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Port wine – An alternative investment?

Luís Tiago Ramos Cardoso

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Professor Paulo Jorge Marques de Oliveira Ribeiro Pereira, Phd

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[1] Torga, M. (1986) "O Doiro", Coimbra, author edition, p.46

Abstract

We investigate the possibility of vintage Port wine being a good investment. We obtained the data for our analysis from auction hammer prices worldwide for a predetermined set of brands. Raw data consists in 14960 observations for sales occurred from 1988 to 2018 from 24 brands and 68 vintage years from 1815 to 2012. Analysis is done using the repeat sales regression method originally proposed by Bailey, Muth and Nourse (1963) and later applied to wine by other authors such as Lucey and Devine (2015). The several indexes are constructed for the period 2000 – 2017 being compared with the Portuguese Stock Index 20 considered to be the representation of the Portuguese capital market. Findings suggest that our calculated indexes outperform the index for the period, with higher index values and average returns, however in some case with high volatility, backed up by the calculation of Sharpe ratios for each of the calculated indexes we conclude that in most of the cases the high volatility and the returns in no excess of the risk free asset are a setback, however there are some exceptions, suggesting that an excess return might be a possibility.

Key Words: Port wine, wine investment, alternative assets, investment return, emotional assets, alternative investment.

JEL classification: Q14, G11, C50

Sumário

Através da nossa dissertação investigamos a possibilidade de o vinho do Porto vintage ser um bom investimento. Obtivemos os dados para nossa análise a partir dos preços de venda em leilões em todo o mundo para um conjunto predeterminado de marcas. Os nossos dados brutos consistem em 14960 observações para vendas ocorridas de 1988 a 2018 de 24 marcas diferentes e 68 anos considerados vintage de 1815 a 2012. A análise é feita usando o método de regressão de vendas repetidas originalmente proposto por Bailey, Muth and Nourse (1963) e mais tarde aplicado ao vinho por outros autores como Lucey and Devine (2015). Os vários índices são construídos para o período de 2000 - 2017 sendo comparados com o índice de acções Portuguesas 20 considerado para representação do mercado de capitais Português. Os resultados sugerem que nossos índices calculados superam o índice para o período, com maiores valores de índice e retornos médios, mas em alguns casos com alta volatilidade, apoiados pelo cálculo do rácio de Sharpe para cada um dos índices calculados, concluímos que na maioria dos casos a alta volatilidade e os baixos retornos em comparação com um ativo livre de risco são um revés na possibilidade de investimento, no entanto existem algumas exceções, sugerindo que em casos específicos um retorno em excesso pode ser uma possibilidade.

Palavras chave: Vinho do Porto, investimento em vinho, ativo alternativo, retorno de investimento, ativo emocional, investimento alternativo.

Classificação JEL: Q14, G11, C50

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1. Introduction

Is wine a good alternative investment? Can this investment have interesting returns? Not always a theme of agreement and concord between investors, emotional assets besides the normal emotional and collectable understandable appeal can be seen as an alternative to the regular markets and as an escape to the volatility of these or simply as a diversification of the investment portfolios. Several studies have been performed over the years regarding this kind of assets and its possible returns with a wide broadband of results. This kind of investments has had a particular great increase of interest in the eyes of investors as they have shown along years that they can deliver great and stable returns comparing to other kind of investments including government bonds, treasury bills, and gold over the long run with very low volatility (Dimson and Spaenjers, 2014).

Investing in art, wine, stamps, furniture, watches, classic cars or other collections can at first glance be strange and seen as a passion only with the sole purpose of serving of pleasure and ownership pride to the collectors according to Dimson, Rousseau and Spaenjers (2015), however if we can put aside the emotional part of such assets and focus on the pure financial result of these investments, by taking into account the returns given by these assets and concluded in studies along the time it becomes quite clear why many investors look at them as an opportunity as they seem to provide great and stable returns in the long term thus being a very good option to regular financial investments.

Our particular interest and the main focus of this study is in wine investment as this is a tendency in the last years especially among wealthy investors, as confirmed by a Barclays report from 2012[2] where the conducted survey concludes that wealthy individuals allocate as much as 2% of their wealth to wine investment.

Recently we also observe a great increase in companies specialized to the wine investment business as well as the creation of vehicles to these investments as funds, bonds and indexes based on the value of wine, such as Live-ex Fine Wine 50 or Live-ex Bordeaux 500 and the Wine Investment Fund, however this kind of investment mainly focus on great and very well-known wines as they are worldwide recognized, considered to be the most exclusive and therefore the most valuable for the purpose.

[2] Barclays (2012). "Profit or pleasure? Exploring the motivations behind treasure trends." Wealth Insights – Vol. 15

The interest in Portuguese wines is increasing and in a general and international opinion from experts Portugal is recognized as to be the place of creation of some of the most amazing wines according to recent specialized critics[3], especially when it becomes to fortified wines with the well-known Port wine, produced in the Douro valley.

Due to the well-known aging potential of this kind of wine, which is a lot more extendable than most wines, and the great value given by experts and collectors we believe that by filling all the necessary characteristics, Port can be a good alternative to investment and can deliver good returns on its storage if done solely with investment purposes.

The main objective of this study is to understand if Port wine can be a good investment through the creation of an index which represents the evolution of Port and calculation of returns based on the trades made along a certain period of time for a particular set of combinations of Port brands and vintage years.

As very few studies of this kind related to Port wine have been made so far, we believe the subject will be of great interest and a good increase to the current and already existent literature on the subject and, at the same time, it will also allow us to understand if Port wine is able to compete with other wines in terms of returns and therefore can also be taken in consideration for investment purposes.

This dissertation is structured as follows: in chapter 2, a literature review of the topic is made, giving an overview over similar studies as well as analyzing the insight. Chapter 3 is composed by a view on the wine investment aspect, justifying the interest that Port wine might have to these investments. In chapter 4 we present the data for our analysis followed by the explanation for the methodology used. To finalize we present our analysis in chapter 6 and our conclusions in chapter 7.

[3] Portuguese wines have been increasing the presence in specialized international critics reviews achieving high scores as it is example the top100 of 2014 from Winespectator where in the top 5, 3 are wines from Portugal (http://top100.winespectator.com/lists).

2. Literature review

Over the time we can find several studies focusing on wine as an alternative investment and some of the aspects that affect its prices. In the recent years we can find an increase of studies on the topic as the interest in this asset as a possible investment has grown over time. However these studies are mainly focused on other wines different than Port, which are worldwide known to be the some of the most expensive and the ones mostly used for investment purposes due to its price, rarity and good returns on investment, transforming them into very tradable assets. Returns for holding these wines are commonly higher than returns on other assets as we conclude by the analysis in the studies below.

Regarding specifically to Port wine we have very few cases where it is studied as a possible investment, meaning as already pointed out, our work can serve to complement the existing literature on this matter and for this specific asset.

A recent study from Correia, Rebelo and Caldas (2015) examines the productive and trade dynamics of Port wine and the impact of Port wine aging on price. The authors compute an annualized return rate of 5% on storing Port wine through a hedonic model using 2010, 2011 and 2012 sales prices from an official public database which accommodate wines from 1934 - 2002 harvests.

Another recent study from Dimson, Rousseau and Spaenjers (2015) published in the JFE also examines the impact of aging on wine and the long term investment performance of these using a unique set of data for historical prices for a pre-determined set of well-known Bordeaux wines where they estimate a real financial return of 4,1% net of storage costs.

Dimson, Rousseau and Spaenjers (2015) also tackle the potentiality of Port wine as such an investment as a check to confirm his study, by using a small sample of 5 vintage Port wines and using the data from auction transactions from 2010 to 2012 they compute returns in the range of 4,6% to 7,2% for those wines.

The wine investment theme has been broadly studied and discussed along time with differences on the findings and results which change depending on the study factors. Krasker (1979) uses auction data from 1973 to 1977 on the price of Bordeaux and California Cabernet Sauvignon to conclude through a repeated sales model that the return was lower than that on risk-free assets (treasury bills) after transaction costs. Using the

same model and the same data, Jaeger (1981), by only extending the data frame from 1969 to 1977, finds an annual return of 12% for storing those two types of wine.

Burton and Jacobsen (2001), through a repeated sales regression, using data from 1986 to 1996 for red Bordeaux wines computes annual returns between 8,3% and 14% depending on the vintage year.

Fogarty (2006) uses an hedonic price regression to calculate returns for the period going from 1989 to 2000 for Australian premium wines for crops starting in 1965, calculating returns between 1,92% and 3,17% for less expensive wines and expensive wines respectively. Few years later, Fogarty (2010) changing the approach for the repeated sales methodology confirms his earlier obtained results, concluding that returns on holding Australian wine are lower than those on standard financial assets, however there is a risk diversification benefit by including them in a Portfolio.

On a different approach, Sanning, Shaffer and Sharratt (2008) use data from monthly auction hammer prices to analyze the level and quality of Bordeaux wine returns using the Fama-French Three-Factor Model and the Capital Asset Pricing Model and conclude that the returns average up to 0.75% per month above those predicted by the models. They also find that investment grade wines benefit from low exposure to market risk factors, thus offering a valuable dimension of Portfolio diversification lowering volatility.

Masset and Weisskopf (2010) use auction hammer prices over the period from 1996 to 2009 to find that wine has higher returns and has a lower volatility compared to stocks especially in times of economic crises, relating wine returns to economic conditions and not to the market risk confirming that the addition of wine to a Portfolio is beneficial for private investors as it reduces volatility.

Similar conclusion is reached by Kourtis, Markellos, and Psychoyios (2012) in a study of wine prices from 2001 to 2010.

Masset and Henderson (2010), computes cumulative return on holding red Bordeaux wine of 145% for the period 1996 to 2007 exceeding Dow Jones Index for the same period which returned 127%, they also conclude that in general the higher quality wines and therefore the most expensive provide the highest returns.

Masset and Weisskopf (2013) using a repeated sales model, show that returns on holding wine exceed those of equities, bonds and commodities.

Lucey and Devine (2015) investigate Bordeaux and Rhone wine returns, using the repeat sales regression model and constructing indexes for the period from January 1996 to January 2007, comparing the results with several other indexes. They calculate a combined average return of 5,20% for those specific wines.

The literature on the subject also includes several studies which take an approach on the aspects that drive wine prices, trying to explain them.

Cardebat and Figuet (2004) try to explain Bordeaux wine prices for the 1996–1999 vintages using a hedonic model to determine the main explanatory factors of price differences. They conclude that reputation is an important determinant of the price as well as the wine sensory characteristics. The increasing competition and reductions in information asymmetries on the wine market also contribute to define prices.

Jones and Storchmann (2001) study the market prices for 21 Crus Class & chateaux from the Bordeaux region of France analyzing the relationship between factors that influence wine quality and those that influence wine prices. In these factors they include climate influences on grape composition (acid and sugar levels) which influences market prices and subjective quality evaluations (Parker-points) effects on market prices as well as the effects of age of the wine on market prices.

Resume of findings on the Table 1 presented next, containing the most important aspects for the reviewed articles.

Author Year	Type of Wine	Sample	Source of data	Method used for calculation	Return calculated (Annual)
Correia, Rebelo and Caldas (2015)	Port	162	IVDP database	Hedonic model	5%
Dimson, Rousseau and Spaenjers (2015)	Port	5	Auction prices: Christie's	Repeat sales regression model	4,6% to 7,2%
Dimson, Rousseau and Spaenjers (2015)	Bordeaux	9495	Auction+retail prices: Christie's + historical	Repeat sales regression model	4,10%
Krasker (1979)	Red Bordeaux and California Cabernet Sauvignon	137	Auction prices: Heublein	Repeat sales regression model	0
Jaeger (1981)	Red Bordeaux and California Cabernet Sauvignon	336	Auction prices: Heublein	Repeat sales regression model	12,4%
Burton and Jacobsen (2001)	Red Bordeaux	10558	Auction prices: Wine Price File	Repeat sales regression model	8,3% to 14%
Fogarty (2006)	Australian Premium wines	14102	Auction Prices: Langtons	Hedonic model	1,92% to 3,17%
Sanning, Shaffer and Sharratt (2008)	Bordeaux	13662	Auction prices: TCWC	CAPM and 3 Factor model	7,5% to 9,5%
Masset and Weisskopft (2010)	Several	430000	Auction prices: TCWC	Repeat sales regression model and CAPM	11,45%
Lucey and Devine (2015)	Bordeaux and Rhone	69903	Auction prices: TCWC	Repeat sales regression model	5,2%

Table 1: Several aspects of the reviewed articles, such as authors, year, type of wine, size of the sample, source of the data, method used for calculation and returns calculated.

From the analysis of the several studies reviewed we conclude that most of these focus on specific very well-known wine types such as Bordeaux, achieving a great variety of conclusions depending on the data collected, but mainly pointing to possible positive returns on investment.

The possible benefits of including these type of assets in Portfolios, lowering volatility is also concluded by some of the studies.

Only two studies have been found over Port wine and its possible returns on investment, which is what is intended to be the focus and aim of this dissertation, therefore transforming our study in a good addition to existing literature.

3. Why Port and why Vintage?

Port is a very well-known Portuguese wine with several centuries of history, the region where it is produced is considered the oldest officially demarcated wine region in the world[4] and its wine has been traded for centuries all over the world.

Due to its organoleptic characteristics, Port wine is capable of improving in quality over time with its aging process, progressively conferring higher prices on the product as it is stated by Correia, Rebelo and Caldas (2015).

This is one of the reasons why we believe Port can be considered as an option when it comes to long term investment decisions, as these wines normally have a great capacity of aging. This is especially true on a specific Port category named vintage Port, which is considered to be the pinnacle in quality when it comes to Port wine as only the best grapes of the best properties in the Douro valley are used for the lots, which are used to the production of these wines, adding to this selection the vintage is only declared when the harvest is considered exceptional, which usually only happens 3 or 4 years in a decade (Mayson, 2016), as all the Port brands like to keep their high standards when it comes to this category of Port wine in order not to disappoint the consumer.

Vintage Port is very simple to produce, they are wines from a single year bottled without any treatment or filtration which spend a maximum of 2 years aging in bulk (Mayson, 2016). After bottled these are known to maintain its fundamental characteristics and improve with long aging.

This special category designated as vintage Port only accounts for a tiny fraction of total production, however it has a great impact on brand reputation and of course a big financial impact on producers.

Vintage Ports are frequently part of auctions worldwide as they are a very desired collectable and investment asset for the interested public all over the world.

For all these characteristics we believe that vintage Port can be compared to the highest quality wines of 1st choice used for this kind of investment which are the ones with highest returns according to Masset and Henderson (2010).

[4] The Douro region is demarcated through laws of 1756 from the government of Marquês de Pombal. (https://www.ivdp.pt)

4. Data

In this chapter we present our data source and the method used for data collection. We also explain how we achieved the final database to perform our analysis.

4.1. Data source

In order to be in line with past studies we used the same approach as most of the existing literature[5] and we collected data from past auctions as these are the main vehicle for trades such as wine, transforming them into the most important platform for data regarding this type of transactions.

By using this type of data we also prevent any kind of deviation that could come from retail prices that might incorporate other factors allowing us to focus only on the actual value that the specific market gives to these assets.

For our approach we followed the method used by Kourtis, Markellos and Psychoyios (2012) and used the same source to collect our data for the study. The data was obtained from a very relevant online database identified as WinePrices.com, which gathers information from several specialized auction houses worldwide on past auctions, which represent together the majority of the current wine auction market. The observations are identified with lot numbers for better identification.

The database WinePrices.com is a free online resource which provides wine price information from auctions and retail worldwide, this aspect allowed us to have data from several locations worldwide and therefore minimize the risk of our study being affected by possible local sales phenomena which might cause deviations to our study. All data is freely available and can be consulted in https://www.vinfolio.com/do/wineprices/home.

Included in the data provided we can find results from auctions at Christie's which is one of the most important auctioneers in the world, which has included wines in their auctions since their first auction in 1766 in London. This long tradition in presenting wines in their lots turns Christie's in a very good source of such information as wine prices (Dimson, 2015). Prices are gathered from the Christie's locations in New York, London, Los

[55] Based on results from Table 1.

Angeles, Paris, Amsterdam, Bordeaux, Chicago, Hong Kong, Germany, Geneva, South Kensington and Glasgow.

Adding to the data from Christie's we also have other well-known auction houses such as Acker, Merrill & Condit in New York and Hong Kong, Sothebys in New York, London and Hong Kong, Zachys in New York, Los Angeles, Las Vegas and Hong Kong, Bonhams in London and Hong Kong, Bonhams & Butterfields in San Francisco, Morrells in New York, Hart, Davis, Hart in Chicago, Edward Roberts International in Chicago and San Francisco, Bloomsbury/Sokolin in New York, WineGavel in San Francisco and Spectrum Wine Auctions in Dana Point and Los Angeles.

This great variety of locations allows us to have extended data worldwide and due to this great variety we could also have some issues with different currencies however all sales prices registered in wineprices.com in different currencies than U.S. dollars are converted to dollars as of the date of the sale, which can be found in the data. This option from the data provider facilitates our collection of information and creates a standard for the exchange rate used.

4.2. Data collection

To create our dataset we conducted our data collection based in all the main Port wine brands detained by the companies associated of "AEVP – Associação das Empresas de Vinho do Porto", which is considered one of the main association between Port traders with their associates representing 90% of all Port trades[6], giving it a very important position in the Port wine market. The list of associated companies is public and can be consulted in the association website http://www.aevp.pt/ASSOCIADOS.

For our analysis we take into account one of the Port wine types known as vintage Port, more specifically each brand classic vintages, as these are known to be the best and rarest Port wines being only declared in special years where the wine is of excellent quality and is up to the highest standards and it is also known for its capacity of ageing which transforms it in one of the most valuables and appreciated Ports worldwide and therefore is considered an asset that gains value through time.

[6] Information can be consulted in http://www.aevp.pt

The focus for our data collection is therefore specifically in single vintage Port bottles in good condition from standard size 0,75L as these are the most common and easily bought for investment purposes.

From the research done we were also able to understand that some of the trades are done in bulk, normally boxes of 6 or 12 bottles as this is the most commonly way of trading wine which is already intended to serve investment or collection purposes, however in these cases of uniform lots of wine (with same brand, year and size) the data provider already supplies us with the price per bottle realized in U.S. dollars inclusive of the buyer's premium for the auction house and location at the time but exclusive of sales taxes or VAT.

Using our data source, wineprices.com, and conducting a research for classic vintage of the 35 brands we were able to obtain a total of 14960 observations for auction hammer prices, including brand, vintage year, selling price and selling year. The gathered initial set of data is therefore bigger than previous studies focused on Port wine.

Our original data contains observations from auction sales occurred from 1988 to 2018 for 24 different brands as only these from the original 35 researched have auction data and a total of 68 different vintage years ranging from 1815 to 2012.

This translates into a count of 346 different combinations of brand and vintage year following the same approach of Dimson, Rousseau and Spaenjers (2015), some with several sales during the period analyzed.

4.3. Final database

To construct our final database, for all combinations which have more than two sales during the observations period and according to Shiller (1991) we treat them as separate pairs without creating overlap in the holding period, meaning all are treated consecutively and without repetition.

To be in accordance with the methodology used we also drop all single sale observations, meaning all wines sold only once during the period are not part of the final observations, same applies to sales without a pair, which are in fact single sales.

Also for all observations in the same year of the same combination of brand and vintage year and as our objective is to create an annual index, instead of dropping any of the observations we decided to follow a similar approach as Dimson, Rousseau and Spaenjers (2015) and we average the price of the observation which take place in the same year for the same combinations.

After all the necessary adjustments for our analysis we count on 2727 individual annual observations to create 2434 pairs of sales of 293 combinations with sales dates between 2000 and 2018, with a price range between 4,01 and 9108 USD.

The 2727 observations of sales will from now on be our base data including data from 24 brands and 52 vintage years from 1847 to 2011.

5. Methodology

This chapter presents the explanation for the methodology used for our analysis.

In line with our research and according to Table 1 we decided to apply the repeated sales method to our data, as it is the most commonly used in similar studies.

This method was initially proposed by Bailey, Muth and Nourse (1963) to construct real estate price indexes and has since then been applied to other infrequently traded assets (Lucey and Devine, 2015) being considered suitable for the type of data which is normally available for wine trades.

The original method uses data on properties sold more than once during a certain period and the necessary information to estimate the model is reduced as it consists only in price, sales date and identification of the property. Comparing to the real estate market we have a bigger number of sales of bottles of the same wine facilitating the estimation of the trend of the wine market (Lucey and Devine, 2015).

According to Shiller (1991),"the method estimates an index of log prices by regressing log price changes on a matrix of dummy variables" (p. 3).

The regression estimates an index by considering the repeated sales of the same item. In our specific case as we are analyzing wine this means to match pairs of combinations of brand and vintage year sold in different dates to obtain our index.

Shiller (1991) explains the model as the matrix of independent variables being the n x T matrix Z whose ijth element is -1 if the first sale of asset i occurred in period j, it is 1 if the second sale of asset i occurred in period j, and it is 0 otherwise. The first column of Z corresponds to $t = 1$ and there is no column for $t = 0$ as the estimated index will be zero at $t = 0$. The dependent variable vector y has ith element equal to the change in log price for the ith asset, using $p_{ij} = \ln(P_{ij})$, where P_{ij} is the price of the ith asset at time j.

The model states that $y = Z\gamma + e$, where the ith element of γ is the log price index for time t, and to calculate, standard errors assumption is that the elements of the vector of error terms e are independent of each other, according to Shiller (1991) reflecting the notion that individual house price variations unrelated to the city-wide variations are due to

idiosyncratic value changes. The estimated log price index for time *t* is the *t*th element of the ordinary least-squares regression coefficient vector $\hat{\gamma} = (Z'Z)^{-1}Z'\gamma$.

The standard error matrix of $\hat{\gamma}$ has the usual form $s^2(Z'Z)^{-1}$ when the change in log price of a house is given by the change in a true city-wide price index γ plus a zero-mean error term that is uncorrelated with the error terms associated with other houses and the variance of this error term is the same, according to Shiller (1991).

Using the same example as Shiller (1991) for the estimator we consider a very small dataset of five houses and three periods, to estimate two index values. If houses 1 and 2 are sold in periods 1 and 2, houses 3 and 5 are sold in periods 0 and 1, and house 4 is sold in periods 0 and 2, we have the following:

$$Z = \begin{bmatrix} -1 & 1 \\ -1 & 1 \\ 1 & 0 \\ 0 & 1 \\ 1 & 0 \end{bmatrix}, \quad y = \begin{bmatrix} p_{12} - p_{11} \\ p_{22} - p_{21} \\ p_{31} - p_{30} \\ p_{42} - p_{40} \\ p_{51} - p_{50} \end{bmatrix}. \qquad (1)$$

The normal equations $Z'Z\hat{\gamma} = Z'y$ interpretation is that the *i*th equation results in the estimated log index for the *i*th period which is the average log price of all assets sold in that period minus the average of their base-period log price inferred from their other sale price using the estimated index.

For the example the model normal equations are:

$$\hat{\gamma}_1 = \frac{p_{11} + p_{21} + p_{31} + p_{51}}{4} - \frac{(p_{12} - \hat{\gamma}_2) + (p_{22} - \hat{\gamma}_2) + p_{30} + p_{50}}{4} \qquad (2)$$

$$\hat{\gamma}_2 = \frac{p_{12} + p_{22} + p_{42}}{3} - \frac{(p_{11} - \hat{\gamma}_1) + (p_{21} - \hat{\gamma}_1) + p_{40}}{3}. \qquad (3)$$

The equation for $\hat{\gamma}_1$ (2) which is the index for the first period, results from the four houses sold in that period, where houses 3 and 5 have another sale in the base period, and houses 1 and 2 are sold in period 2. The equation is corrected by subtracting $\hat{\gamma}_2$ to infer a base-period price. The same way the equation $\hat{\gamma}_2$ (3), results from the three houses that were sold in period 2 minus the average inferred log price of these three houses in period 0.

The estimated log price index is based on averages of log price changes of each asset, if we take $\exp(\hat{\gamma})$ as our index level, it is based on the geometric average of prices.

6. Analysis

6.1. Descriptive statistics

Table 2 below shows the descriptive statistics for the observations in our final database. All data was collected from the online auction database wineprices.com as described above in chapter 4. Panel A shows the number of yearly observations (after averaging observation for the same year as described in point 4.3) of each one of the 24 Port brands analyzed. Panel B shows summary statistics for the distributions of prices for each brand in US Dollars.

Panel A: Number of yearly observations per brand

Brand	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Total
Borges	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	2
Burmester	0	1	0	1	0	1	1	0	0	0	2	0	0	1	0	0	0	0	0	7
Cálem	1	1	0	0	0	1	2	1	1	0	0	0	0	0	0	2	0	0	0	9
Churchill's	1	1	2	3	3	4	0	3	1	1	3	3	3	3	0	0	4	1	0	36
Cockburn	8	11	10	7	13	12	15	14	15	12	13	9	11	5	5	9	9	8	3	189
Croft	5	8	9	10	14	12	13	10	10	12	9	7	7	7	4	12	13	9	2	173
Dalva	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2
Dow's	6	9	11	10	13	16	16	17	15	14	14	14	10	12	6	13	12	15	11	234
Ferreira	1	2	0	3	1	2	2	3	2	0	3	0	0	2	0	1	2	4	0	28
Fonseca	6	6	15	13	14	16	18	17	18	16	18	13	12	15	9	16	16	16	14	268
Gould Campbell	2	2	1	3	5	6	4	5	4	2	2	3	0	6	0	1	3	4	2	55
Graham's	3	9	14	15	15	18	17	17	18	17	17	15	12	17	10	14	15	17	12	272
Kopke	0	0	0	0	1	0	1	0	0	0	1	1	1	0	0	1	0	0	0	6
Krohn	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	2
Martinez	3	2	1	2	2	1	4	3	3	3	1	1	1	1	1	1	2	2	0	34
Niepoort	0	2	4	2	4	7	4	8	5	3	2	6	2	7	1	3	2	6	2	70
Noval Nacional	8	7	9	15	14	15	19	11	19	9	9	15	6	10	14	10	12	14	10	226
Noval	10	6	11	14	12	14	13	11	11	11	10	12	10	10	5	7	10	13	7	197
Quarles Harris	0	3	1	1	2	3	2	1	3	2	0	1	2	2	0	1	1	0	0	25
Quinta do Vesuvio	4	5	3	5	5	8	11	10	7	7	3	9	2	3	3	1	2	3	2	93
Sandeman	8	5	7	5	12	10	12	11	7	8	7	7	7	7	2	5	7	4	3	134
Smith Woodhouse	0	3	2	7	5	7	8	10	3	3	3	3	1	4	0	1	3	7	3	73
Taylor's	9	9	19	19	20	19	22	21	22	20	20	20	19	16	13	18	21	22	17	346
Warre's	6	14	14	13	15	15	14	12	14	18	16	13	10	14	12	10	13	12	11	246
Total	82	106	133	148	170	188	198	185	178	158	153	152	116	143	85	127	148	158	99	2727

Table 2, Panel A: Descriptive statistics for the observations in our final database, detailing the number of yearly observations for each one of the 24 brands analyzed.

Panel B: Summary statistics of prices per brand (in US Dollars)

Brand	Mean	Standard Deviation	Minimum	Maximum
Borges	94,60	0,00	94,60	94,60
Burmester	44,71	26,34	14,38	83,60
Cálem	33,15	9,59	16,92	47,00
Churchill's	29,00	7,20	12,15	42,47
Cockburn	201,00	259,42	16,45	1338,39
Croft	113,85	149,30	4,01	716,62
Dalva	30,21	6,07	25,92	34,50
Dow's	141,81	239,09	16,54	2106,54
Ferreira	413,37	877,33	20,83	4230,00
Fonseca	212,05	312,43	18,52	2591,61
Gould Campbell	39,62	28,86	13,29	214,40
Graham's	192,11	264,08	17,61	2049,53
Kopke	27,21	9,26	11,87	35,95
Krohn	40,08	16,13	28,67	51,48
Martinez	128,19	170,62	16,79	788,12
Niepoort	74,89	96,20	13,98	480,00
Noval Nacional	860,30	1123,21	103,44	9108,00
Noval	375,65	827,34	11,83	6000,00
Quarles Harris	33,89	12,29	15,21	61,10
Quinta do Vesuvio	37,76	12,31	16,04	77,60
Sandeman	205,27	213,45	19,59	976,00
Smith Woodhouse	35,01	11,86	16,51	73,60
Taylor's	296,50	351,87	19,36	2011,50
Warre's	101,36	131,64	10,72	796,00

Table 2, Panel B: Summary statistics of prices in US Dollars, containing mean, standard deviation, minimum and maximum prices for each of the 24 brands analyzed.

From the analysis of the table we can easily understand that there exists a big difference in the number of observations between the several brands, having the most observed brand which is Taylor's 346 observations, while the least observed brands Borges, Dalva and Krohn have 2 observations each. This might happen because of reputation of each brand or rarity of the wine and in our case this clearly divides our sample according to quantity of sales observations as almost 50% of our observed brands have over 100 observations. The average of observations for all brands is 113,63. If we take into account the yearly observations for the all sample we conclude that the year with more sales observed is 2006 with 198 while the year with fewer sales is 2000 with 82. The average of number of annual observations is 144 for the 19 years which are part of our sample.

In line with the difference in number of observations the hammer prices for each brand also show a very big discrepancy between brands. This also indicates that some brands are more appealing and therefore have a greater ease of being transacted through specialized auctions and achieve higher hammer prices. Analyzing the means for our observed brands we also conclude that this measure clearly divides our sample in 2 with around 50% of our sample having a mean superior to 100 USD. In our sample the highest hammer price achieved is 9108,00 USD for Quinta do Noval Nacional while the lowest price observed is 4,01 USD for Croft, if we analyze the average prices for each brand we conclude that

means vary from 27,21 USD for Kopke to 860,30 USD for Quinta do Noval Nacional, while the general mean for all sales included in our analysis is 240,50USD, however this value should be used with caution for any possible detailed analysis due to the differences in number of observations for each brand.

6.2. Results

6.2.1. Vintage Port index

Through the application of the methodology described above to our database and executing our model estimation through the software Eviews we obtained the results that allow us to create the index presented below, which we will from now on call vintage Port index. This index is a result of the application of the repeated sales model to all our 2727 observations from our 293 combinations of brand and vintage year.

Fig. 1 below shows the evolution of our calculated vintage Port wine index for the period from 2000 to 2017. Our index is calculated on base 100.

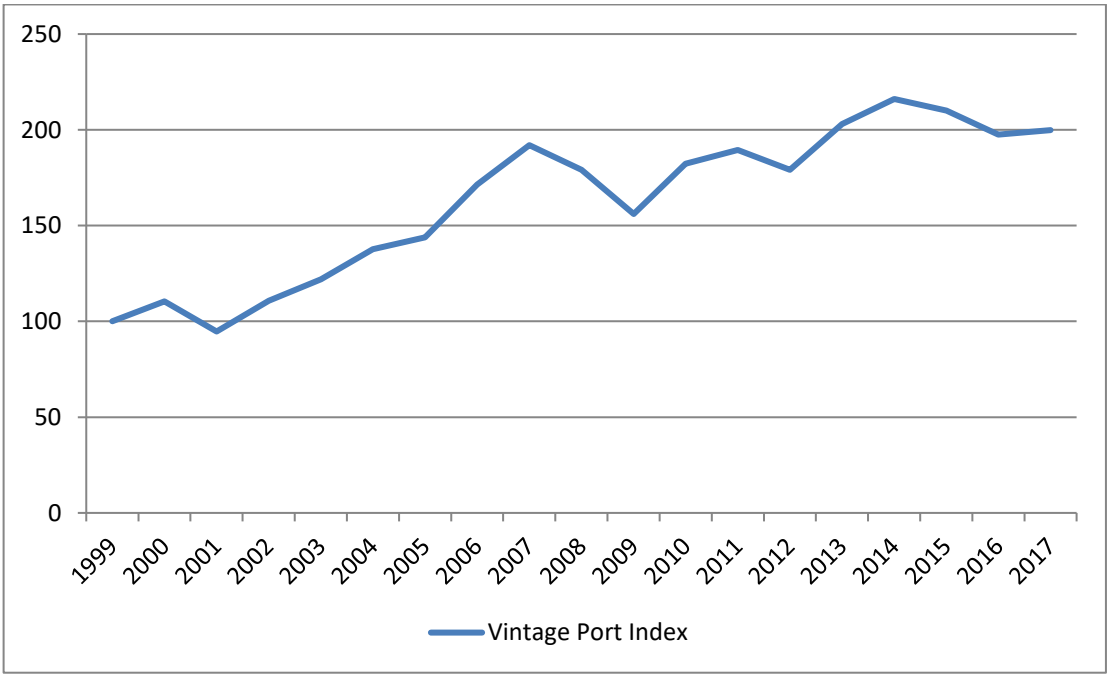

Fig.1 : Evolution of our calculated vintage Port index for the period from 1999 to 2017, calculated in base 100.

Our calculated vintage Port index shows a constant appreciation in trend over all the period analyzed achieving its highest result of 2,19 in 2018. The increase trend is only reversed on specific points in time as 2001, which is the only period where the index value decreases below 1. From 2007 to 2009 we can also verify a drop in the index values related to previous periods and again in 2011 we verify a small drop in value, however the depreciation is not significant and is recovered in the years right after.

The evolution of the price trends for our analyzed combinations is therefore positive and might indicate that the trend will be maintained through time without great variation or volatility, even through recent known periods of economic recession.

Through our previously calculated vintage Port index we computed the yearly returns for our index.

Fig. 2 shows the calculated yearly returns for our index through the years analyzed.

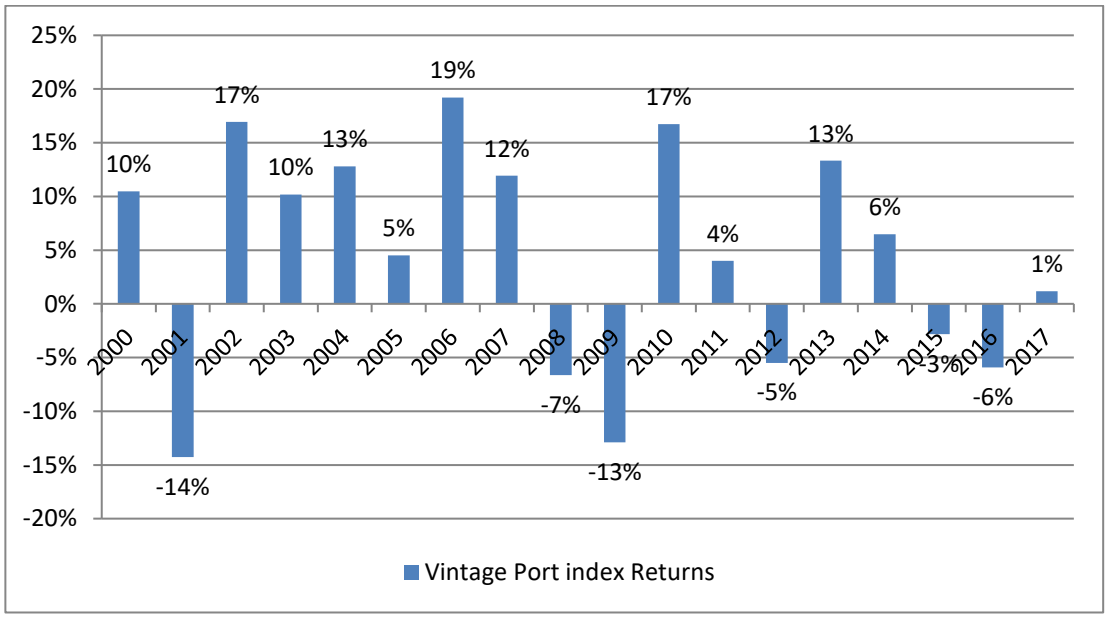

Fig. 2: Vintage Port index yearly returns calculated from our index for the period 2000 to 2017.

Our results show that from the 18 years analyzed only 6 have negative returns which might be an indicator of the general appreciation trend in our vintage Port index. Returns are very different from year to year however in the long term we are not able to find great variations, positive or negative, which goes in accordance with the appreciation trend.

Our highest return of 19,20% is achieved in 2006 and our lowest return of -14,28% happens in 2001. The average of returns calculated from our estimated index for the period is 4,43%, being the standard deviation of 10,42%.

6.2.2. Top brands indexes

Through our descriptive analysis we were able to understand that our sample was clearly divided in 2 types of brands in terms of number of transactions, in order to investigate this fact we decided to create an individual index for each one of the top brands in terms of observations in our sample. To perform our analysis we included all brands with more than 100 yearly observations in a total of 10 different brands and we apply the repeated sales methodology used to construct our vintage Port index to the observations of each brand individually.

Fig 3 shows the computed indexes for each of the top 10 brands individually.

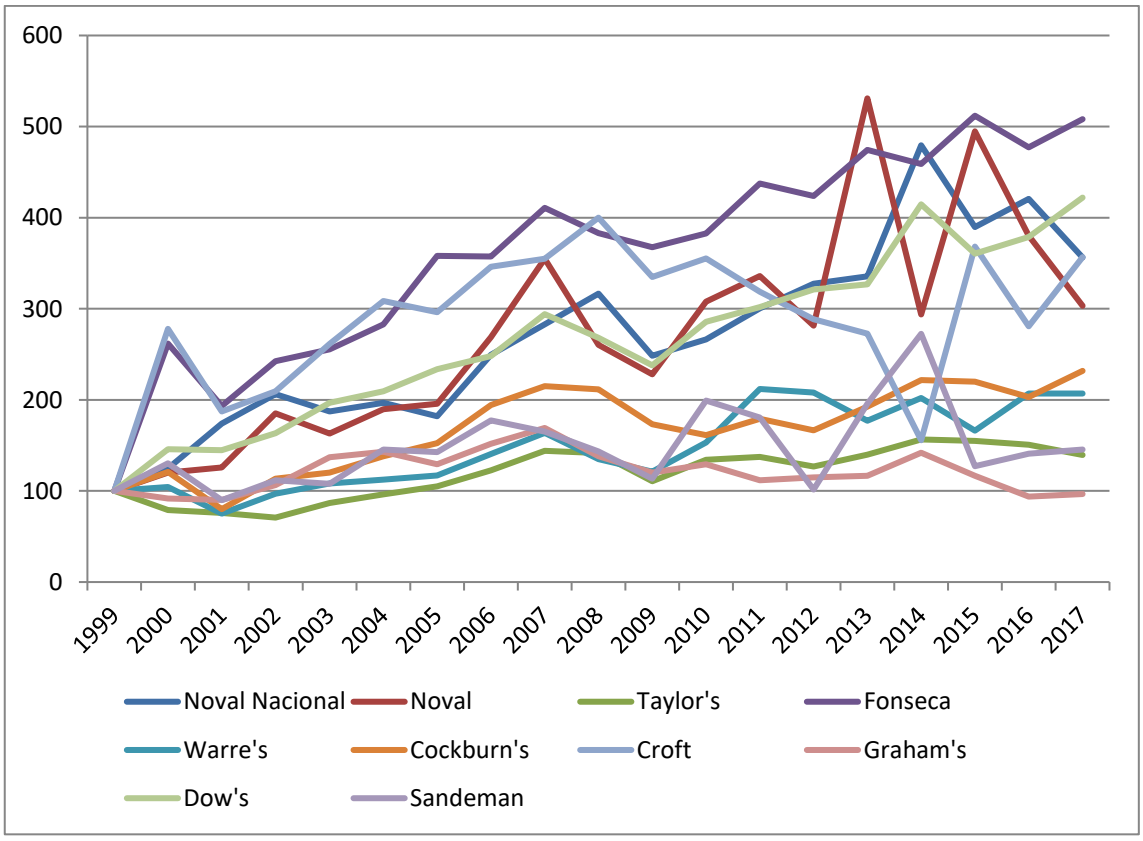

Fig.3: Evolution of our top 10 brands calculated indexes for the period 1999 to 2017, calculated in base 100.

From the analysis to the graph we are able to understand that depending on the brand the trend of the index is different and in our case as we are analyzing the trend over an extended period the differentiation between the several brands is particularly clear. From the 10 brands analyzed, 4 show index values for the final period 2018 between 4 and 6[7] being Fonseca the one with highest value in 2017, 3 show index values between 2 and 4[8] and 2 brands between 1 and 2[9]. There is also 1 brand with an observed index below 1, which is Graham's.

From our analysis we are also able to understand that some brands have a more stable index through time than others as Noval and Croft which do not have a clear trend over the period showing several periods of big increase and decrease of the index, demonstrating higher volatility.

Average return for each brand for our 18 year period can be found in Table 3 below.

Index	Average Return
Cockburn's	6.23%
Croft	16.09%
Dow's	9.18%
Fonseca	13.50%
Graham's	0.82%
Noval	11.50%
Noval Nacional	8.90%
Sandeman	8.42%
Taylor's	2.69%
Warre's	5.71%
All	8.30%

Table 3: Average return calculated for each of the 10 top brands for the period 2000 to 2017.

[7] Brands Fonseca, Dow's , Noval Nacional and Croft have the highest index values in 2017
[8] Cockburn's, Warre's and Noval
[9] Taylor's, Sandeman

Croft has the highest average return for the period achieving 16,09% while Graham's has the lowest average return to the considered period of 0,82%. The average return for the group of all our variables is 8,30%.[10]

In terms of maximum and minimums individual returns, the highest yearly return is from Croft in the year 2000 of 178,01% and lowest yearly return is from Sandeman in the year of 2015 of -53,36%.

Comparing the several indexes for our set of samples and in order to compare the averages between themselves we computed the test Anova through Eviews software.

Based on our set of data and according to the computed test there is no significant difference between the average returns from the 10 brands[11] for the period as can be seen in Table A.1 in Appendix 1, however if we run the same test for our index values, it is shown that there is a significant difference between the index average of each of the 10 brands[12], as can be consulted in Table A.2 in Appendix 1.

6.2.3. Top vintage years indexes

Following the same approach as the used for brands and taking into account that the specific vintage year might be an indicator of the wine performance we also decided to analyze the top 5 harvest years and compare them between themselves. These were the vintage years identified as being the 5 with more observations ranging from 148 to 193 observations. Index for each is computed using all available combinations of brand and vintage year for that specific harvest and the same repeated sales model is applied to the dataset.

Fig. 4 shows the computed indexes for each of the top 5 vintage years

[10] Average returns calculated through Eviews software
[11] Pvalue=0,9085 >0,05 therefore we do not reject H0: u1=u2=…=u10
[12] Pvalue=0,000 <0,05 therefore we reject H0: u1=u2=…=u10

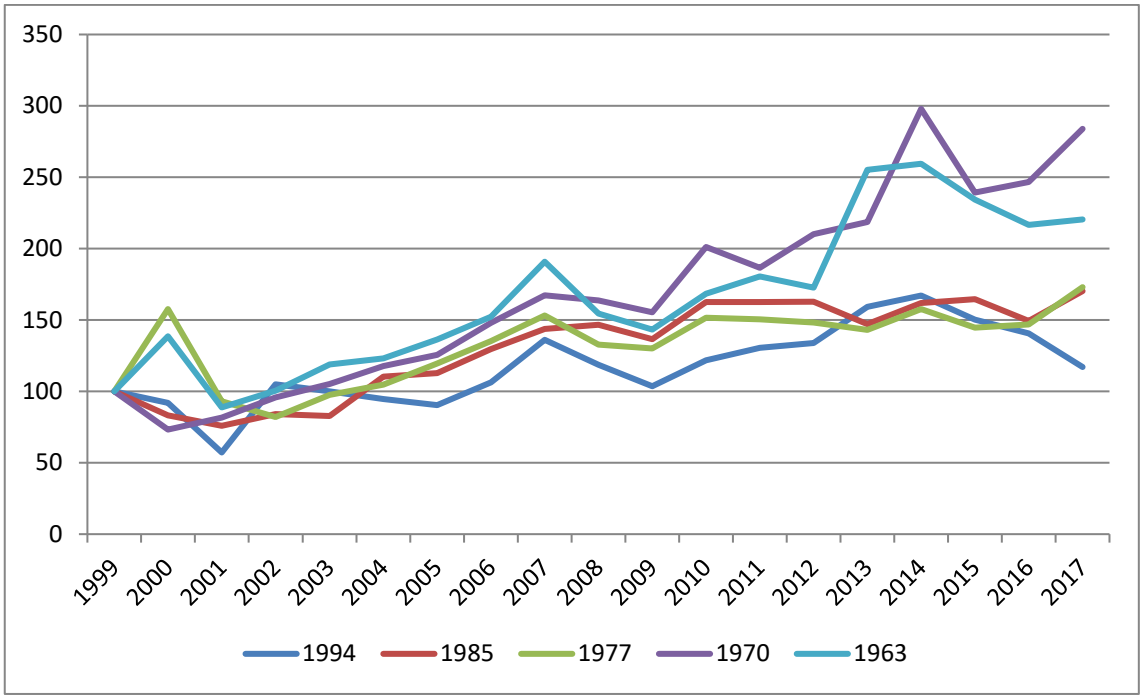

Fig. 4: Evolution of the top 5 vintage years calculated indexes for the period 1999 to 2017, calculated in base 100.

Analyzing the results in the same way as brands we are able to understand that the trend also depends on the vintage year specifically and we have big variances between the different indexes.

Indexes for 1970 and 1963 perform better than the remaining ones which are in line with each other. We are also able to understand some peaks in the indexes for the periods 2000, 2007 and 2014 followed by drops in the following years.

Doing a direct comparison to indexes calculated for our top brands which show higher results might indicate that even being the most traded harvests these might not be the ones that produce better returns as the indexes for top brands show higher values, this suggests that the brand is more determinant than the vintage year in the price definition.

Through our index we calculated the returns in Table 4.

Index	Average Return
1963	6.31%
1970	7.10%
1977	4.91%
1985	3.68%
1994	3.39%
All	5.08%

Table 4: Average return calculated for the top 5 vintage years for the period 2000 to 2017.

In terms of returns the harvest of 1970 show us the highest average return for the period of 7,10%, closely followed by 1963 with 6,31%. Lowest average return is for 1994 harvest of 3,39%. These average returns are lower than the ones for top brands in line with the index values difference, this is something we can easily understand from the average return for all indexes of 5,08% against 8,30% from the top brands.

The same way as for our top brand indexes we decided to run the test Anova to compare averages of our vintage year samples between themselves.

Based on our set of samples and according to the computed test we conclude there is no significant difference between the average returns from the 5 harvest years[13] for the period according to result on Table A.3 of Appendix 1, however if we run the same test for our index values, it is shown that there is a significant difference between the index average of each of the 5 harvests[14], as can be consulted in Table A.4 of Appendix 1. The result of the test is in line with the previous one run for top brands.

6.2.4. Vintage Port index vs Portuguese stock index 20

In line with previous studies as Lucey and Devine (2015) or Dimson, Rousseau and Spaenjers (2015) between others we decided to compare our calculated vintage index Port with an index that represents the capital market, in our case we decided to use the Portuguese stock index 20 or PSI20 as this represents the Portuguese market, in this specific case the index is based in the performance of the top 20 companies in Portuguese

[13] Pvalue=0,9716 >0,05 therefore we do not reject H0: u1=u2=…=u10
[14] Pvalue=0,0008 <0,05 therefore we reject H0: u1=u2=…=u10

stock market, or in different words it is constructed by shares of the 20 highest ranked companies listed on Euronext Lisbon in terms of free float market capitalization. Data to compute PSI 20 index for comparison was obtained from Pordata[15] which uses as data source "BP - Securities Issues Statistics" and adjusted to reflect the same period as our analysis.

Fig. 5 shows the evolution of our computed index and the evolution of PSI20 index for the period 2000 to 2017.

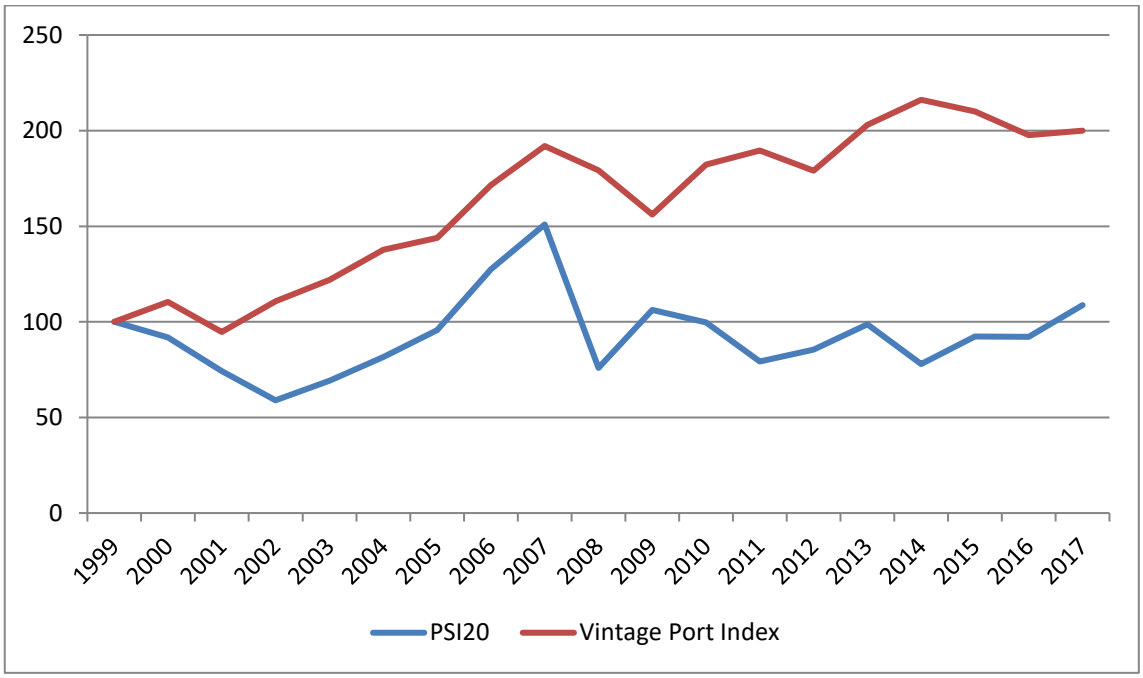

Fig. 5: Evolution of our calculated vintage Port index comparing to the evolution of the PSI20 index through the period from 1999 to 2017.

Vintage Port index has smaller depreciation than PSI20 in the period 2007-2008 and recovers faster maintaining the appreciation trend through years. Vintage Port index shows a more stable posture than PSI 20 which has several periods of depreciation of value.

Comparing to PSI20 for the same period we understand that for the long run and through the 18 years analyzed our estimated vintage Port index seems to have a better performance than PSI20 and a better final result being the index value almost the double.

We also decided to compare both indexes averages and according to Jarque Bera test which tests the normality of variables we do not reject null hypothesis on which variables follow

[15] Data source for Pordata is from Banco de Portugal

normal distribution, therefore the t-test of comparing averages is the most suitable for this comparison. When running the t-test to the average of our indexes during the period we find significant difference between the 2 indexes being vintage Port index superior to PSI20[16], result can be consulted in Table A.6 in Appendix 1.

Through our indexes we were able to calculate returns for the period which we present below.

Fig. 6 shows the comparison of returns of vintage Port index and PSI20 index during our analysis period from 2000 to 2017.

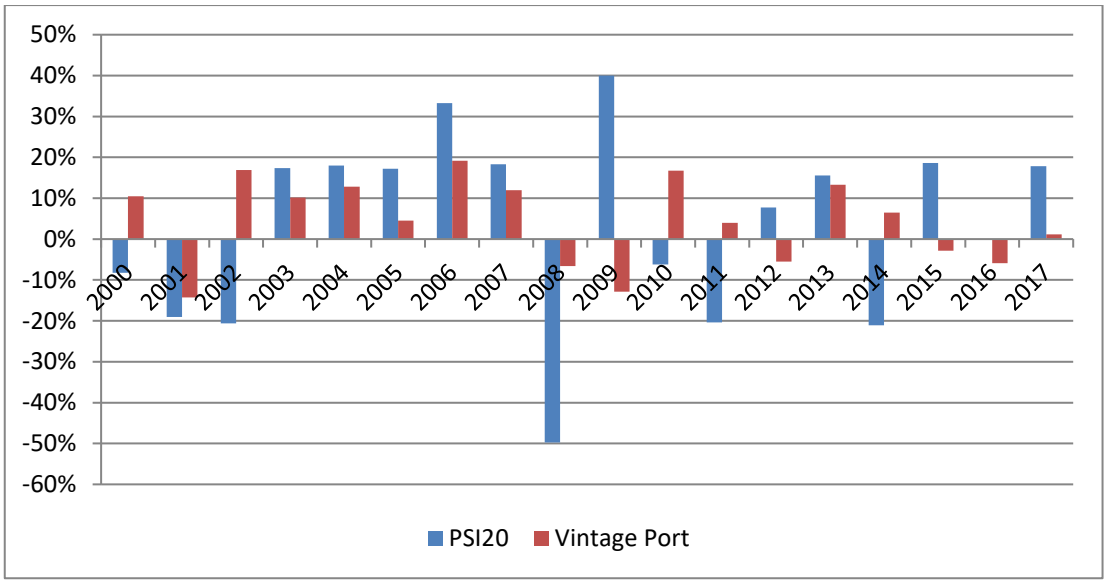

Fig. 6: Calculated returns from the vintage Port index comparing to calculated returns from PSI20, for the period 2000 to 2017.

Comparing the returns computed from our Port vintage index already analyzed before with the computed returns from PSI20 index we can understand that the volatility of returns of the vintage Port index is lower than the volatility of PSI20 returns. The number of periods of negative returns for PSI20 (7) is also higher than the vintage Port index (6).

Table 5 below shows the detailed returns for each year for both indexes.

[16] Pvalue =0,000 < x=0,05 therefore we reject H0: u1=u2=…=u10

	PSI20 returns	Vintage Port Index Returns
2000	-8.22%	10.48%
2001	-19.04%	-14.28%
2002	-20.65%	16.93%
2003	17.39%	10.19%
2004	18.00%	12.79%
2005	17.19%	4.52%
2006	33.27%	19.20%
2007	18.31%	11.93%
2008	-49.72%	-6.63%
2009	39.96%	-12.89%
2010	-6.21%	16.74%
2011	-20.37%	4.00%
2012	7.70%	-5.50%
2013	15.60%	13.32%
2014	-21.12%	6.48%
2015	18.61%	-2.83%
2016	-0.17%	-5.91%
2017	17.83%	1.17%

Table 5: Returns calculated from vintage Port index and returns calculated from PSI20 index for the period 2000 to 2017.

The maximum return from PSI20 is 39,96%, higher than the 19,20% for our vintage Port index however the minimum return is also lower for PSI20 with -49,72% than for vintage Port index with -14,28%. This higher volatility with big drops in returns for certain periods translates in a higher return average for our estimated vintage Port index of 4,43% against 3,24% from PSI20.

The standard deviation calculated for the average of returns of our index is 10,42% which is less than half of the 22,97% of standard deviation of PSI20 Index. This difference shows that our estimated index has lower volatility than the index representing the market.

Our results go in line with Masset and Weisskopf (2010) and Lucey and Devine (2015) results which state that wine has higher returns and lower volatility compared to stocks especially in times of economic crises.

Applying to returns the same t-test applied before to index averages we do not find any significant differences between the averages of the returns for the period, results can be consulted in Table A.5 in Appendix 1.[17]

6.2.5. Top brand index vs PSI20

Below we can find the comparison between the 2 indexes, for the top brand index we decided to use the Fonseca index as it is the one with a higher index value in 2017 as shown in subsection 6.2.3. We also added our vintage Port index for comparison purposes.

Fig. 7 shows the evolution of our 2 computed indexes and the evolution of PSI20 index for the period 2000 to 2017.

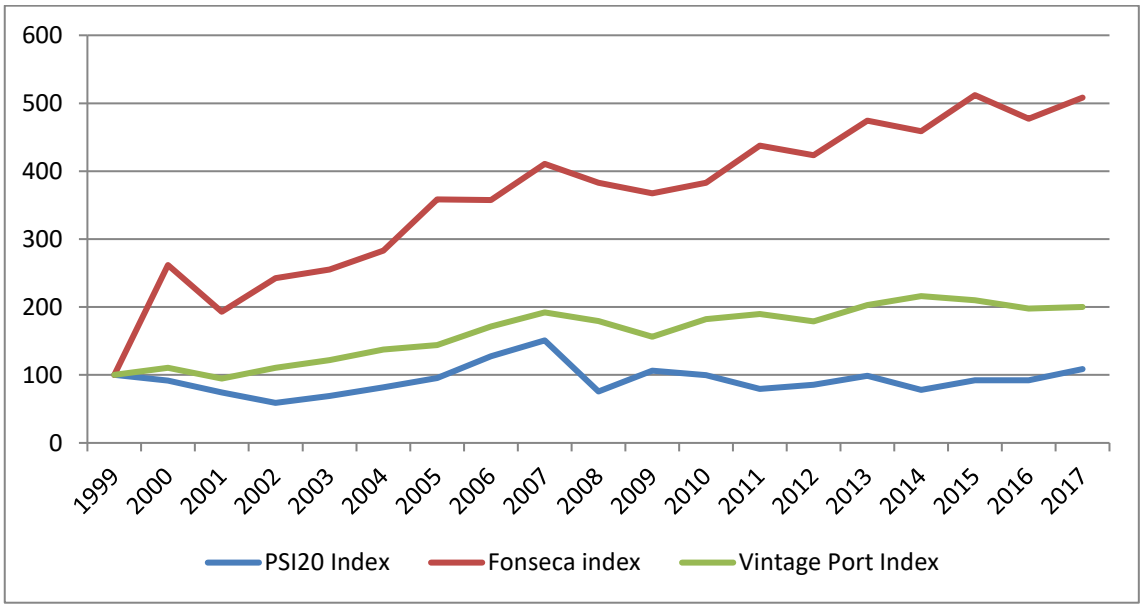

Fig. 7: Calculated index for our top brand comparing to PSI20 index and the vintage Port index, for the period 1999 to 2017.

Through the analysis of Fig. 7 we can understand that the gap between the indexes is bigger than the one previously analyzed for the vintage Port index. The permanent appreciation trend of the Fonseca index is higher than PSI20, and the index value in the

[17] Pvalue = 0,8430 > x=0,05 therefore we do not reject H0: u1=u2=…=u10

final period is almost 5 times superior to this one. This indicates that to the analyzed period performance of our index is superior to the Portuguese stock index 20.

Table 6 below shows the calculated returns for Fonseca index and PSI20:

Index	Average Return
FONSECA	13.50%
PSI20	3.24%

Table 6: Average returns from Fonseca index and the PSI20 index for the period 2000 to 2017.

In the same way as the difference in the indexes the average return calculated for our Fonseca index of 13,50% is much higher than the average return for PSI20 of 3,24% calculated for the period, however in this case the standard deviation of the calculated average return of 39,09% is higher than the one for PSI20 of 22,97%.

For both indexes and in order to compare the averages between themselves we again computed the t-test which show us that there is no significant difference between the average returns of the 2 indexes[18] for the period, however computing the same test for both our index values we find significant difference between their averages[19], results can be checked in Table A.7 and Table A.8 in Appendix 1.

6.2.6. Top vintage year vs PSI20

In the same way as for top brands we compared our top vintage calculated index with PSI20, following the same approach we maintained our vintage Port index for comparison.

Fig. 8 shows the evolution of our calculated indexes.

[18] Pvalue=0,3440 >0,05 therefore we do not reject H0: u1=u2=…=u10
[19] Pvalue =0,0000 < x=0,05 therefore we reject H0: u1=u2=…=u10

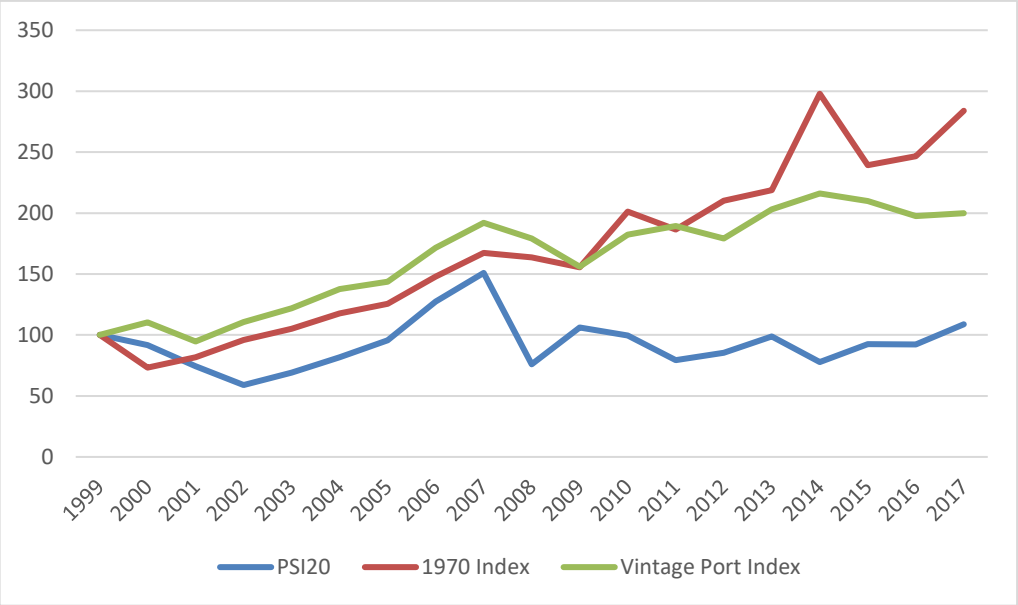

Fig. 8: Evolution of our calculated top vintage year index comparing to the PSI20 index and the vintage Port index for the period 1999 to 2017.

By analyzing the graph we conclude that our harvest index underperforms our vintage Port index during the initial 10 years of our analysis and even underperforms PSI20 during the first year. This tendency is reversed and 1970 index is able to obtain higher values in the last years of our analysis, however this is a clear sign than this index behavior also underperforms the Fonseca index calculated before, which might suggest that brand is more important than vintage year in terms of valuation, which goes in line with Cardebat and Figuet (2004) which states that reputation is an important determinant on price definition.

Index	Average Return
PSI20	3.24%
1970	7.10%

Table 7: Average returns from the 1970 Index and the PSI20 index for the period 2000 to 2017.

On the other hand by analyzing the average returns for the period our 1970 index outperforms PSI20 with 7,10% average return for the period, but with a very high standard deviation of 67,68% superior to the PSI20 21,18%.

Evaluating the results of the t-test performed we conclude that there is no significant difference between the average returns of the 2 indexes[20] for the period, but there exists a significant difference for our index values averages in line with the previous tests[21], both can be consulted in Table A.9 and Table A.10 in Appendix 1.

6.2.7. Sharpe ratio for calculated indexes

In order to measure how our calculated indexes perform relative to their levels of risk, we decided to follow the same approach as Lucey and Devine (2015) and compute the Sharpe ratio for each of the indexes. We use our calculated data for average returns of each index and standard deviations, for the risk free rate we follow the same line as when we choose PSI20 and we use the average rate for the Portuguese treasury bonds of 10y for the same period[22], even that these show higher risk than others.

Sharpe ratio is calculated as follows:

$$\text{Sharpe} = \frac{\bar{r}_p - r_f}{\sigma_p} \qquad (4)$$

Where $\bar{r}_p$ represents the expected portfolio return, r_f represents the risk free rate of return and σ_p is the standard deviation of the portfolio.

Table 8 shows the results for our calculated Sharpe ratios for each index.

[20] Pvalue=0,5589 >0,05 therefore we do not reject H0: u1=u2=…=u10
[21] Pvalue =0,0000 < x=0,05 therefore we reject H0: u1=u2=…=u10
[22] Data is obtained from pordata following same approach as before for Psi20 index

Index	Average index returns	Standard deviation	Risk free rate	Sharpe ratio
PSI20	0,0324240	0,2296630	0,0496667	-0,07508
Vintage Port	0,0442880	0,1042190	0,0496667	-0,05161
Y1963	0,06309	0,198751	0,0496667	0,067538
Y1970	0,070951	0,154655	0,0496667	0,137625
Y1977	0,049124	0,197527	0,0496667	-0,00275
Y1985	0,036776	0,123599	0,0496667	-0,10429
Y1994	0,033939	0,253461	0,0496667	-0,06205
Cockburn's	0,062286	0,174034	0,0496667	0,072511
Croft	0,160925	0,552824	0,0496667	0,201255
Dow's	0,091752	0,142264	0,0496667	0,295826
Fonseca	0,134971	0,390852	0,0496667	0,218252
Graham's	0,008215	0,14733	0,0496667	-0,28135
Noval	0,114955	0,351873	0,0496667	0,185545
Noval Nacional	0,089003	0,190746	0,0496667	0,206224
Sandeman	0,084154	0,379632	0,0496667	0,090844
Taylor's	0,026902	0,132038	0,0496667	-0,17241
Warre's	0,057105	0,18507	0,0496667	0,040192

Table 8: Calculated Sharpe ratio for each of the indexes presented.

Analyzing our results for the calculated Sharpe ratio, 7 out of our 17 calculated indexes show a negative Sharpe ratio meaning that those indexes performed worse than the risk-free asset used for calculation. In these cases the return for investor would be better for the period if the bet was in the risk free asset. In this group it is included our vintage Port index, Graham's and Taylor's indexes and the annual indexes for 1977, 1985 and 1994. The lowest Sharpe ratio is for Graham's of -0,28. Regarding our vintage Port index even returning a negative Sharpe ratio it is still higher than the PSI20 negative ratio.

Regarding the remaining indexes all show positive ratios, however always lower than 1. In this group the lead is for Dow's with a ratio of 0,2958 followed by Fonseca, Noval Nacional and Croft all with ratios superior to 0,2. All other calculated indexes have results between 0,04 and 0,19.

These values can be seen as a result of the high volatility that makes these assets risky with similar average returns to the risk free asset.

7. Conclusions

Through our analysis we are able to conclude that our vintage Port index and most of our brand and year calculated indexes show a better overall performance than the index PSI20 chosen to serve as comparison to the market over the analyzed period, this goes in line with previous studies as Masset and Weisskopf (2010) and Lucey and Devine (2015) as our indexes show generally higher returns and lower volatility than the market. However we also need to notice that the volatility for these indexes is generally high as can be easily concluded by the results obtained in the Sharpe ratio calculation, meaning that the investment carries high risk without enough compensating returns in some of the cases. The high volatility and the returns in no excess of the risk free asset are a setback to possible investment decisions, however there are some exceptions, suggesting that an excess return might be a possibility in some particular cases.

Adding to these market risks we also need to highlight the risk of breaking bottles or wine to spoil as it is a perishable asset and normally a low percentage of bottles is even expected to perish during its life, returning a total loss to investor.

Our results also suggest that brand might be a more determinant factor for price definition than the vintage year as our calculated top brand indexes seem to have better results than the vintage year indexes.

From the small number of observations gathered compared to other studies we also conclude that the great illiquidity of wine market is also a drawback for this kind of investments in comparison to others and can serve as a barrier for these investments to be considered interesting. The simplicity and fastness of the trades nowadays in the capital market turns the wine market illiquidity obvious. This great illiquidity also counts as a hidden cost according to Dimson and Spaenjers (2014).

In terms of costs and as most of the sales are done through auctions we also conclude that transactions costs tend to be high for wine as for all emotional assets trades, fees and mark ups from auction houses and dealers on collectibles are high, easily achieving more than 25% of the assets price as it is stated by Dimson, Rousseau and Spaenjers (2015).

Adding to transaction costs, holding costs for investing in wine can become high as the collector or investor has to keep the quality of the asset and in the case of wine as it is a

perishable item this means that the bottles need to be storage in very specific conditions or pay a yearly fee for the wine to be storage professionally.

All these costs can also be a drawback to a possible investment decision, however we decided not to include any cost in our analysis as there is no common line across the hypothetical costs for transactions in literature and also we did not account transaction costs for the market.

With all these drawbacks and following our results we conclude that wine is a risky and very illiquid asset, however we highlight that there is the possibility of specific portfolios to deliver interesting returns under certain specific conditions.

During our research and even through our analysis we are in constant contact with other possible points of interest which might be later used as future research topics mostly related to our main theme, between those we can think of analyzing returns for other types of Portuguese wines such as Madeira wine, other type of Port wines as tawny or Port rarities and also for other Portuguese wines. We can also think into all the aspects that drive the prices of these wines to move as for example the renowned critics power on price definition or the impact of the yearly weather on prices, we can even try to predict the future returns of a specific wine according to several possible inputs in a predefined model.

To finalize and due to the enormous prestige and quality of Port wine worldwide we must always leave open the option that the enjoyment of the consumption in some cases turns that value to exceed the value of storing this wine for possible returns.

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10. Appendix 1

Table A.1: Output for test of equality of means between the calculated returns of the top 10 brands.

Test for Equality of Means Between Series
Date: 09/13/18 Time: 22:41
Sample: 1 18
Included observations: 18

Method	df	Value	Probability
Anova F-test	(9, 170)	0.445463	0.9085
Welch F-test*	(9, 68.8349)	0.663362	0.7388

*Test allows for unequal cell variances

Analysis of Variance

Source of Variation	df	Sum of Sq.	Mean Sq.
Between	9	0.355460	0.039496
Within	170	15.07248	0.088662
Total	179	15.42794	0.086190

Category Statistics

Variable	Count	Mean	Std. Dev.	Std. Err. of Mean
COCKBURN_S	18	0.062286	0.174034	0.041020
CROFT	18	0.160925	0.552824	0.130302
DOW_S	18	0.091752	0.142264	0.033532
FONSECA	18	0.134971	0.390852	0.092125
GRAHAM_S	18	0.008215	0.147330	0.034726
NOVAL	18	0.114955	0.351873	0.082937
NOVAL_NACIONAL	18	0.089003	0.190746	0.044959
SANDEMAN	18	0.084154	0.379632	0.089480
TAYLOR_S	18	0.026902	0.132038	0.031122
WARRE_S	18	0.057105	0.185070	0.043621
All	180	0.083027	0.293581	0.021882

Table A.2: Output for test of equality of means between the calculated index values of the top 10 brands.

Test for Equality of Means Between Series
Date: 09/13/18 Time: 22:44
Sample: 1 19
Included observations: 19

Method	df	Value	Probability
Anova F-test	(9, 180)	23.30101	0.0000
Welch F-test*	(9, 72.1614)	26.83360	0.0000

*Test allows for unequal cell variances

Analysis of Variance

Source of Variation	df	Sum of Sq.	Mean Sq.
Between	9	123.6153	13.73504
Within	180	106.1030	0.589461
Total	189	229.7183	1.215441

Category Statistics

Variable	Count	Mean	Std. Dev.	Std. Err. of Mean
COCKBURN_S	19	1.681950	0.456283	0.104678
CROFT	19	2.880883	0.781693	0.179333
DOW_S	19	2.659748	0.926921	0.212650
FONSECA	19	3.624842	1.132880	0.259901
GRAHAM_S	19	1.209641	0.221500	0.050816
NOVAL	19	2.694773	1.178903	0.270459
NOVAL_NACIONAL	19	2.707708	1.009054	0.231493
SANDEMAN	19	1.468558	0.443613	0.101772
TAYLOR_S	19	1.196012	0.281631	0.064611
WARRE_S	19	1.477473	0.446762	0.102494
All	190	2.160159	1.102470	0.079982

Table A.3: Output for test of equality of means between the calculated returns of the top vintage years.

Test for Equality of Means Between Series
Date: 09/13/18 Time: 22:48
Sample: 1 18
Included observations: 18

Method	df	Value	Probability
Anova F-test	(4, 85)	0.128710	0.9716
Welch F-test*	(4, 41.8363)	0.163814	0.9555

*Test allows for unequal cell variances

Analysis of Variance

Source of Variation	df	Sum of Sq.	Mean Sq.
Between	4	0.018736	0.004684
Within	85	3.093253	0.036391
Total	89	3.111989	0.034966

Category Statistics

Variable	Count	Mean	Std. Dev.	Std. Err. of Mean
Y1963	18	0.063090	0.198751	0.046846
Y1970	18	0.070951	0.154655	0.036453
Y1977	18	0.049124	0.197527	0.046558
Y1985	18	0.036776	0.123599	0.029133
Y1994	18	0.033939	0.253461	0.059741
All	90	0.050776	0.186992	0.019711

Table A.4: Output for test of equality of means between the calculated index values of the top vintage years.

Test for Equality of Means Between Series
Date: 09/13/18 Time: 22:50
Sample: 1 19
Included observations: 19

Method	df	Value	Probability
Anova F-test	(4, 90)	5.229689	0.0008
Welch F-test*	(4, 44.059)	4.711290	0.0030

*Test allows for unequal cell variances

Analysis of Variance

Source of Variation	df	Sum of Sq.	Mean Sq.
Between	4	4.088758	1.022190
Within	90	17.59131	0.195459
Total	94	21.68007	0.230639

Category Statistics

Variable	Count	Mean	Std. Dev.	Std. Err. of Mean
Y1963	19	1.660509	0.521364	0.119609
Y1970	19	1.693800	0.676800	0.155269
Y1977	19	1.327085	0.258882	0.059392
Y1985	19	1.309145	0.326836	0.074981
Y1994	19	1.170577	0.271245	0.062228
All	95	1.432223	0.480249	0.049272

Table A.5: Output for test of equality of means between the calculated returns of the vintage Port index and PSI20.

Test for Equality of Means Between Series
Date: 09/13/18 Time: 23:08
Sample: 1 18
Included observations: 18

Method	df	Value	Probability
t-test	34	-0.199585	0.8430
Satterthwaite-Welch t-test*	23.71664	-0.199585	0.8435
Anova F-test	(1, 34)	0.039834	0.8430
Welch F-test*	(1, 23.7166)	0.039834	0.8435

*Test allows for unequal cell variances

Analysis of Variance

Source of Variation	df	Sum of Sq.	Mean Sq.
Between	1	0.001267	0.001267
Within	34	1.081317	0.031803
Total	35	1.082584	0.030931

Category Statistics

Variable	Count	Mean	Std. Dev.	Std. Err. of Mean
PSI20	18	0.032424	0.229663	0.054132
VINTAGE_PORT_INDEX_RETURNS	18	0.044288	0.104219	0.024565
All	36	0.038356	0.175872	0.029312

Table A.6: Output for test of equality of means between the calculated index values of the vintage Port index and PSI20.

Test for Equality of Means Between Series
Date: 09/13/18 Time: 23:10
Sample: 1 19
Included observations: 19

Method	df	Value	Probability
t-test	36	-6.759498	0.0000
Satterthwaite-Welch t-test*	27.42638	-6.759498	0.0000
Anova F-test	(1, 36)	45.69082	0.0000
Welch F-test*	(1, 27.4264)	45.69082	0.0000

*Test allows for unequal cell variances

Analysis of Variance

Source of Variation	df	Sum of Sq.	Mean Sq.
Between	1	4.647962	4.647962
Within	36	3.662150	0.101726
Total	37	8.310112	0.224598

Category Statistics

Variable	Count	Mean	Std. Dev.	Std. Err. of Mean
PSI20	19	0.929788	0.211778	0.048585
VINTAGE_PORT_INDEX	19	1.629259	0.398250	0.091365
All	38	1.279523	0.473917	0.076880

Table A.7: Output for test of equality of means between the calculated returns of the top brand and PSI20.

Test for Equality of Means Between Series
Date: 09/13/18 Time: 23:15
Sample: 1 18
Included observations: 18

Method	df	Value	Probability
t-test	34	0.959714	0.3440
Satterthwaite-Welch t-test*	27.48880	0.959714	0.3456
Anova F-test	(1, 34)	0.921050	0.3440
Welch F-test*	(1, 27.4888)	0.921050	0.3456

*Test allows for unequal cell variances

Analysis of Variance

Source of Variation	df	Sum of Sq.	Mean Sq.
Between	1	0.094643	0.094643
Within	34	3.493679	0.102755
Total	35	3.588322	0.102523

Category Statistics

Variable	Count	Mean	Std. Dev.	Std. Err. of Mean
FONSECA	18	0.134971	0.390852	0.092125
PSI20	18	0.032424	0.229663	0.054132
All	36	0.083697	0.320193	0.053365

Table A.8: Output for test of equality of means between the calculated index values of the top brand and PSI20.

Test for Equality of Means Between Series
Date: 09/13/18 Time: 23:18
Sample: 1 19
Included observations: 19

Method	df	Value	Probability
t-test	36	10.19298	0.0000
Satterthwaite-Welch t-test*	19.25651	10.19298	0.0000
Anova F-test	(1, 36)	103.8969	0.0000
Welch F-test*	(1, 19.2565)	103.8969	0.0000

*Test allows for unequal cell variances

Analysis of Variance

Source of Variation	df	Sum of Sq.	Mean Sq.
Between	1	69.00149	69.00149
Within	36	23.90883	0.664134
Total	37	92.91032	2.511090

Category Statistics

Variable	Count	Mean	Std. Dev.	Std. Err. of Mean
FONSECA	19	3.624842	1.132880	0.259901
PSI20	19	0.929788	0.211778	0.048585
All	38	2.277315	1.584642	0.257063

Table A.9: Output for test of equality of means between the calculated returns of the top vintage year and PSI20.

Test for Equality of Means Between Series
Date: 09/13/18 Time: 23:24
Sample: 1 18
Included observations: 18

Method	df	Value	Probability
t-test	34	-0.590342	0.5589
Satterthwaite-Welch t-test*	29.78817	-0.590342	0.5594
Anova F-test	(1, 34)	0.348504	0.5589
Welch F-test*	(1, 29.7882)	0.348504	0.5594

*Test allows for unequal cell variances

Analysis of Variance

Source of Variation	df	Sum of Sq.	Mean Sq.
Between	1	0.013359	0.013359
Within	34	1.303279	0.038332
Total	35	1.316637	0.037618

Category Statistics

Variable	Count	Mean	Std. Dev.	Std. Err. of Mean
PSI20	18	0.032424	0.229663	0.054132
RETURN_1970_INDEX	18	0.070951	0.154655	0.036453
All	36	0.051687	0.193954	0.032326

Table A.10: Output for test of equality of means between the calculated index values of the top vintage year and PSI20.

Test for Equality of Means Between Series
Date: 09/13/18 Time: 23:27
Sample: 1 19
Included observations: 19

Method	df	Value	Probability
t-test	36	4.696046	0.0000
Satterthwaite-Welch t-test*	21.49141	4.696046	0.0001
Anova F-test	(1, 36)	22.05285	0.0000
Welch F-test*	(1, 21.4914)	22.05285	0.0001

*Test allows for unequal cell variances

Analysis of Variance

Source of Variation	df	Sum of Sq.	Mean Sq.
Between	1	5.545286	5.545286
Within	36	9.052360	0.251454
Total	37	14.59765	0.394531

Category Statistics

Variable	Count	Mean	Std. Dev.	Std. Err. of Mean
INDEX_1970	19	1.693800	0.676800	0.155269
PSI20	19	0.929788	0.211778	0.048585
All	38	1.311794	0.628117	0.101894