index and other assets. Classic cars have performed on an average annual arithmetic mean of 6,03% and a geometric mean of 3,41%. On a more economical point of view, we report as well, a compound annual growth rate of 3.31%. The risk of the asset explained by its volatility is 25,22%. Gold has performed during the same period at an annual arithmetic mean of 3,37% for a 16,07% volatility. Classic cars also did well against real estate, though the average returns of bonds and equity were higher for the period.

Table 13: Comparison of classic cars and other assets.

	Average annual return: Arithmetic mean	Average annual return: Geometric mean	Average annual log return	volatility
Classic Car	6,03%	3,41%	3,35%	25,22%
S&P500	9,47%	8,19%	7,87%	15,88%
DAX	12,92%	9,59%	9,16%	28,35%
US global Bonds	8,00%	7,79%	7,50%	6,91%
Real Estate	1,14%	0,99%	0,99%	5,42%
Gold spot	3,37%	2,09%	2,07%	16,07%
10 years T-bills	6,44%	6,38%	6,18%	3,70%
3 Month T-bills	4,24%	4,19%	4,10%	3,58%

We present in table 14 the computation of a conditional CAPM for the classic car as an asset. In order to take into account European investors, a CAPM has been estimated on the German stock index as well; the DAX. Being in a long term oriented investor scenario, we used the Ten Years Treasury Bond rate as our risk-free asset. We noticed that classic cars have a small negative beta of -0,028 when using the S&P500 to represent the market, with a p-value of 91,35%. This means that we cannot statistically reject the hypothesis that beta is equal to 0. Corroborating the above result, we can dismiss the hypothesis that the beta is equal to 0,5 at a significant threshold of 4,48%. Finally, the 95% confidence interval shows that our beta will either be small or negative between -0,54 and 0,49. A small beta represents a small systemic risk. The beta obtained with the DAX is slightly higher at 0,256. however, we cannot statistically refute the null hypothesis nor the hypothesis of a beta equal to 0,5. The 95% confidence interval tells us that the beta should lie between -0,02 and 0,54 at a statistically significant threshold of 5%. The Jensen's Alphas show that our asset underperformed both benchmarks during the period.

Table 14: Classic Car, conditional CAPM

				95% confidence interval		Annual Jensen's Alpha (arith/arith)	-0,32%
Beta (S&P500)	-0,028	t* with H0: beta=	Two-tailed p-value	Inferior Beta	superior Beta	Alpha (geom/geom)	-2,92%
	0	91,35%	-0,54	0,49	Alpha (log/log)	-2,78%	
	0,5	4,48%			Alpha (log/arith)	-3,05%	
				95% confidence interval		Annual Jensen's Alpha (arith/arith)	-1,18%
Beta (DAX)	0,256	t* with H0: beta=	Two-tailed p-value	Inferior Beta	superior Beta	Alpha (geom/geom)	-3,43%
	0	7,08%	-0,02	0,54	Alpha (log/log)	-3,26%	
	0,5	8,53%			Alpha (log/arith)	-3,45%	

*Ten Years US Treasury Bond rate used as the risk-free asset.

We show in table 15 the summary of alternative investments discussed at the end of point 1.2, to which we have now included our new index data. First, we see a smaller average annual return compared to the HAGI index. In general, the volatility is relatively higher in comparison to other assets. However, the beta is similar to the one computed for wine. In comparison to the study of Renneboog and Spaenjers (2013), we show higher returns for a higher standard deviation.

Table 15: Summary of alternative investment returns with corresponding periods.

Author	Year	Sample	Period	Type of Index	Real return	Std deviation	Beta
Pesando	1993	Prints	1977-1991	repeat sales regression	1,50%	19,94%	0,315
Pesando and Shum	1996	Picasso prints	1977-1991	repeat sales regression	2,10%	23,38%	0,43
Mei and Moses	2002	American, impressionist and old masters	1875-2000	repeat sales regression	4,90%		0,718
Ashenfelter and Graddy	2003	Modern and Impressionist	1980-1991	hedonic regression	4,00%		
		Modern and Impressionist	1980-1991	repeat sales regression	9,00%		
Campbell	2008	Old masters, European impressionist, modern and contemporary	1980-2006	repeat sales regression	6,50%	7%-15%	
Renneboog and Spaenjers	2013	Paintings and works on paper	1957-2007	hedonic regression	3,97%	15%	
Burton and Jacobsen	2001	Fine wine	1986-1996	repeat sales regression	3,10%		
Lucey and Devine	2015	Fine wine	1996-2007	repeat sales regression	5,20%	9,10%	About 0
Sanning et al.	2008	Fine wine	1996-2003	repeat sales regression	6,2%-11,1%	6%	About 0
HAGI	2015	Classic cars top 38	1980-2008	/	11,70%		
Classic Car Index	2017	General market	1980-2017	hedonic regression	6,03%	25,22%	-0,028

Moving on to the correlation with other asset classes, table 16 displays classic cars in comparison to other investments for the period 1980-2017. We show a relatively low correlation with other assets with a maximum of 34,95% with the Ten-Year Treasury Bonds and a negative correlation with the gold market of -7,24%.

Table 16: Correlation with other assets

	S&P500	DAX	US Global Bonds	Real Estate	Classic Car	Gold Spot	10 Years T-Bills	3 Month T-Bills
S&P500	1							
DAX	63,01%	1						
US global Bonds	24,34%	17,81%	1					
Real Estate	23,45%	23,31%	-15,79%	1				
Classic Car	3,71%	32,46%	25,40%	12,31%	1			
Gold spot	-2,04%	11,54%	4,87%	-11,02%	-7,24%	1		
10 years T-bills	5,30%	7,03%	74,01%	-18,50%	34,95%	-30,49%	1	
3 Month T-bills	5,40%	7,52%	53,44%	-15,62%	29,94%	-39,43%	92,56%	1

In table 17, we present three ratios to compare classic cars to other assets. Other ratios, tests and the results that have been used to compute them, can be found in the appendix (appendix 8). Data concerning classic cars are shown in blue. Highlighted in green, we show assets that statistically underperformed our index for a specific ratio, and highlighted in red, assets that have statistically over performed. The results that were higher or lower, though not significantly were written in red and green respectively. The ratios are computed on excess returns, discounted on a three-month Treasury Bond rate. The annualized Sharpe ratio displays excess returns divided by the volatility of the asset. It measures the excess returns received for the extra volatility supported. A 95% confidence interval for the Sharpe ratio has been created for the classic cars as an asset. It showed that values of the Sharpe ratio between -0,27 and 0,41 are statistically significant at a 5% threshold. Therefore, we clearly show that classic cars outperformed real estate during the period 1980-2017 based on the Sharpe ratio. The Sortino ratio follows the same principle, but it is based on the downside volatility which measures the standard deviation of negative returns. Classic cars with a ratio of 0,555 outperformed gold and real estate, but plotted under the other assets. Finally, the Treynor ratios stress the systemic risk diversification benefits, dividing returns by the beta. Classic cars outperformed most of classes except the US global bonds index.

Table 17: Comparison of classic cars and other assets.						
	S&P500	DAX	US Global Bonds	Real Estate	Classic Car	Gold Spot
beta S&P500	1	1,105	0,071	0,133	-0,028	0,091
Annualized Sharpe ratio	0,329	0,306	0,543	-0,574	0,071	-0,055
t-ratio test with H0: SR=0	1,974	1,836	3,259	-3,441	0,425	-0,328
Two-tailed p-value	5,61%	7,47%	0,24%	0,15%	67,33%	74,49%
95% confidence interval	Inferior SR=	-0,267	Superior SR=	0,409		
Downside volatility	8,41%	11,31%	0,60%	3,46%	10,88%	9,72%
Annualized Sortino ratio	1,126	1,142	13,348	0,329	0,555	0,346
Treynor ratio	0,039	0,047	0,508	-0,253	0,313	-0,285
Active Treynor ratio	0,000	0,028	0,190	-0,430	0,427	-0,370
Modified Treynor ratio	0,241	0,294	3,159	-1,570	1,948	-1,769

*Classic cars are highlighted in blue. The assets that significantly underperformed our index are highlighted in green. The ones highlighted in red statistically over performed. Results that were not significantly higher or lower were written in red and green respectively. The Treynor ratio and modified Treynor ratio use a geometric average of annualized excess returns, the modified one uses the volatility of excess returns while the others use the standard volatility. The active Treynor ratio uses the Jensen's alpha for the returns. The risk-free used to discount the returns is a three-month US Treasury Bond rate.

4.4 Portfolio analysis

As stated in the methodology, a standard portfolio was created to reflect an average European investor. Then, seven other portfolios were created to include classic cars. Be reminded that for PF2 to PF6 we gradually increased the weight of classic cars by removing weights equally from each of the other investments. PF7 and PF8 were created to show the replacement of some real estate and gold by cars. Table 6 shows the eight portfolios.

Table 6: Weights of portfolios.						
	S&P500	DAX	US Global Bonds	Real Estate	Classic Car	Gold
PF1	25%	20%	25%	10%	0%	20%
PF2	24%	19%	24%	9%	5%	19%
PF3	23%	18%	23%	8%	10%	18%
PF4	22%	17%	22%	7%	15%	17%
PF5	21%	16%	21%	6%	20%	16%
PF6	20%	15%	20%	5%	25%	15%
PF7	25%	20%	25%	5%	10%	15%
PF8	25%	20%	25%	0%	10%	20%

*PF: portfolio. Figures in bold show the replacement of gold and real estate.

We performed back-tests on these portfolios that go back to 1980. We computed the same ratios used above and added the passive information ratio, which allows us to evaluate a well-diversified portfolio performance against a benchmark. Table 18 presents the results obtained. In blue, we report PF1 that does not contain classic cars. Highlighted in green are the portfolios that significantly outperformed the blue portfolio and finally highlighted in red the ones that significantly underperformed PF1. The results that were higher and lower than PF1 but not significantly are written in green and red respectively. First, we report lower average returns for the portfolios that include classic cars, except for PF7 and PF8 which were the ones that replaced gold and real estate. For none of the Sharpe ratios, we can statistically dismiss the hypothesis that the ratio is equal to 0,35 with a significant threshold of 5%. We can stress a significant over performance of PF7 and PF8 compared to PF1 for the information ratio, the returns being negative, the smaller the ratio the better. However, the information ratio is used to measure how a portfolio behaves in comparison to a benchmark. Here, the eight portfolios have underperformed. Therefore, it is not relevant to analyse these ratios here. Concerning the downside volatility, portfolios with classic cars clearly out performed PF1 as was the case for the different Treynor ratios. In general, we can either prove significant over performances of the PF7 and PF8, or slightly higher results that were not statistically significant.

Table 18: Portfolios performances.										
	SP500	DAX	PF1	PF2	PF3	PF4	PF5	PF6	PF7	PF8
Average annual Return: Arithmetic mean	9,47%	12,92%	7,74%	7,69%	7,64%	7,59%	7,55%	7,50%	8,11%	8,23%
Average annual Return: Geometric mean	8,19%	9,59%	7,27%	7,24%	7,20%	7,14%	7,07%	6,99%	7,61%	7,71%
Volatility	15,88%	28,35%	10,13%	10,02%	10,05%	10,24%	10,57%	11,03%	10,67%	10,87%
Annualized Sharpe ratio	0,329	0,306	0,345	0,344	0,338	0,327	0,313	0,295	0,363	0,366
t-ratio test with H0: SR= 0,35	-0,126	-0,264	-0,032	-0,036	-0,072	-0,136	-0,224	-0,328	0,075	0,099
Two-tailed p-value	90,06%	79,31%	97,44%	97,12%	94,33%	89,24%	82,38%	74,46%	94,04%	92,19%
Downside volatility	8,41%	11,31%	3,53%	3,23%	2,97%	2,79%	2,71%	2,79%	3,23%	3,17%
Annualized Sortino ratio	1,126	1,142	2,190	2,383	2,570	2,720	2,780	2,685	2,511	2,591
(Passive) Information ratio - Indice Based	-	13,193	-11,894	-11,903	-11,866	-11,776	-11,635	-11,444	-19,546	-24,173
t-ratio test with H0: IR= -12	-	151,156	0,633	0,580	0,805	1,341	2,193	3,338	-45,278	-73,039
Two-tailed p-value	-	0,00%	53,05%	56,54%	42,62%	18,83%	3,49%	0,20%	0,00%	0,00%
95% confidence interval for PF1	Inferior IR= -12,232 superior IR= -11,556									
Treynor ratio	0,039	0,047	0,057	0,059	0,062	0,064	0,067	0,069	0,066	0,068
Active Treynor ratio	0,000	0,028	-0,005	-0,005	-0,005	-0,004	-0,004	-0,003	0,003	0,005
Modified Treynor ratio	0,241	0,294	0,351	0,368	0,384	0,400	0,415	0,431	0,408	0,420

*The portfolio without classic cars is highlighted in blue. The portfolios that significantly over performed PF1 are highlighted in green. The ones highlighted in red statistically underperformed PF1. Results that were not significantly higher or lower than PF1 were written in green and red respectively. The Treynor ratio and modified Treynor ratio use a geometric average of annualized excess returns, the modified one uses the volatility of excess returns while the others use the standard volatility. The active Treynor ratio uses the Jensen's alpha for the returns. The risk-free used to discount the returns is a three-month US Treasury bond rate.

Finally, *figure 4* shows 1.000 efficient portfolios according to the Markowitz theory, illustrating the benefits of investing in classic cars. Each dot in the figure below represents a portfolio with its average annual return and standard deviation plotted on the chart. The weights of each portfolio have been computed under constraints that were reviewed in the methodology. The dots in blue are portfolios without classic cars. The orange dots are portfolios for which the weight of classic cars is not null. The minimum weight for classic cars in the orange group is 6,65%. The black lozenges on the efficient frontiers (*figure 4*) represent the two portfolios that maximise the Sharpe ratio. We also plotted the other portfolios analysed above. We can observe that none of them lies on the efficient frontier. However, PF7 and PF8 are the closest.

Figure 4: Efficient portfolios with varying weights.

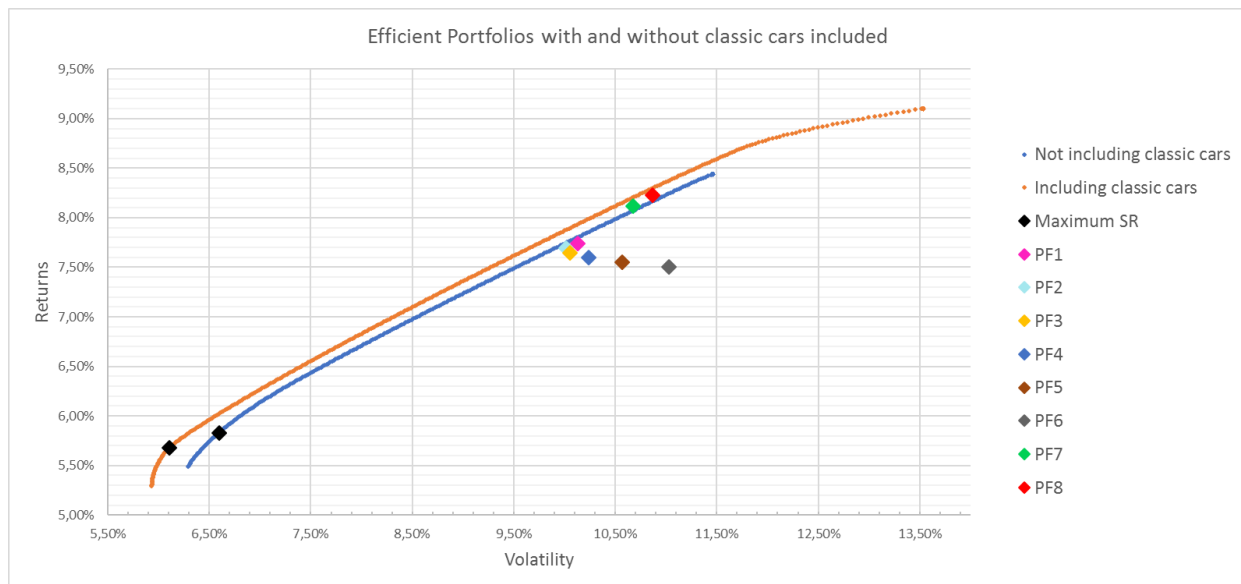


Table 19 is an overview of the extreme points of each group as well as the two portfolios that had the highest Sharpe ratio.

	Average annual returns	Volatility	Sharpe ratio		S&P500	DAX	US Global Bonds	Real Estate	Classic Car	Gold
Minimum Risk	5,49%	6,29%	0,87	Weight	25,00%	0,00%	25,00%	25,00%	0,00%	25,00%
Maximum Return	8,44%	11,46%	0,74	Weight	25,00%	25,00%	25,00%	0,00%	0,00%	25,00%
Maximum Sharpe ratio	5,83%	6,59%	0,88	Weight	25,00%	3,56%	25,00%	25,00%	0,00%	21,44%
Minimum Risk	5,29%	5,93%	0,89	Weight	18,47%	0,00%	25,00%	25,00%	7,42%	24,12%
Maximum Return	9,10%	13,53%	0,67	Weight	25,00%	25,00%	25,00%	0,00%	25,00%	0,00%
Maximum Sharpe ratio	5,68%	6,10%	0,93	Weight	25,00%	0,00%	25,00%	25,00%	7,09%	17,91%

Chapter 5. Discussion

In this study, we investigated the possibility that classic cars could be considered as a viable alternative investment. To do so, we will go back to each section of the results. First, let us come back to the estimators of the different variables. It is interesting to compare the results with what we reviewed in point 1.2. Before discussing these coefficients, we should emphasise that some of the explanatory variables are missing. Some of our variables might be correlated with them and partly reflect it in their estimators (Triplet, 2006). Moreover, other estimators need to be brought into context. For example, Sotheby's probably do not obtain prices 100% higher than the constant. There is definitely an impact. However, it is most likely that Sotheby's only sell very high value cars for which all the price determinants were not accounted for in our model, such as famous owners, good history etc. Nevertheless, our theory that famous sales and auction houses might influence prices was indeed confirmed by our results. Some results were predictable such as the strong impact on prices of the makes; Ferrari and Porsche, as detailed in point 1.2. Both makes produced limited editions and are still very active today in promoting their history. The two makes were successful in the racing World as well. The importance of races is demonstrated here, with a strong positive impact on prices of the racer variable, which held for each adjacent period. We saw that the cars presented in famous movies achieved significantly higher prices. The part played by the variable movie was confirmed by the fact that the same variable for older periods was less and less significant since the films had not yet been produced. Other results are more surprising, for example the success of the colour orange which had the biggest impact on prices. This might be explained by the fact that they are rarer. Indeed, we see that the total sample only shows 536 items that present the colour orange (appendix 4.4). Another explanation, though less likely, is that the insurance costs for an orange car are usually lower, which might explain a higher price for the more affordable models. The number of cars produced, which represents the rarity of the car, only had a small impact on prices in our regressions. However, it is evident that this factor is one of the main price drivers. The most likely explanation could be, that the small number of cars produced is closely related with the make of the car. Therefore, a part of the impact on price is probably already captured by the make variable.

The current theory is that the classic car market is shifting. The most wanted cars would change depending on the period in function of their year of production. The shift of the market would be explained by the fact that people are buying cars that were famous in their youth. In our

regressions for the three later periods, we can see that the production decade that accounted for the highest prices is 1940-1950 for the regression of 1980-1991, then the decade 1950-1960 for the regression 1991-1993 and finally 1960-1970 for the regression 1993-1996. This confirms the theory that the market is shifting. Nevertheless, the regression of the last period stopped the trend and clearly showed that the older the car the higher the price.

The second part of this study consists in the creation of our own Classic Car Index. We compared our work with the financial analysis of the car market that has been done previously and reviewed in point 1.2. We obtained smaller returns compared to the ones reported by HAGI with their top 38 car index (Hatlapa, 2014). Despite this discrepancy, the comparison between figures 3 and 5, demonstrates that the general trend is sustained.

Figure 3: Classic Car Index over time.

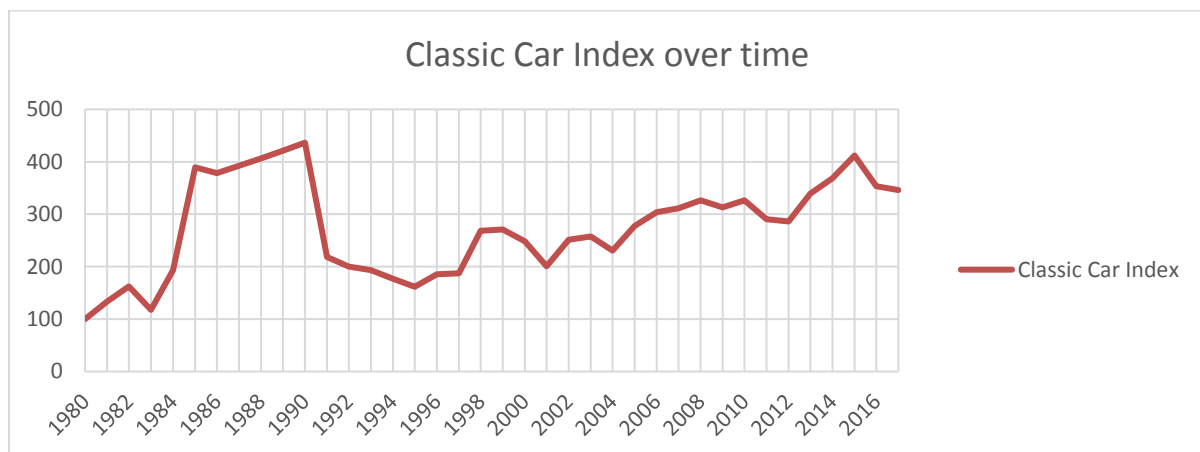
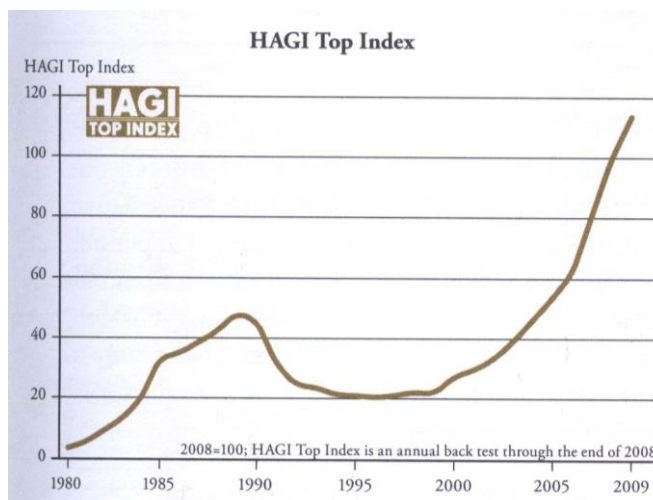


Figure 5: HAGI Top Index



Source: Hatlapa, D. (2014). *Better than gold investing in historic cars*. Tortola: HAGI Publishing.

Both indices show the appearance of a speculative bubble in the market in 1985 which subsequently burst in 1991. At the time, the Baby-Boomer generation was buying cars, while the market was booming. Everybody wanted in and people started to buy anything and everything, sometimes taking out loans for their acquisitions. Our Classic Car Index measures the whole market in opposition to the HAGI index, which only measures blue chips. Therefore, the size and downfalls of this bubble had a stronger impact on our computations. Again, people rushed to buy any model just to be in and contrary to blue chip assets, not all models recovered from the burst bubble. Another explanation of the over performance of the HAGI index, is that its constituents were selected in 2008 and then their price evolution was tracked back to 1980. So, a car that did not perform well over a period of years might not have attracted the attention of the HAGI team and been included in their index.

Market experts and the news outlets over the last two years have shown us that the market was flat and paused. Our results show in fact, that the market has been decreasing since the beginning last year 2016. Their pronouncements could possibly be motivated by their financial interest in the market. They would not appreciate panic conditions in the car market. The possibility of a new speculative bubble is often discussed. It is true that in the context of historically low interest rates, car prices have been driven up in past years. However, we face a different scenario compared to the late 80s, as the rise of prices has been more gradual and not exponential as before.

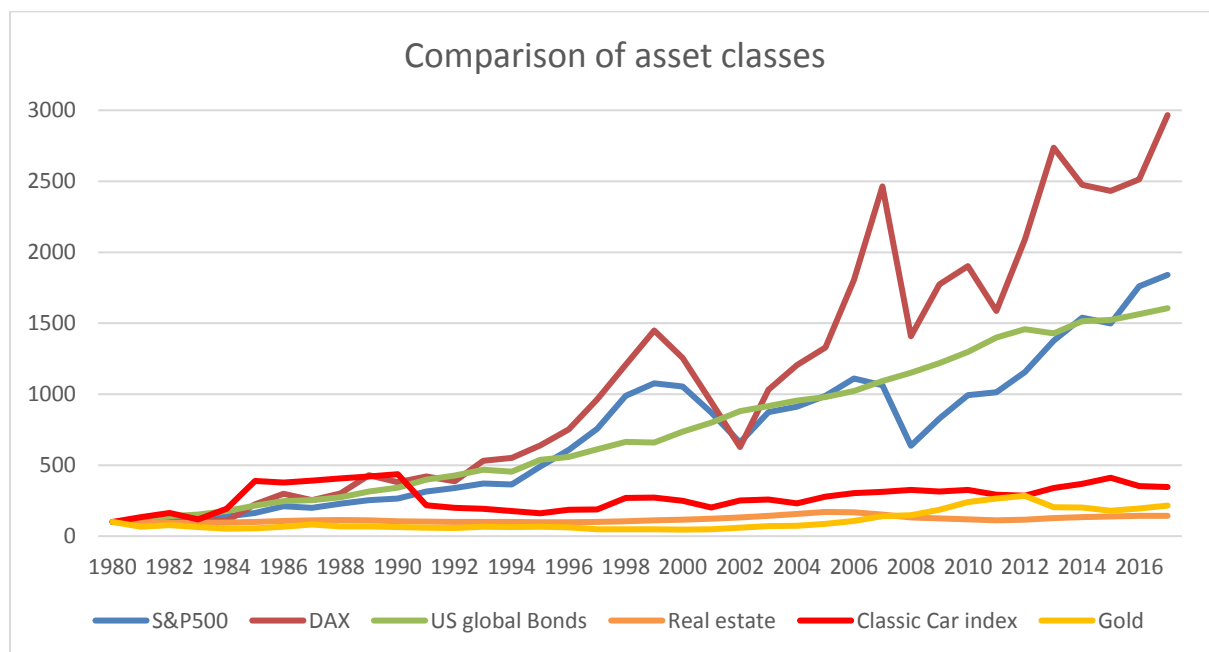
When we compare classic cars with alternative investments such as wine and paintings that were covered in the literature above (Anderson, 1974; Mei and Moses, 2002; Renneboog and Spaenjers, 2013), we notice that classic cars showed higher returns though coupled with higher risk. When we look at the most coherent period to compare our assets, we see that wine was just below in terms of returns (Devine and Lucey, 2015). Both the beta of wine and classic cars is around 0, characterizing a low sensitivity to the systemic risk of the market. This is unexpected. We would have thought that the market is a pertinent tool to assess the increase in wealth and that when the market is booming, people would tend to buy wine and cars. This would corroborate the theory discussed in point 1.1 that art is above all a luxury consumption good. One of the explanations would be that annual returns are not sufficient to determine a precise beta. A different explanation would be that when the market is doing badly, people would have a tendency to invest in alternative investments. The beta for paintings were significantly higher. The returns for relatively comparable periods were not as good as the ones for cars. However, the costs and fees will be lower than for classic cars and wine. In point 1.3,

the main criticism and challenge concerning the hedonic regression was the ability to determine enough variables to explain the price of the asset. Our adjusted R^2 from our regressions are usually higher than what was obtained in other studies such as the ones from Renneboog & Spaenjers (2013) and Anderson (1974). We can therefore assume that our results are relevant.

Finally, in the literature review, we either did not find evidence of the masterpiece effect or we found a slight one (Ginsburgh and Jeanfils, 1995; Ashenfelter and Graddy, 2003; Goetzman et al., 2013). We did not test the masterpiece effect here. However, our index represents the whole market for the same period as the HAGI Top 38 Index. Therefore, when comparing the two, we can evaluate the possibility of such an effect and in this case, demonstrate the existence of a masterpiece effect.

Now that we have compared alternative investments, we may pursue the comparison with more standard asset classes. *Figure 6* gives us the first insights. Note that the indices reviewed in *figure 6* were analysed in tables 13 and 16.

Figure 6: Comparison of indices evolution over time



We can see in our results and in *figure 6*, that standard investments such as equity and bonds outperformed our index during the studied period. However, classic cars should not be compared to equity or bonds. When you invest in classic cars, you detain a tangible asset which is also the case for real estate. The point of the study was to weight the potential of classic cars as a diversification tool. On this matter, our analysis showed many attributes that would make the asset eligible. First, we reported a low correlation with other assets with a maximum of

35%. The asset also has a low beta allowing to hedge against systemic risk. When comparing the returns, classic cars offered higher yields than gold and real estate but not bonds and equities. Our ratio of performances showed a better performance compared to those two investments. Finally, as discussed above, classic cars like gold and real estate are tangible investments. Cars additionally offer many benefits other than financial.

On the other hand, being a tangible asset also implies costs. For classic cars, we have reviewed that they can be significant, including storage, insurance, maintenance amongst others. These costs were not considered in any of our computations and analyses. Moreover, similarly to other collectibles, classic cars are illiquid. This is a source of risk. If the buyer needs to generate some cash rapidly, he will most probably sell below the real value of the car. Finally, compared to gold, real estate and other investments, the volatility of classic cars over the last 30 years was found to be high. One of the explanations, is that the crisis in the car market in the late 80s has shown more extreme peaks than during the 2008 subprime crisis for example. When performing back-tests, we cannot just ignore a certain period. Nevertheless, without the bubble, the volatility obtained would be much lower. The same explanation can justify the important difference between our geometric and arithmetic annual mean returns.

Nevertheless, when we included classic cars in a standard portfolio and gradually increased its weight, our back-test analyses demonstrated mixed results and were unable to prove a clear over performance of portfolios with classic cars. On the other hand, PF7 and PF8 which were built to prove the benefits of replacing part of the allocation in gold and real estate by classic cars clearly outperformed the other portfolios. We should stress that our analyses are in year returns, which renders them highly sensitive to the sample period. As said before, classic car results are hindered by the significant volatility of the asset.

Regarding the arguments outlined above, classic cars represent a viable investment though some conditions and precautions should be considered. Especially, an investor should consider diversifying his portfolio by allocating part of his capital invested in real estate and gold into classic cars. However, considering the different disadvantages linked to a tangible asset, a private investor should not consider the investment unless he is passionate about cars and benefits from non-financial attributes or has enough capital to only allocate 10-15% of his capital to this asset.

As shown, the investment offers several advantages. However, the many challenges stated above make it difficult. The high prices of classic cars make it hard for private investors to step in the market and almost impossible to diversify within.

One way for an investor to overcome these challenges would be to invest part of his capital in a hedge fund specialized in classic car investments. In the following part, we will approach the creation of such a company and outline the opportunities it would offer as well as the challenges that the company would face. The analysis will also include a market study on these kinds of funds.

Chapter 6. Creation of a hedge fund specialised in classic car investments

A hedge fund is a particular type of collective investment undertaking. Its appellation goes back to 1949, when the first hedge fund was created by Alfred Winslow. At that time, those companies were only proposing as their names state: hedge products. Since then, those firms have evolved. Although they kept the same appellation, they are no longer limited to hedge products. Currently, hedge funds differentiate from other investment trusts by their smaller size, a wider spectrum of types of investments and finally by less stricter regulations (Investopedia, n.d.). Indeed, most of the alternative and more eccentric investments are usually handled by those companies. A hedge fund will focus on one type of investment and market opportunity and become fully committed to that field. They will pursue diversification within the chosen market but not on a higher level. Therefore, leaving the investors the task of allocating and diversifying their capital across investments and hedge funds.

A hedge fund like other investment trusts is obliged to have a fund administrator who will be in charge of computing its net periodic value. To generate profits, the norm for hedge funds is a fee on the capital managed. There are two fees. First, the management fee that will be extracted from the capital managed. It represents usually 1 or 2% of the capital. Second, there is the performance fee. This fee is applied on the return on investment if applicable (Hedge Funds, n.d.). It is usually 20% of the return, however, with the increasing number of hedge funds these fees are diminished. Fund managers are normally evaluated through benchmarks. Considering the management fee, the company will need to beat the yearly return of the benchmark by at least one or two percent.

In our case, the hedge fund manager will be an expert in classic car investments. The feasibility and analysis of such a firm will be structured as follows. First, we will conduct a market study of existing companies on the market. We will then address how such a hedge fund will overcome the challenges outlined in our discussion. Finally, we will proceed to detail the opportunities and the value propositions as well as the targeted market segments. The analysis will also include a Business Model Canvas.

6.1 Market research

Considering the high interest classic cars have faced these last years, the idea of a hedge fund in the field is not disruptive. Indeed, three management specialised firms were found on the internet. It is possible that other companies of the kind exist though they might not be referenced online. In this point, we will detail the value propositions of the three hedge funds and report the information available online.

- The Classic Car Fund

This firm was established in 2012 and proposes two funds with a minimum subscription of 200K and 10K. Their value proposition is to offer higher returns than other assets. Their proposition is based on several charts of returns that are available in the appendix (appendix 9.1). They focus on the purchase process. The transport, insurance and storage of the car are handled by a tierce company. Their fees consist of 2% for management and 20% for performance (The Classic Car Fund, n.d.).

Website: http://www.countofcustoza.com/countofcustoza.com/Home_CCF.html

- Ultimate Classic Car Fund

The information concerning this company is limited. They based their value proposition on a chart of returns and press releases that can be visualized in the appendix (appendix 9.2) (UCCF, n.d.).

Website: <http://ultimateclassiccarfund.com/>

- Cohen & Cunild

Like the previous company, information concerning this company is scarce. Their value proposition is based on the same charts as the ones provided by the company “Ultimate Classic Car Fund” and is available in the appendix (appendix 9.3). They offer to invest a customer’s money in a car that will be owned and drivable by the client. They propose some advisory as well (Cohen & Cunild, n.d.).

Website: <http://www.cohencunild.com/investments/>

6.2 Challenges

The first challenge discussed previously is the illiquidity of the classic car as an asset. The hedge fund, by purchasing and maintaining a large portfolio of cars will be able to have a circulating stock. This would facilitate the generation of cash at all times which would reduce the illiquidity problem though not solve it. Therefore, the firm would be obliged to keep a part of the capital in cash or in a Money Market Fund. The lock-up period of such a hedge fund would typically be longer than the one for an equity fund for example (Investopedia, n.d.).

- Costs

Every fund management company faces fixed costs. The costs, usually expressed as a percentage of the capital managed are the following: infrastructure, employees, legal, administrative and back office, compliance investment, tax, audit, technology and marketing (Mike Coglianese, 2016).

However, as underlined above, investing in a tangible asset like cars is accompanied by additional costs. To overcome and limit these fees, the principle of economy of scale will be at stake. The storage rent and other related costs will be shared for an important number of cars and for a larger capital than one for a private individual. Where a single investor would need to pay an expert for the purchase process for each car, as well as a garage for repairs or restoration, a hedge fund would have its own experts and mechanics to handle the tasks for numerous cars which would minimize the extra costs. Nevertheless, we should stress that the fees of such a hedge fund would be slightly higher than others.

- Dividends

The last limit, which was not reviewed previously, is the fact that investors usually expect to receive dividends on their investments. That would be difficult to materialize in the case of classic cars. To replace dividends, the hedge fund could consider offering non-financial benefits as an alternative. For example, the cars could be stored by the company in a show room. The investors would be members of a club allowing them to visit, attend cocktails, bring guests or even organize events at the clubhouse. One could equally imagine the participation of investors to car rallies. In the end, an investor would own a small part of an important classic car collection.

6.3 Strategy

The overall strategy of the company would be to achieve better performances than the general classic car market. To do so, the firm will overcome the disadvantages of the classic car asset as discussed above. Thanks to its own experts and analysis tools, the management company would be competent in selecting the adequate cars. The analysis tools would consist in using hedonic regressions as done by us but for smaller adjacent periods, in view of determining the evolution of trends and predicting which cars would be trendy in the short term. Finally, the important capital of the fund would allow to diversify its portfolio between type, period and make. This capital would propel the hedge fund as an important market player and attract key partners ensuing interesting private deals.

6.4 Opportunities and value proposition

The opportunities the asset can offer have been intensively analysed in our discussion. Contrary to the competitors in the market, the value proposition will not be based on higher returns but rather offering diversification. With a long-term vision, the hedge fund would propose an asset that allows to diversify and hedge against systemic risk. The firm would constitute a way for private investors lacking capital to invest in the market. The hedge fund would also offer a diversification within the classic car market. Finally, it would offer the access to a club and a vast collection of classic cars.

6.5 Clients

First, both the high net worth individual (HNWI) and other private investors would be potential customers. The possibility to buy shares of a collection of cars instead of the car itself would democratise the prices and allow potential investors to take part in the investment. The second type of targeted client would be the institutionals such as pension funds. A hedge fund in classic cars would be ideal for these clients since it would save them the trouble of acquisition and storage and will guarantee them expert advice.

6.6 Business Model Canvas

Table 20: Business Model Canvas – Classic Car Hedge fund

Key Partners	Key Activities	Value Propositions	Customer Relationships	Customer Segments
• Auction houses • Private dealers • Restoration garages • Event organizers (appendix 2) • Clubs and organizations (access to rallies)	• Manage funds • Evaluate market trends • Buy and sell classic cars	• Higher revenues than gold, real estate or other alternative investments • Low correlation and beta: diversification tool • Overcome the important prices, fees and illiquidity of the asset for private investors • Advisory on personal car purchase • Membership to the club, non financial benefits.	• Monthly reports on the investments based on the valuation of the market • Periodic meetings • Events with the club	• High net worth individuals willing to diversify their capital without wanting to take care of the purchase or other hassles • Private individual investors who can now access the market correctly. • Institutionals such as pension funds
Key Resources • Model created in the thesis to evaluate the trends • Important capital allowing diversification and access to certain deals • Own experts and key partners			Channels • Sponsorship at events (see key partners) • Guests brought to the club • Regular approach of institutionals	
Cost Structure Hedge fund regular fees: infrastructure, IT, employees, administrative, audit, tax and other fixed fees. Extra car related fees: storage, external parts for restoration and insurance.			Revenue Streams Fixed management fee: about 1-2% of the capital Performance fee: 20% of the returns	

Chapter 7. Conclusions

Based on numerous studies on the painting and fine wine market, we used a hedonic regression to create a Classic Car Index. Through the analysis of 46.000 auction sales, we showed the trend of the entire car market since 1980. Several conclusions were drawn based on the index. First, the confirmation of an important speculative bubble in the late 80s as well as a drop in the market over the last two years. We reviewed in our introduction several press releases affirming the superiority of classic cars as an alternative investment. In this study, we have analysed the question in depth. We demonstrated several diversification benefits compared to other investments, as well as a beta of -0,028. From 1980 to 2017 our Classic Car Index has performed at an annual average rate of 6,03%. Our results enabled us to conclude, that the asset is interesting and should be considered as a replacement of part of the allocation for real estate and gold. Our analyses of portfolios including classic cars have strengthened this conclusion. Classic cars may be considered as a viable alternative investment and a powerful diversification tool. Nevertheless, one should consider the related costs, the illiquidity and as with any other collectible, selecting the right car. As reviewed, the price determinants are numerous and every one of them should be considered in the purchase process. Therefore, we discussed the impossibility for an individual with limited capital to invest in such a market unless he is passionate about the asset. We saw that these challenges can be overcome by investing through a hedge fund specialized in classic cars.

This study is hampered by several limitations. On the one hand, there are limits concerning the database and model and on the other hand, ones related to the portfolio creation. First, our entire index is based on public auctions. We are conscious that many deals are private and therefore not considered in this work. However, auctions are representative of the market and can be used as benchmarks. Moreover, even if we did not limit the number of auctions, we had to create various clusters to organize the variables. The reliability of the index depends on the accuracy of the model. With additional variables such as; whether the parts match or not, the kilometres, the cars history and ownership, the accuracy would increase. In our database, some periods offered less information. For example, information concerning the colour or engine type, were sometimes lacking. Finally, during a period of four years, no sales were recorded on the database. We used geometric interpolation to fill in these years. The general trend is correct, although the detail of each of these years is not.

We assumed being under a European investor scenario and constructed a standard portfolio. However, to find indices that went back to 1980, we sometimes had to use American data. Moreover, we employed general indices to construct our portfolios and perform our analyses. A more realistic portfolio would be more accurate than just based on trackers. The final limitation, is that all our analyses are based on annual returns which limits the number of data and the significance of results.

This study is on-going, and there are still many aspects to be researched. Building the database was tremendous work but it now offers a myriad of possibilities for further analyses and tests. For example, we only tested three lists measuring the buyer's sentiment. Additional traits should be considered such as the effect of models driven by celebrities or models that won races. Some extensive research could be done on each individual car to add variables as well. In terms of analysis, measuring adjacent periods of maximum two years could inform us on the evolution of trends. This technique could help prove the market shifting theory. One could investigate the link between the increase in wealth and classic car prices as was done for the painting market. The same goes for the masterpiece effect discussed in point 1.1. Finally, on the financial side, some more elaborate portfolios could be constructed with actual investments and not only general indices.

This study is the first to question the HAGI analyses and results. Its advantages are the size of the database analysed as well as the extensive period covered. Moreover, the entire market was investigated in detail for the first time. Not only did we develop an index, we also attempted to define the price constituents of a car. Finally, using advanced performance ratios we fully investigated the investment opportunities.

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