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Article

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Testing the efficiency of the wine market using unit root tests with sharp and smooth breaks^{☆, ☆ ☆}

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Abstract

This paper examines the efficient market hypothesis for the wine market using a novel unit root test while accounting for sharp shifts and smooth breaks in the monthly data. We find evidence of structural shifts and nonlinearity in the wine indices. Contrary to the results from conventional linear unit root tests, when we account for sharp shifts and smooth breaks, the unit root null for each of the wine indices has been rejected. Overall, our results suggest that the wine market is inefficient when we incorporate breaks. We provide some practical and policy implications of our findings.

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Keywords: Wine market; Efficiency; Sharp and smooth breaks; Unit root tests

1. Introduction

The concept of market efficiency has been drawing considerable attention from policy makers, investors, scholars, and financial advisors. The efficient market theory follows from the efficient market hypothesis, which states that current asset prices fully reflect all available information about the intrinsic value of the asset (Fama, 1970). Practically, this means that asset returns are not predictable and thereby investors cannot systematically earn excess return from their investment strategies. In contrast, asset returns in inefficient markets can be predicted on the basis of past price changes, suggesting the possibility of investors to outperform the market. For regulators and policy-makers, enhancing the flow of market information to have speedier price discovery, through the improvement

in legal and regulatory frameworks and in transparency, is an endless burden. For scholars, the search for inefficient markets and ways to exploit them remains a rich and appealing research ground. Financial advisors, who often recommend fine wines as an alternative investment, also care about the wine market efficiency.

While the theory of price efficiency has been studied extensively in stock markets (Fama, 1970; Urquhart and McGroarty, 2016), bond markets (Hotchkiss and Ronen, 2002), credit default swaps (CDS) markets (Kiesel et al., 2016), exchanges rates (Charles et al., 2012) and commodities (Smith, 2002 for gold; Charles and Darné, 2009 for crude oil, and Kristoufek and Vosvrda, 2013 for 25 commodities futures), it remains unexplored in the fine wine market. The latter has recently captured wide attention from the media and financial press given that fine wines represent an alternative and valuable investment asset (Storchmann, 2012; Masset and Henderson, 2010; Bouri, 2015). According to Barclays (2012) about one quarter of high-net-worth people own a wine collection that is worth an average of 2% of their wealth.

Like markets for other conventional financial assets such stocks, bonds and commodities, investing in fine wines is

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becoming easier with the introduction in 2000 of the London International Vintners Exchange (Liv-ex). This market platform has brought transparency and liquidity to the market place. Liv-ex publishes leading fine wine benchmarks that are used by several wine investment funds (see, among others, The Wine Investment Fund in Bermuda, Lunzer Wine Fund in British Virgin Islands, Patrimoine Grands Crus in France). The introduction of such wine funds has also accelerated the pace of financialization and made fine wine investment more accessible.

In addition to its consumption role, fine wine is appreciated by wine private collectors because it is a store of value. Compared to conventional financial assets, wine prices are affected by non-financial factors that include the name of the producer, ranking of the wine, weather, year of vintage, grape composition, reputation, and production technology (Hadj et al., 2008; Storchmann, 2012). Climate change has also been related to fine wine prices and quality (Ashenfelter and Storchmann, 2014). Accordingly, wine economists suggest that wine return is weakly correlated with the fluctuations in equity and bond markets. In this regard, a first strand of research has considered the diversification capabilities of fine wines within bond and equity portfolios during tranquil and turbulent periods. Fogarty (2010) highlights the importance of adding fine wine investment to enhance the risk-adjusted return of a portfolio of stocks and bonds. Sanning et al. (2008) stress on the ability of fine wine investment to diversify equity portfolios. Masset and Henderson (2010) show that fine wines are essential to investors who are concerned about the skewness of their equity portfolios. In addition to the positive impact on return and risk, Masset and Weisskopf (2010) show the effects of wine investment on portfolio skewness and kurtosis. They also reveal the defensive characteristics of fine wine during times of market stress. In examining the relationship across the performance of stock markets, interest rates, and agriculture and food industries, Kourtis et al. (2012) point to the advantages of diversification across the different wine markets in Europe. Bouri (2014) argues that fine wines can act as a safe have against adverse movements in equities given the negative relationship between fine wine return and its conditional volatility. In addition the hedging capability, Bouri (2015) also shows that fine wines have a safe haven property against world major equities during times of stress.

Another strand of research has examined fine wines in relation to macro-economic variables. Anderson and Wittwer (2013) show the importance of accounting for bilateral real exchange rates and the growth in China's import demand in modeling the global wine market. Trellis Wine Investments (2013) indicate that fine wine is a good hedge against inflation risk and also insensitive to the US stock market uncertainty. Cevik and Saadi Sedik (2014) show the importance of macroeconomic variables in determining fine wine price, in particular the demand growth from emerging economies and the abundant global liquidity. Jiao (2016) shows that both the weakening in the US dollar and the demand from emerging markets have the most significant impact on fine wine prices. Qiao and Chu (2014) reveal the predictability of GDP in

developed economies based on fine wine prices. Faye et al. (2015) show a strong effect of the global equity market on wine prices over the period 2003–2012.

The above literature clearly indicates a lack of studies on the efficiency in the wine market. If fine wines represent an asset class on its own, as suggested by prior studies, its related literature must be extended to cover wine market efficiency which matters to all market participants. In fact, the value added by portfolio managers and investment strategists depends on whether the market is efficient or not. Furthermore, it is not clear whether the above developments in the wine market has contributed to making fine wine returns unpredictable (i.e. following a random walk). It is well documented that market frictions may hinder efficiency. Most of the wine market specificities (no cash-flows thus prone to behavioural biases, decentralization, and transaction costs) actually explain its lack of efficiency.

In this paper, we therefore aim to contribute to the extant literature of market efficiency, and in particular, for the wine market by examining its efficiency using a unit root test that allows us to account for potential sharp shifts and smooth breaks in wine prices. It is well-known that the persistence parameter of a process may be overestimated if structural breaks are omitted or ignored from the unit root tests, consequently decreasing the power to reject a unit root when the stationarity alternative is true (Perron, 1989). Hence, we model breaks in our unit root testing methodology, with the regime changes being both smooth and sharp, given that we use monthly data, and hence, both types of structural breaks are likely to co-exist. Our methodology also allows us to model any number of sharp breaks, unlike standard unit root tests which only permit either one (Zivot and Andrews, 1992) or two breaks (Lumsdaine and Papell, 1997; Lee and Strazicich, 2003). Hence, our approach is more general, and robust to misspecifications due to less number of breaks being specified, and also because of omission of smooth breaks. To the best of our knowledge, this is the first paper to test for efficiency in the five widely used indices of wine prices, by accounting for smooth and sharp breaks.

The remainder of the paper is organized as follows: Section 2 discusses the methodology. In Section 3 we present the data and the results, and Section 4 concludes.

2. Methodology

We apply a unit root test by taking into account both sharp shifts and smooth breaks. Let y_t denote the log of wine price and ε_t a serially uncorrelated error term. An AR(q) process for log wine price with drift a and deterministic trend t is given by:

$$y_t = a + bt + \sum_{i=1}^q \gamma_i y_{t-i} + \varepsilon_t, \quad t = q+1, q+2, \dots, n. \quad (1)$$

The focus of our study is the measure of persistence, as given by the sum of the autoregressive coefficients is

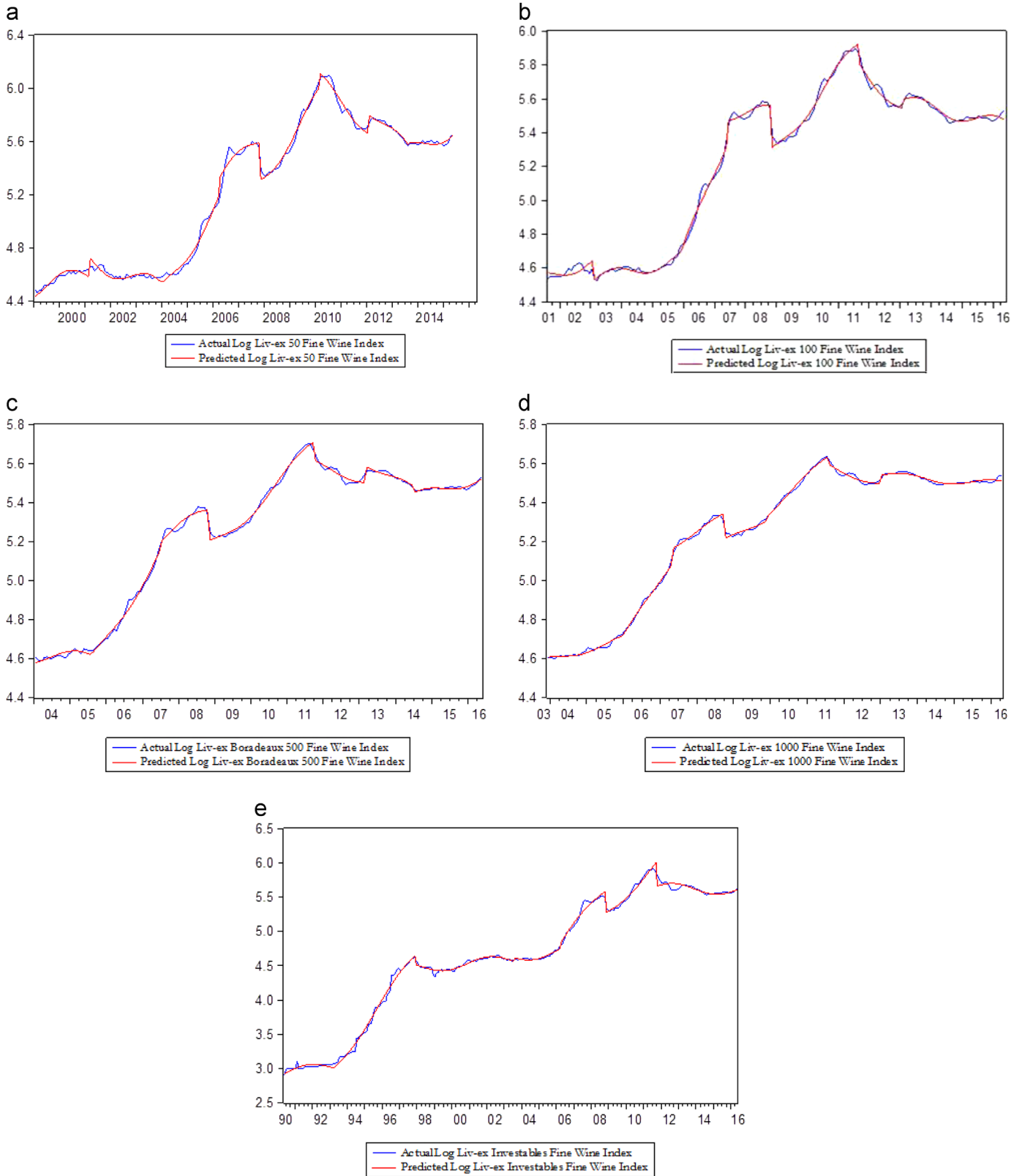


Fig. 1. (a) Plots of actual and predicted log of Liv-ex 50 Fine wine index; (b) Plots of actual and predicted log of Liv-ex 100 Fine wine index; (c) Plots of actual and predicted log of Liv-ex Bordeaux 500 Fine wine index; (d) Plots of actual and predicted log of Liv-ex 1000 Fine wine index; (e) Plots of actual and predicted log of Investables Fine wine index.

$\alpha = \sum_{i=1}^q \gamma_i$. We can rewrite Eq. (1) as follows:

$$y_t = \alpha y_{t-1} + a + bt + \sum_{i=1}^{q-1} \phi_i \Delta y_{t-i} + \varepsilon_t \tag{2}$$

If $\alpha = 1$, then wine price has a unit root and, therefore, shocks have permanent effects on wine price. If we have $\alpha < 1$, then wine price is stationary, with shocks having only temporary effects.

Following Bahmani-Oskoe et al., (2014, 2015), we model mean reversion properties in wine price using both sharp and smooth breaks using the following equation:

$$y_t = \alpha + \beta t + \sum_{l=1}^{m+1} \theta_l DU_{l,t} + \sum_{l=1}^{m+1} \rho_l DT_{l,t} + \sum_{k=1}^n \gamma_{1,k} \sin\left(\frac{2\pi kt}{T}\right) + \sum_{k=1}^n \gamma_{2,k} \cos\left(\frac{2\pi kt}{T}\right) + \varepsilon_t \tag{3}$$

In Eq. (3), t , T , and m are time trend, sample size and the optimum number of breaks, respectively. The other regressors are defined as the follows:

$$DU_{k,t} = \begin{cases} 1 & \text{if } TB_{k-1} < t < TB_k \\ 0 & \text{otherwise} \end{cases} \tag{4}$$

$$DT_{k,t} = \begin{cases} t - TB_{k-1} & \text{if } TB_{k-1} < t < TB_k \\ 0 & \text{otherwise} \end{cases} \tag{5}$$

Note that, the terms DU and DT capture the sharp shifts.¹ In order to obtain a global approximation of the smooth transition, we use the Fourier approximation and enter two terms:

$\sum_{k=1}^n \gamma_{1k} \sin\left(\frac{2\pi kt}{T}\right)$ and $\sum_{k=1}^n \gamma_{2k} \cos\left(\frac{2\pi kt}{T}\right)$ into the model (Gallant, 1981). Note that, n and k represent the number of frequencies with $n \leq \frac{T}{2}$, and the particular frequency, respectively.

To estimate Eq. (3), we need to deal with the choices of m , n and k . Following the suggestions of Becker et al. (2004), we restrict $n=1$, since if $\gamma_{1,k} = \gamma_{2,k} = 0$ can be rejected for one frequency, then the null hypothesis of time invariance is rejected as well. Further, imposing the restriction of $n=1$ is useful in order to save the degrees of freedom and prevent over-fitting (Enders and Lee, 2012). Therefore, we can re-specify Eq. (3) as follows using $n=1$:

$$y_t = \alpha + \beta t + \sum_{l=1}^{m+1} \theta_l DU_{l,t} + \sum_{l=1}^{m+1} \rho_l DT_{l,t} + \gamma_1 \sin\left(\frac{2\pi kt}{T}\right) + \gamma_2 \cos\left(\frac{2\pi kt}{T}\right) + \varepsilon_t \tag{6}$$

Note that, we can remove the effect of possible structural breaks on wine price based on the information of break dates. In this regard, we follow the approach of Tsong and Lee (2011) to reconstruct the time series of wine price by taking

¹Eq. (3) can be considered to be not only an extension of Enders and Holt (2012), but also a combination of the works of Carrion-I-Silvestre et al. (2004) and Becker et al. (2006).

Table 1
Descriptive Statistics of the Log of Wine Indices.

| Statistic | Variable | | | | |
|--------------|-----------|------------|---------------------|-------------|--------------------|
| | Liv-ex 50 | Liv-ex 100 | Liv-ex Bordeaux 500 | Liv-ex 1000 | Liv-ex Investables |
| Mean | 5.2151 | 5.2252 | 5.2547 | 5.2501 | 4.6310 |
| Std. Dev. | 0.5303 | 0.4561 | 0.3474 | 0.3387 | 0.8874 |
| Skewness | -0.0999 | -0.4540 | -0.8355 | -0.8466 | -0.5054 |
| Kurtosis | 1.3823 | 1.5811 | 2.2335 | 2.2062 | 2.1930 |
| Observations | 197 | 178 | 149 | 149 | 313 |

Note: Std. Dev. stands for standard deviation, while probability corresponds to the Jarque-Bera test of normality.

into account both sharp shifts and smooth breaks by using the following equation:

$$y_t = wine_t - \alpha - \beta t - \sum_{l=1}^{m+1} \theta_l DU_{l,t} - \sum_{l=1}^{m+1} \rho_l DT_{l,t} - \gamma_1 \sin\left(\frac{2\pi kt}{T}\right) - \gamma_2 \cos\left(\frac{2\pi kt}{T}\right) + \varepsilon_t \tag{7}$$

where y_t is wine price adjusted for the effect of both sharp and smooth breaks, $wine_t$ is log of wine price. For further details regarding the estimation of Eq. (6), the reader is referred to Bahmani-Oskoe et al., (2014, 2015).²

3. Data and empirical results

We use monthly data on five wine market price indices maintained by London International Vintners Exchange (Liv-ex). Founded in 1999, Liv-ex is a UK-based exchange for investment-grade wine and provides a marketplace for wine merchants. Based on the wine transactions, Liv-ex also publishes several fine wine price indices which are widely used to gauge general price developments for the “fine wine” market in general. The five Liv-ex indices considered in this paper are:

- (a) The Liv-ex Fine Wine 50 (Liv-ex 50) index, which tracks the price movement of the most heavily traded commodities in the fine wine market - the Bordeaux First Growths. It includes only the ten most recent vintages (excluding En Primeur, currently 2004–2013), with no other qualifying criteria applied. The data covers the monthly period of 1999:12–2016:04;
- (b) The Liv-ex Fine Wine 100 (Liv-ex 100) index is the industry leading benchmark. It represents the price movement of 100 of the most sought-after fine wines on the secondary market. The data period covered in this cases is 2001:08–2016:05;

²As pointed out by an anonymous referee, there are indeed other approaches to remove trends and smooth changes that can also be adopted; for instance the Chebyshev polynomials in time (see, Hamming (1973), Smyth (1998), Bierens (1997)).

Table 2a
Unit Root Tests in Log-Level.

| Variable | ADF | | PP | | DF-GLS | | KPSS | | NP | |
|---------------------|----------|------------------|----------|------------------|----------|------------------|----------|------------------|----------|------------------|
| | Constant | Constant + Trend | Constant | Constant + Trend | Constant | Constant + Trend | Constant | Constant + Trend | Constant | Constant + Trend |
| Liv-ex 50 | -1.275 | -1.246 | -1.144 | -1.161 | 0.191 | -1.398 | 1.485* | 0.222* | 0.229 | -4.442 |
| Liv-ex 100 | -1.326 | -1.072 | -1.353 | -0.895 | 0.122 | -1.197 | 1.367* | 0.313* | 0.128 | -3.542 |
| Liv-ex Bordeaux 500 | -1.982 | -1.122 | -1.807 | -0.882 | 0.424 | -0.982 | 1.173* | 0.316* | 0.422 | -2.406 |
| Liv-Ex 1000 | -2.058 | -0.798 | -1.994 | -0.654 | 0.414 | -1.120 | 1.233* | 0.327* | 0.412 | -3.223 |
| Liv-Ex Investables | -1.841 | -1.379 | -1.777 | -1.259 | 1.298 | -1.225 | 1.863* | 0.227* | 0.836 | -4.122 |

Notes: KPSS test has a null of stationarity, while the other tests have a null of unit root; C (C+T) indicates that the unit root testing equation has a constant (constant and trend).

*Indicates rejection of the null hypothesis at 1% level.

- (c) The Liv-ex Bordeaux 500 is Liv-ex's most comprehensive index and reflects trends in the wider fine wine market. It represents the price movement of 500 leading wines and is calculated using the Liv-ex Mid Price. The index spans the period of 2004:01–2016:05;
- (d) The Liv-ex Fine Wine 1000 (Liv-ex 1000) tracks 1000 wines from across the world using the Liv-ex Mid Price, and covers the period of 2003:12–2016:04;
- (e) Finally, the Liv-ex Fine Wine Investables (Liv-ex Investables) index tracks the most "investable" wines in the market around 200 wines from 24 top Bordeaux chateaux. In essence, it aims to mirror the performance of a typical wine investment portfolio. The index data starts in 1990:5 and ends in 2016:05; hence it goes further back than any other Liv-ex indices.

The data on these five indices have been sourced from the official website of Liv-ex (<https://www.liv-ex.com>). All indices are transformed to their natural logarithms, with the start and end dates being purely driven by data availability at the time of writing this paper. The data has been plotted in Fig. 1 (along with the sharp and smooth breaks-based fitted data, and also discussed in detail later).

We present the summary statistics of the log of the wine indices in Table 1. The mean and variance in the data across the five indices are quite similar. In addition, all the indices are skewed to the left and depict excess kurtosis. We also conduct the Jarque-Bera normality test and the unreported results indicate that all the series are non-normally distributed (the null of normality is rejected at the highest level of significance as the p -value is less than 0.00005).

To test the efficiency of the wine market, we start with the conventional linear unit root and/or stationarity tests namely, the Augmented Dickey and Fuller (1979, ADF), Phillips and Perron (1988, PP), Elliot et al.'s (1996) GLS-detrended Dickey-Fuller (DF-GLS), Kwiatkowski et al. (1992, KPSS), and Ng and Perron (2001, NP). The tests are first applied to the log-levels with a constant, and constant and trend in the unit root test equations. As can be seen from Table 2a, the null of unit root cannot be rejected even at ten percent level of

significance for the ADF, PP, DF-GLS and NP tests. While, the null of stationarity for the KPSS test is rejected at the one percent level of significance. The fact that all the five indices are integrated or order one ($I(1)$) under a constant, and constant plus trend in testing equations, is vindicated by the fact that the first-differences of the series are found to be stationary, i.e., $I(0)$, at the highest level of significance, as observed from Table 2b. In other words, using standard unit root tests, which does not account for breaks, we would conclude that the wine market is efficient.³

Next, all the above tests are now applied to adjusted series that account for sharp shifts and smooth breaks as shown in Eq. (7). The results are presented in Table 3, with the testing equation of unit root including only a constant. Based on the ADF, PP, DF-GLS and NP tests, we reject the null hypothesis of unit root at one percent level of significance. Similarly, using the KPSS test, we cannot reject the null hypothesis of stationarity even at the ten percent level of significance. These findings suggest that all the five wine indices are stationary in log-levels, i.e., the wine market is not efficient.⁴

Recall that we have used the Fourier approximation to 'mimic' the time-varying parameter and hence nonlinearity in the wine indices. In Table 4, we present the optimum breaks

³As pointed out by an anonymous referee, that we should be cautious about making this statement; whereby we assume that the data follows a random walk process. But random walk is a particular case within the $I(1)$ class, and some degree of predictability can be achieved through the short run (ARMA) dynamics, which we do not consider here.

⁴Based on the suggestions of an anonymous referee, we estimated AR (1) models of the log of the five wine prices with a trend. We observed that the persistence parameter (i.e., the estimate corresponding to the lag of the dependent variable) is exceptionally close to unity, with the null that it is equal to unity cannot be rejected even at the 10 percent level of significance. In addition, we estimated AR(1) models without trend for the differences between the actual and the fitted series (i.e., by accounting for smooth and sharp breaks). In this case, the null that the persistence parameter is equal to 1, was overwhelmingly rejected at the highest possible significance level. These results, in turn, again validate the fact (observed with the unit root tests) that while the natural logarithm of wine prices tend to suggest that the wine market is efficient, when corrected for breaks, in fact the market is not efficient. Complete details of the estimates of the AR(1) models are available upon request from the authors.

Table 2b
Unit Root Tests in First-Difference.

| Variable | ADF | | PP | | DF-GLS | | KPSS | | NP | |
|---------------------|----------|------------------|----------|------------------|----------|------------------|----------|------------------|----------|------------------|
| | Constant | Constant + Trend | Constant | Constant + Trend | Constant | Constant + Trend | Constant | Constant + Trend | Constant | Constant + Trend |
| Liv-ex 50 | -7.245* | -7.277* | -7.302* | -7.293* | -5.505* | -6.463* | 0.174 | 0.125 | -45.750* | -56.819* |
| Liv-ex 100 | -6.891* | -6.943* | -6.885* | -6.937* | -6.729* | -6.976* | 0.247 | 0.117 | -57.480* | -59.956* |
| Liv-ex Bordeaux 500 | -6.237* | -6.480* | -6.124* | -6.548* | -4.927* | -5.537* | 0.333 | 0.077 | -36.096* | -42.097* |
| Liv-Ex 1000 | -4.464* | -6.578* | -6.015* | -6.488* | -4.221* | -4.375* | 0.429 | 0.085 | -29.338* | -30.894* |
| Liv-Ex Investables | -6.992* | -13.616* | -14.728* | -14.652* | -3.456* | -5.673* | 0.268 | 0.071 | -20.633* | -48.101* |

Note: See Notes to Table 2a.

Table 3
Unit Root Tests in Log-Levels Accounting for Smooth and Sharp Breaks.

| Variable | ADF | PP | DF-GLS | KPSS | NP |
|---------------------|---------|---------|---------|-------|----------|
| Liv-ex 50 | -8.671* | -5.157* | -3.730* | 0.020 | -24.526* |
| Liv-ex 100 | -7.997* | -4.701* | -3.983* | 0.019 | -29.098* |
| Liv-ex Bordeaux 500 | -7.036* | -6.697* | -4.100* | 0.028 | -27.265* |
| Liv-Ex 1000 | -6.826* | -5.419* | -6.808* | 0.024 | -55.967* |
| Liv-Ex Investables | -7.759* | -7.925* | -7.650* | 0.016 | -83.221* |

Note: See Notes to Table 2a.

and frequency from the mean reverting function in Eq. (6) alongside with the estimated F -statistic that enables us to test for the absence of the nonlinear component in Eq. (6). In other words the F -statistic is computed by comparing the sum of squared residual (SSR) from Eq. (6) with the nonlinear component (unrestricted model) with the SSR from Eq. (6) without the nonlinear component (restricted model). However, the critical values for the F -test is non-standard due to nuisance parameters (Becker et al. 2004), hence we follow Bahmani-Oskooee et al. (2014, 2015) and use Monte Carlo simulation to compute the critical values based on 10000 replications. We fixed k at a maximum of 10 and m at a maximum of 6. From Panel A of Table 4, we observe that the optimum frequency vary from one wine index to the other with a minimum of 4 and maximum of 6 optimal frequencies. The computed F -statistics are in all cases greater than the critical values, even at the one percent level. Hence, the mean reverting function with the nonlinear component is accepted in favour of the one without the nonlinear component. Turning to the results from panel B of Table 4, we observe that there are 6 breaks in each of the wine series, thus vindicating the decision to model sharp breaks besides the smooth ones. We note that several of the break points lie close to the start and the end of the global financial crisis that provoked a severe recession in the US, Eurozone, and the UK. Some others break points coincide with later stress periods such as the multi-year European debt crisis and the significant fears of European Union collapse. During

Table 4
Estimation results for the Mean Reverting function (Eq. (6)).

| Panel A: The results for optimum frequency and the F -statistic and its critical values | | | | | | |
|---|-------------------|-----------|--------|--------|--------|--------|
| Index | Optimum Frequency | F -stat | 90% | 95% | 97.50% | 99% |
| Liv-ex 50 | 5 | 68.549 | 2.362 | 3.068 | 3.729 | 4.832 |
| Liv-ex 100 | 6 | 69.395 | 2.421 | 3.097 | 3.828 | 4.875 |
| Liv-ex Bordeaux500 | 4 | 77.32 | 2.354 | 3.076 | 3.771 | 4.744 |
| Liv-ex 1000 | 5 | 45.81 | 2.324 | 3.139 | 3.802 | 4.657 |
| Liv-ex Investables | 5 | 90.47 | 2.343 | 3.016 | 3.606 | 4.486 |
| Panel B: The results for sharp drift (break) dates in Eq. (6) | | | | | | |
| Liv-ex 50 | 2001:2 | 2004:6 | 2006:4 | 2009:7 | 2012:1 | 2014:1 |
| Liv-ex 100 | 2003:1 | 2005:9 | 2006:8 | 2007:6 | 2009:8 | 2012:1 |
| Liv-ex Bordeaux500 | 2005:6 | 2007:04 | 2008:9 | 2011:9 | 2013:3 | 2014:7 |
| Liv-ex 1000 | 2004:1 | 2005:7 | 2007:1 | 2008:3 | 2010:5 | 2012:2 |
| Liv-ex Investables | 1992:2 | 1997:7 | 2004:9 | 2007:1 | 2011:3 | 2014:1 |

those important stress periods, the demand for fine wines from emerging countries has been adversely affected leading to a decrease in wine indices. In some wine indices that cover longer sample periods, some other break dates may be related to the US recession of 1991 and 2001.

Finally, we present the time paths of the wine indices in Fig. 1a–e. The sub-figures shows that there are structural shifts in the wine series, and hence points to the need to allow for both sharp shifts and smooth breaks in testing for a unit root and/or stationarity. We superimpose the predicted time paths from our model on the actual time paths, and we observe that the predicted series tracks the dynamic behaviour of the actual wine series well, suggesting that the decision to include the dummy variables and Fourier approximations is quite reasonable since the data generating process are indeed nonlinear. It must be emphasized here, that the predicted time paths are

obtained using the full-sample of the data, i.e., in-sample based, and are not derived using out-of-sample forecasting.

4. Conclusion

The question as to the efficiency of a particular market is usually of interest to both investors and practitioners. This study investigated the efficiency of the wine market using a novel unit root test that accounts for both sharp shifts and smooth breaks in the data, with the latter captured using Fourier approximation. Our analysis involves monthly data on five wine indices maintained by London International Vintners Exchange. We conducted a host of conventional unit root tests on the original series and our newly constructed series that account for both sharp shifts and smooth breaks. Results based on these tests are in contrast with each other, with the tests applied to the original series were not able to reject the null of unit root, while the tests on the transformed series rejected the null of unit root for all the wine indices. Formal statistical tests provided evidence of structural breaks and nonlinearity in the data, and, hence, vindicated the decision to model both sharp and smooth breaks. Our findings have some important implications. They point to the importance of allowing for sharp shifts and smooth breaks as in modelling the wine market, since failure to do so lead to the conclusion that the wine market prices are unit root processes. More importantly, the evidence of mean reverting behaviour in all the wine series suggests that shocks to the markets are short-lived and wine returns can be predicted; hence, the market is not efficient. In other words, since wine prices do not fully reflect all available information in the market, market participants can incorporate any hidden information into their investment and/or management strategies and consequently make excessive gains from participating in the market. While it is understandable that the role of policy is limited here, since shocks are temporary, and somehow there are forces that will bring the market to its equilibrium in the long run, policies that improve investors' access to market information may act as incentives to participate in such market, especially for smaller investors. Realizing that asymmetric information is the basic source of inefficiency-mispricing, bubbles, crashes, transparency in trade can help to reduce the observed inefficiency in the wine market. Notably, the lack of a clear differentiation between the three levels of market efficiency, weak form, semi-strong and strong form efficiency, as documented by Fama (1970), is an important limitation to our research. This would be an interesting topic for future research.

Conflict of interest

None

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