Who is the natural heir to Robert Parker in the *en primeur* wine market?

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Introduction

- Bordeaux *en primeur* process
- Impact of wine critic ratings and wine prices
- Robert Parker and Neal Martin
- Copula functions and their use in modelling nonlinear dependence
- Data and Other Wine Critics
- Results and Conclusion

En Primeur Process

The Bordeaux En Primeur Process

- Existed in France for centuries as a form of futures market
- Spring of each year, after the prior harvest, merchants, wine critics and trade associations gather to taste and rank barrel samples of wines that are frequently eight to ten months old
- Wine is then sold ahead of bottling and ultimate release of the vintage, which may be up to two years later
- Benefit to Purchaser - provides the opportunity for the purchaser to secure a vintage before it is bottled and released, typically at a much lower price
- Benefit to Producer - cash flow prior to the release and sale of the wine in the retail market
- Uncertainty - the chateau must decide how much wine to allocate to futures sales as opposed to the retail market, when the wine is bottled and released
- Risk is mitigated the higher the en primeur price, and prices have been shown to be heavily dependent on the critic barrel scores achieved

Wine Critic Barrel Ratings

Impact of Parker Barrel Ratings

En primeur prices are heavily dependent upon the ranking of the wine based on the barrel tastings. The barrel scores of the prestigious wine critic Robert Parker Jr. have had a great influence on the *en primeur* price offerings by the chateaux. **Cyr et al. (2017), Noparumpa et al. (2015), Ali et al. (2010), Ashenfelter, (2010), Jones and Storchmann, (2001).**

Parker's ratings have been largely viewed as the authority on Bordeaux en primeur wines

His reign as the world's leading wine critic on Bordeaux wines has not been without some controversy, however, - criticized with advocating style over substance and creating a homogenous world of highly oaked and over-extracted wines. He has been credited with having pushed the Bordeaux wine industry into investments in newer technology and equipment, resulting in greater consistency over the years

Wine Critic Barrel Ratings

Impact of Wine Critics Ratings on Wine Prices

- A fairly large body of literature deals with the impact of the ratings of wine critics on the demand for wine and wine prices. Studies of this nature have been carried out for wines originating from several countries and over different time periods

- *"Over 60 studies and 180 hedonic wine price models over a 20 year period....."*
- *"The research identifies that the relation between the price of wine and its sensory quality rating is a moderate partial correlation of +0.30."*

Oczkowski, E., & Doucouliagos, H. (2015). Wine prices and quality ratings: A meta-regression analysis. *American Journal of Agricultural Economics*, 97(1), 103-121.

Wine Critic Barrel Ratings

Comparison of Wine Critics Ratings

- Ashton, R. H. (2012). Reliability and Consensus of Experienced Wine Judges: Expertise Within and Between? *Journal of Wine Economics*, 7(01), 70-87.. - Mean reliability between judges is .5 across various studies.

- Cardebat, J. M., & Livat, F. (2016). Wine experts' rating: a matter of taste?. *International Journal of Wine Business Research*, *28*(1), 43-58. – Variation might be explained by taste preferences of critics

- Cardebat, J. M., & Paroissien, E. (2015). Standardizing expert wine scores: An application for Bordeaux en primeur. *Journal of Wine Economics*, 10(03), 329-348. - non parametric methodology to express the scores of each wine expert on the same rating scale

Wine Critic Barrel Ratings

Noparumpa, T., Kazaz, B., and Webster, S. (2015), "Wine futures and advanced selling under quality uncertainty", *Manufacturing & Service Operations Management*. 17(3), 1-16

Notes some non-linearity in the relationship of Parker ratings and wine prices

Model Risk– Risk due to assumptions regarding the fundamental dependence structure between variables and its stationarity.

Generally a regression analysis is used, assuming the dependence structure is captured fairly well by linear correlation.

It appears that this is not often the case.

One solution to the issue is the use of copula functions to fit multivariate distributions, incorporating nonlinear dependence

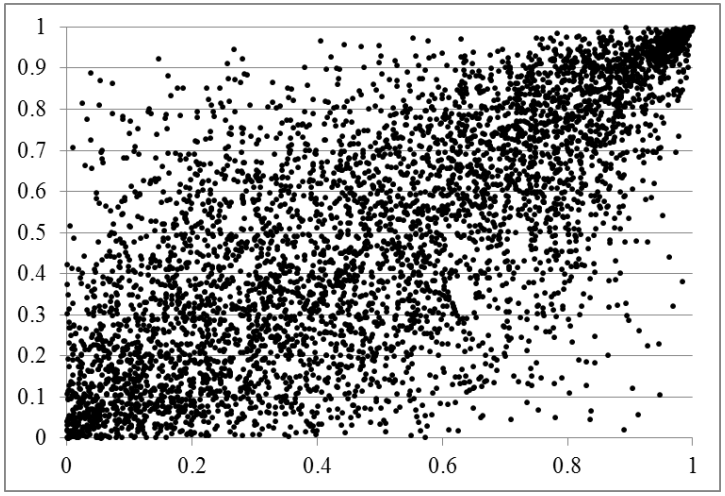
Useful for capturing "tail dependence" – higher correlation at the "tails" of the univariate (marginal) distributions comprising the multivariate distribution

Wine Critic Barrel Ratings

Cyr, D., Kwong, L. & Sun, L. (2017). An examination of tail dependence in Bordeaux futures prices and Parker ratings. *Journal of Wine Economics*, 12(3), 252-266.

Given the copula function and the marginal distributions we can then use Monte Carlo simulation to generate ratings and prices from a bivariate distribution based on the Gumbel copula that allows us to generate probabilities. We used Monte Carlo simulation to generate 5,000 combinations of ratings and prices

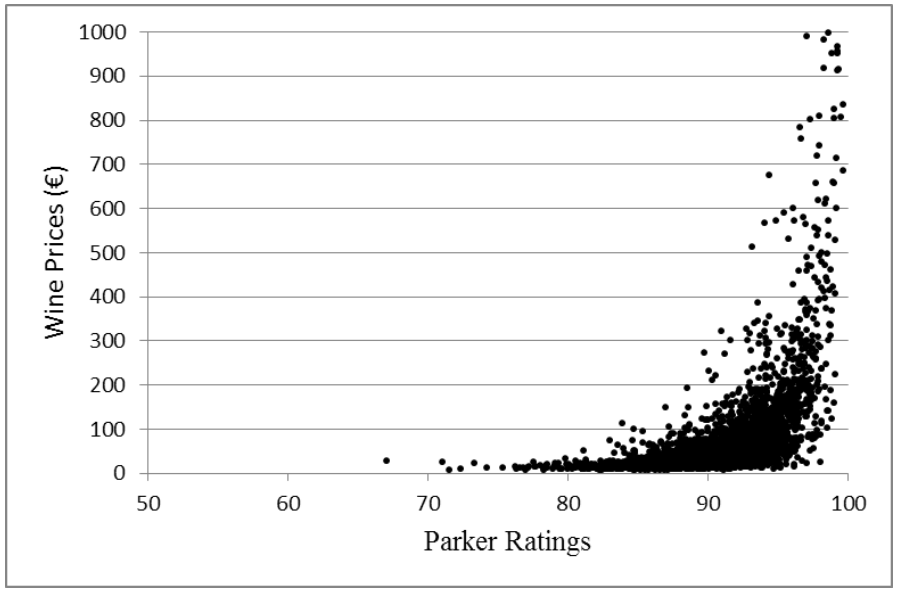
Figure 5: Bivariate Uniform Distribution Plot of Simulated Parker Ratings and Price Data



Wine Critic Barrel Ratings

Given the copula function and the marginal distributions we can then use Monte Carlo simulation to generate ratings and prices from a bivariate distribution that allows us to generate probabilities. We used Monte Carlo simulation to generate 5,000 combinations of ratings and prices

Figure 6: Graph of Simulated Parker Ratings and Wine Prices



Rating	Average Price	Standard Deviation	Pearson Correlation
75-80	15.83 €	5.81 €	0.27
80-85	19.42 €	12.05 €	0.15
85-90	27.55 €	16.93 €	0.21
90-95	59.27 €	63.68 €	0.36
95-100	391.96 €	779.63 €	0.52

Wine Critic Barrel Ratings

- **February 2015** After 38 years, Parker announced that he would no longer review Bordeaux wine futures; turning the responsibility over to his successor Neal Martin, a British wine critic.
- Martin – a wine blogger who started the website *Wine Journal* in 2003 gained a substantial following over a short period of time and joined Parker's prestigious publication, *The Wine Advocate* as a wine writer and critic in 2006.
- **April 2016** - Martin assumed responsibility for the review of all Bordeaux wines, both in barrel and bottle, for *The Wine Advocate*
- **November 2017** - Martin leaves *The Wine Advocate* to become senior editor for the wine magazine *Vinous*. Parker announces that *The Wine Advocate*'s editor-in-chief Lisa Perrotti-Brown would assume responsibility for all Bordeaux wines for *The Wine Advocate* commencing 2018. She samples the 2017 *en primeur* vintage in spring 2018.

Wine Critic Barrel Ratings

Creates a lot of uncertainty for the chateaux, particularly for Bordeaux right bank (merlot) wine producers which Parker tended to have a penchant for

Much concern within the industry as to who is the true successor to Parker:

Millar, R. (2015). End of an era: Parker hands Martin the reins for Bordeaux primeurs. *The Drinks Business*,

Livsey, A. (2016). Wine expert Robert Parker leaves a pointed legacy. *Financial Times*, December 16th, 2016

Pickford, J. (2016), Critic Neal Martin named as successor to influential wine guru. *Financial Times*. April 25th, 2016.

Shaw, L. (2017a). Neal Martin leaves *The Wine Advocate* for *Vinous*. *The Drinks Business*, November 20th, 2017

Shaw, L. (2017b). Perrotti-Brown named Bordeaux reviewer at The Wine Advocate. *The Drinks Business*, November 28th, 2017

COPULA Functions

Based upon Sklar's Theorem (1959)

If F is a joint distribution function of m random variables ($y_1,...,y_m$) with marginal distributions $F_1,.....,F_m$

Then there exists an m-dimensional copula $C:[0,1]^m \rightarrow [0,1]$ (from the unit *m*-cube to the unit interval) which satisfies the following conditions:

1. $C(1,...,1,a_n, 1,...,1) = a_n$ for every $n \leq m$ and for all a_n in [0,1]

If the realizations of *m*-1 variables are known, each with a probability of one, then the joint probability of the *m* outcomes is the same as the probability of the remaining uncertain outcomes.

2. $C(a_1,...,a_m) = 0$ if $a_n = 0$ for any $n \leq m$

The joint probability of all outcomes is zero if the marginal probability of any outcome is zero.

3. *C* is m-increasing

C-volume of any m-dimensional interval is non-negative.

COPULA Functions

Sklar's Theorem (1959)

Given $F(y_1,...,y_m)$ with univariate marginal distributions $F_1(y_1),...,F_m(y_m)$ and inverse functions $F_1^{-1},..., F_m^{-1}$, then

$y_1 = F_1^{-1}(u_1) \sim F_1, ..., y_m = F_m^{-1}(u_m) \sim F_m$

Where $u_1,...,u_m$ are uniformly distributed variates.

$$\begin{aligned} F(y_1,...,y_m) &= F(F_1^{-1}(u_1),..., F_m^{-1}(u_m)) \\ &= \Pr[U_1 \le u_1,..., U_m \le u_m] \\ &= C(u_1,...,u_m) \end{aligned}$$

Is the unique copula function associated with the distribution function and

$$(F_1(y_1),...,F_m(y_m)) \sim C$$

and if U ~ C, then

$$(F_1^{-1}(u_1),..., F_m^{-1}(u_m)) \sim F$$

Essentially Copulas can be used to express a multivariate distribution in terms of its marginal distributions!

COPULA Functions

Sklar's Theorem (1959)

For an *m*-variate function *F*, the copula associated with *F* is a distribution function $C:[0,1]^m \rightarrow [0,1]$ that satisfies.

$$F(y_1,\ldots,y_m) = C(F_1(y_1),\ldots,F_m(y_m); \theta)$$

Where θ is a vector of parameters called the dependence parameter which measures dependence between the marginal distributions.

In bivariate applications θ is typically a scalar.

The joint distribution is expressed in terms of its respective marginal distributions and a function C that binds them together. This allows for the consideration of marginal distributions and dependence as two separate but related issues. Useful for comparing wine ratings where raters used different scales.

COPULA Functions

Application of Copula Functions

For a variety of reasons, largely due to the high dimensionality of $m \geq 3$ copula estimation, most research has focused on bivariate parametric copulas – relationship between two variables. Useful for our purposes.

Parametric copulas

Although there are theoretically an infinite number of copula functions most applications focus on some simple structures (Parametric copulas) that capture some basic non-linear relationships between variables.:

-Implicit (Gaussian and Student t copula) – implied by known multivariate distribution functions and do not have simple closed forms.

-Explicit (Archimedean Copulas) – simple closed forms.

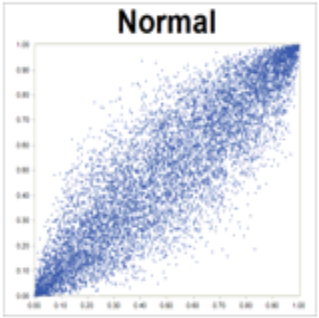
COPULA Functions

Two Parametric Families of Copula Functions are commonly used.

1. ELLIPTICAL COPULAS

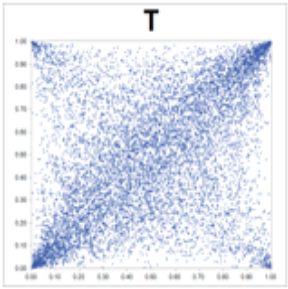
Can capture some degree of tail dependence but are limited in that they are symmetric. Tend to under estimate tail dependence if it is asymmetric.

Gaussian (Normal) Copula



Student-T Copula

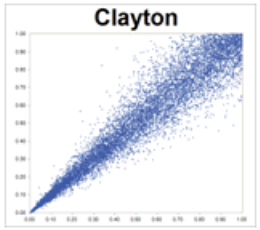
More flexible than the Gaussian copula because It does not assume that uncorrelated variables are independent.



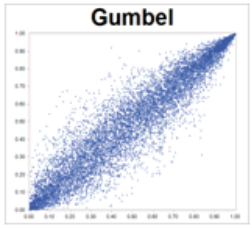
COPULA Functions

ARCHIMEDEAN COPULAS– allow for a wider variety of dependence structures, particularly asymmetric

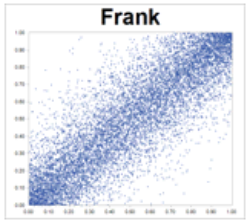
Clayton Copula
Greater dependence in the lower tail.



Gumbel Copula
Greater dependence in the upper tail.

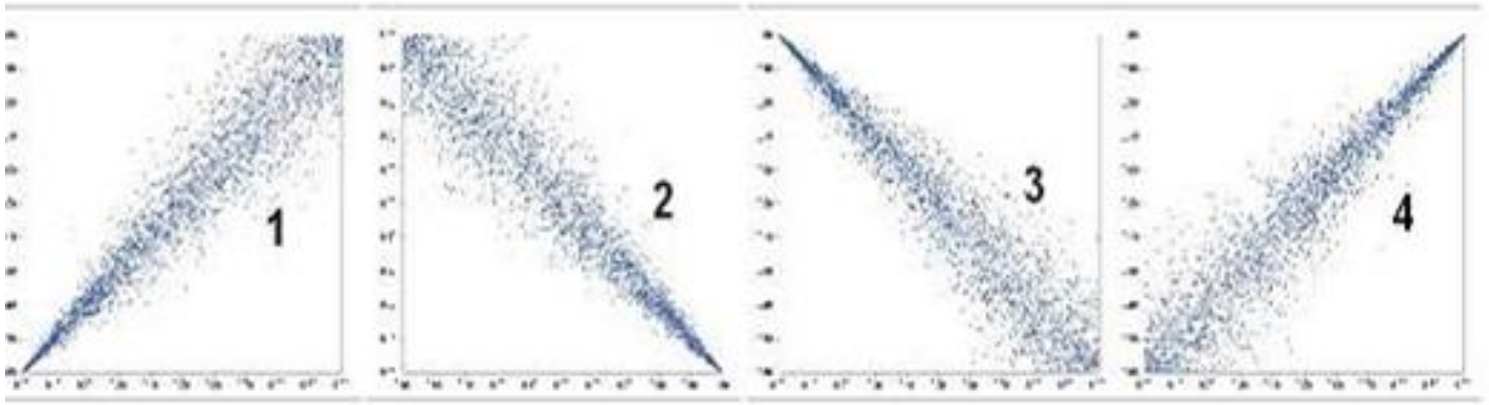


Frank Copula
Greater correlation in the middle section than in the tails.



COPULA Functions

Clayton and Gumbel Copulas can also be estimated as transformations of the variables (u, v) by taking one or both of the variables and transforming them as 1-u and/or 1-v, resulting in three additional patterns that can be tested. This provides for directional patterns of 1, 2, 3 and 4.



Goodness of Fit Tests for Copulas

Standard Approach to Copula Function Modelling:

Fit several copula functions to the data and apply maximum likelihood goodness-of-fit tests to see which function models the dependency structure relatively better.

Information Criteria Tests (varying penalties for additional parameters)

Akaike Information Criteria (AIC)

Bayesian (Schwartz) Information Criteria (BIC)

Hannan-Quinn Information Criteria (HQIC)

Problem is that they do not provide the power of the decision rule.

COPULA Functions – An Aside

Mathematics of Copula Functions developed in 1959 by Sklar

First application in Financial Economics:

Embrechts, P., A. McNeil, and D. Straumann (1999). Correlation and dependence in risk management: Properties and pitfalls. *RISK*, May 1999, 69–71

2008 Financial Crisis

Seminal article that led to the development of Collateralized Debt (Mortgage) Obligations (CDO's):
Li, D. X. (2000). On Default Correlation: A Copula Function Approach. *The Journal of Fixed Income,* 9(4), 43-54.

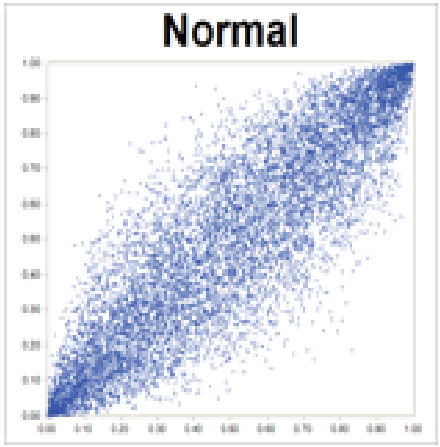
Interesting connection between copula function modelling and the 2008 Financial Crisis - the incorrect use of the Gaussian copula to model CDO's comprised of multiple mortgages:

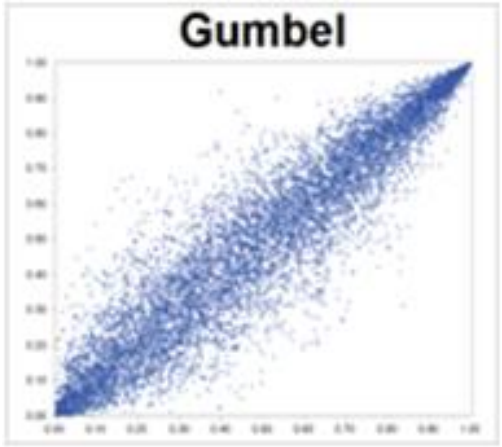
Salmon, F. (2009). Recipe for Disaster: The Formula That Killed Wall Street, *Wired Magazine*

COPULA Functions – An Aside

2008 Financial Crisis

Fundamental issue is that the Normal (Gaussian) function was employed to characterize the risk associated with a portfolio of mortgages – giving the impression that through diversification the risk of the portfolio was greatly reduced. In reality the true association between the probability of two mortgages defaulting has tail dependence. If the economy has a downturn the likelihood of default with respect to two unrelated mortgages is much higher.





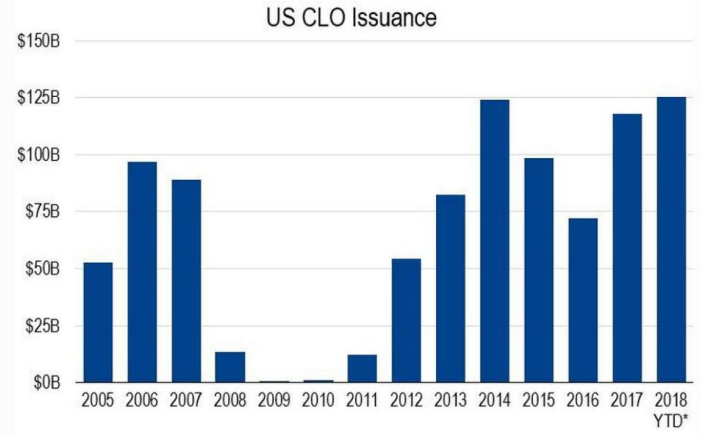
COPULA Functions – An Aside

Is the Same Thing Happening Again?

Collateralized Loan Obligations (CLO's)

Faced with greater constraints over the securitization of mortgages, investment bankers have been selling collateralized loan obligations (CLO's) which are portfolios high risk commercial/business loans. The same argument about diversification and the Normal Copula is being used to sell them!

***Rating Agencies Sound Alarm About Leveraged Loans And CLOs*, Forbes Dec 18th, 2018**



Ratings and En Primeur Price Data

Database of en primeur prices along with wine critics ratings 2004 – current
http://www.bordoverview.com
Bolomey Wijnimport Amsterdam – wine sellers

2004 through 2010 was chosen as the period of study as it reflects a time period starting from the renown 2005 harvest and carrying through 2010 of a stable sustained bull run in futures prices. It has been alluded to that Parker's barrel ratings had a significant impact on rising en primeur prices. After 2010 (until 2014) lower sales plagued the market along with downward pressure on prices.

In addition 2003 Parker's barrel ratings were released after the en primeur prices were set by chateaux (Ali et al., 2010)

Data and Analysis

en primeur **wine database www.borderview.com**

Data is also provided for LEFT Bank (south of the Gironde and Garonne rivers - Cabernet Sauvignon dominant) and RIGHT bank (north of the Gironde and Dordogne rivers - Merlot dominant) wines

Support Bordoverview: buy your Bordeaux 2015 primeurs at Bolomey Wijnimport Amsterdam.
Read about Bordeaux 2015 on Bolomey Blog. Follow Bordoverview on Twitter.

Overview settings: 2010 | Left bank | Update

Wine	Year	AOC	Class.	Size	By	RP	NM	JR	TA	BD	JS	JL	De	RVF	JA	PW	RG	Price	+/–
Haut-Brion	2010	Pessac-Léognan	1st GCC	43	Masclef, J-P	98-100	96-98	18++	·	·	97-98	·	19.5	18.75	98-99	5	19	€ 925	+9%
Lafite-Rothschild	2010	Pauillac	1st GCC	103	Boissenot, J.	98-100	95-97	19	·	·	100	·	20	20	99	5	20	€ 1300	+44%
Latour	2010	Pauillac	1st GCC	67	Boissenot, J.	98-100	96-98+	19	·	·	98-99	·	20	·	98	5	19	€ 1150	+28%
Margaux	2010	Margaux	1st GCC	81	Boissenot, J.	96-98	97-99	19	·	·	100	·	20	20	99-100	5	20	€ 950	+12%
Mouton-Rothschild	2010	Pauillac	1st GCC	83	Boissenot, J.	97-100	98-100	18.5	·	·	99-100	·	19.5	19.75	99-100	4½	19	€ 925	+9%
Brane-Cantenac	2010	Margaux	2nd GCC	90	Lurton, H.	93-96	94-96	17	·	·	91-92	·	18	17	92	4	17	€ 76	+25%
Cos d'Estournel	2010	St-Estèphe	2nd GCC	64	Boissenot, J.	95-97	96-98	18.5	·	·	96-97	·	19	19.25	94-95	4½	19	€ 273	–6%
Ducru-Beaucaillou	2010	St-Julien	2nd GCC	55	Boissenot, J. & E.	96-98+	95-97	18	·	·	99-100	·	19	19.5	98	5	19	€ 207	–17%
Durfort-Vivens	2010	Margaux	2nd GCC	30	Lurton, G.	89-91	89-91	16	·	·	91-92	·	18	15.5	90	3½	17	€ 45	+29%
Gruaud-Larose	2010	St-Julien	2nd GCC	82	Pauli, G./Boissenot	92-94	92-94+	16	·	·	93-94	·	18	18.5	94+	4½	17	€ 63	+13%
Lascombes	2010	Margaux	2nd GCC	84	Rolland, M.	94-97	·	17.5	·	·	91-92	·	17.5	17	93+	4½	19	€ 100	+19%
Léoville-Barton	2010	St-Julien	2nd GCC	47	Boissenot, J.	91-93+	96-98	17.5+	·	·	97-98	·	18.5	18.75	94-95	4½	18	€ 100	+15%

Parker and Martin

For the period of 2010 through 2012, Robert Parker and Neal Martin independently rated many of the same Bordeaux *en primeur* wines, providing the opportunity to examine the bivariate distributional relationship between their evaluations.

Provides for 325 left bank concurrent wine ratings and 332 in the case of the right bank, over the three year period.

it has been noted that both critics have expressed a preference for Merlot dominated blends stemming from Bordeaux right bank wines

Both critics use the same Parker rating system of 50 – 100.

Parker and Martin

Best Fitting Copula Function, Robert Parker and Neal Martin Ratings: 2010 - 2012

Left Bank				
Year	*obs*	*Copula*	$*\rho_S$	λ_U
2010	114	Normal	0.68	0.00
2011	98	**Clayton $^{-1}$	0.59	0.58
2012	113	Clayton $^{-1}$	0.52	0.57
2010-2012	325	Clayton $^{-1}$	0.66	0.67

Right Bank				
Year	*obs*	*Copula*	$*\rho_S$	λ_U
2010	107	Clayton $^{-1}$	0.68	0.68
2011	117	Normal	0.49	0.00
2012	108	Normal	0.67	0.00
2010-2012	332	Gumbel	0.62	0.52

*Spearman rank correlation

**The notation -1 indicates the fitting of a copula function to the inverted uniform distribution data. In the case of the Clayton copula, which captures lower tail dependence, when fitted to the transformed (inverted) data, indicates upper tail dependence in the untransformed data.

Parker and Martin

Significant tail dependence in the multivariate distribution of Parker's and Martin's ratings, particularly for left bank wines.

2011, 2012: Martin's ratings of left bank wines appear to be highly correlated with that of Parker's when the ranking is high (upper tail dependence), but less so at the lower range.

<u>The right bank exhibits a different correlation pattern!</u>
2010 – upper tail dependence
2011, 2012. - Gaussian (Normal) copula - lack of tail dependence

Did Martin start to develop his own idiosyncratic preferences in terms of Bordeaux wines and particularly highly ranked right bank wines?

If so, does this add risk for Bordeaux wine producers?

Wine Critic Barrel Ratings

Prominent *En Primeur* Wine Raters Other Than Robert Parker and Neal Martin

En primeur Wine Raters	*Rating Scale*
***Decanter* (De):** English wine magazine. Before 2015 the wines were tasted by Steven Spurrier, James Lawther, and Beverley Blanning.	Prior to 2007 employed a 1 to 5 rating scale; 2007-2014 a 10 - 20 scale; since 2015 the 100 point scale.
***Michel Bettane & Thierry Desseauve (B&D):** French wine critics publishing in *TAST*.	Rating scale from 10 to 20.
***Perswijn* (PW):** Dutch wine magazine, ratings by Ronald de Groot.	1 to 5 stars.
****René Gabriel (RG):** Swiss wine critic publishing in *WeinWisser*. No ratings post 2015	10 to 20 scale.
***James Suckling (JS):** American wine critic published in the American magazine *Wine Spectator* up to and including the Bordeaux 2009 vintage. Post 2009 he publishes ratings on his website JamesSuckling.com.	Scale of 75 to 100.
***Jancis Robinson (JR):** British wine critic, currently writes a column for the *Financial Times*, and for her website JancisRobinson.com,	Scale of 12 to 20.
***Jane Anson (JA):** English wine journalist writing for the *Decanter* magazine and publishing on her website *New Bordeaux*. Became the rater for *Decanter* after 2015.	Scale of 75 to 100.
****La Revue du Vin de France* (RVF):** French wine magazine. The wines are tasted by Olivier Poels, Hélène Durand and Philippe Maurange.	Scale from 10 to 20.
****Le Point* (LeP):** French magazine. The leading taster is Jacques Dupont.	Scale from 10 to 20.
***Jeff Leve (JL):** American wine critic publishing on his website TheWineCellarInsider.com.	Scale from 75 to 100.

*continues to rate *en primeur* wines
** does not appear to continue to rate *en primeur* wines

Wine Critic Barrel Ratings

Number of *En Primeur* Wines Jointly Rated by Various Wine Raters and Robert Parker

Right Bank

Year	**DE*	**B&D*	**PW*	***RG*	**JS*	*JR*	**JA*	**RVF*	***LeP*	**JL*
2005	114	107			132	116		73	98	
2006	96	94	97	125	90	92		79		
2007	86	98	103	126	83	117		94		
2008	114	134	116	146	17	119	68	76		
2009	147	151		155	155	129	108	87		
2010	122		124	140	115	113	43	81		
2011	130		99	140		103	74	77		
2012	127		118		49	108	58	46		
2005-2012	**936**	**584**	**657**	**832**	**641**	**897**	**351**	**613**	**98**	

Left Bank

Year	**DE*	**B&D*	**PW*	***RG*	**JS*	*JR*	**JA*	**RVF*	***LeP*	**JL*
2005	138				139	142		87	113	
2006	110		98		99	87		83		
2007	97		93		79	98		86		
2008	120		113		29	124		84		
2009	138				138	139		88		
2010	123		115		108	124		84		88
2011	108		102			100		85		100
2012	119		103		32	113		73		
2005-2012	**953**		**624**		**624**	**927**		**670**	**113**	**188**

*continues to rate *en primeur* wines

** does not appear to continue to rate *en primeur* wines

Parker and Other Raters

Best Fitting Copula Function, and Dependence Measures for Jointly Rated *En Primeur* Wines by Various Wine Raters and Robert Parker for the period of 2010-12.

Time Period: 2010-12				
Rater	*Obs*	*Copula*	ρ_S	λ_U
De	379	Gumbel	0.65	0.54
PW	341	Clayton^{-1}	0.53	0.50
*JS	164	Clayton^{-1}	0.66	0.65
JR	324	Clayton^{-1}	0.37	0.26
JA	175	Clayton^{-1}	0.26	0.16
RVF	204	Gumbel	0.61	0.49
NM	332	Gumbel	0.62	0.52

*Note that no data was available in terms of jointly ranked *en/primeur* wines by JS and Parker for the year 2011, accounting somewhat for the lower number of observations over the 2010-12 period.

Parker and Other Raters

Best Fitting Copula and Resulting Dependence Measures for James Suckling and Robert Parker Jointly Rated Right Bank *En Primeur* Wines: 2010 and 2012.

Year	*obs*	*Copula*	ρ_S	λ_U
2010	115	Clayton^{-1}	0.70	0.69
2012	49	Clayton^{-1}	0.56	0.48
2010-12	164	Clayton^{-1}	0.66	0.65

Parker and Other Raters

Best Fitting Copula Function, and Dependence Measures for Jointly Rated Right Bank *En Primeur* Wines by Various Wine Raters and Robert Parker for the period of 2005-2009.

2005-2009				
Rater	*Obs*	*Copula*	ρ_s	λ_U
De	557	Gumbel	0.63	0.48
PW	316	Clayton^{-1}	0.49	0.44
JS	477	Gumbel	0.66	0.52
JR	1163	Clayton^{-1}	0.48	0.46
JA	176	Clayton^{-1}	0.49	0.44
RVF	409	Gumbel	0.49	0.43

Conclusions

Our results would indicate that of the prominent *en primeur* wine critics the ratings of James Suckling had the highest association, both in terms of rank correlation and well as upper tail dependence with that of Parker. Although the *Decanter* wine ratings also appear to have a relatively high correlation (ρ_s = 0.63) and upper tail dependence ($\lambda U = 0.48$) with that of Parker's, the Decanter ratings are now carried out by Jane Anson (JA), whose ratings again exhibit a much lower correlation ($\rho_s = 0.49$) and upper tail dependence ($\lambda_U = 0.44$) on average.

Conclusions

Lisa Perrotti-Brown (now the rater for *The Wine Advocate*) did rate the 2017 *en primeur* vintage in the spring of 2018. Some suggest her ratings are close to that of Neal Martin:

Millar, R. (2018). Perrotti-Brown awards eight 100s to Bordeaux. *The Drinks Business*, December 3rd, 2018.

Copula function analysis of Lisa Perrotti-Brown vs Neal Martin and vs James Suckling:

		Right Bank 2017		
Raters	***obs***	***Copula***	**ρs**	**λ U**
LPB and NM	127	Clayton-1	0.70	0.69
LPB and JS	128	Gumbel	0.76	0.61

Other Areas of Research with Copula Functions

Increased use of Copula functions in Agricultural Economics for the modelling of the relationship between weather variables, prices and crop yields

Vedenov (2008)) - *Application of copulas to estimation of joint crop yield distributions*
Woodward et al. (2011) - *Impact of copula choice on the modeling of crop yield basis risk*
Bokusheva (2011) - *Measuring dependence in joint distributions of yield and weather variables*
Okhrin et al., (2013) - *Systemic weather risk and crop insurance: the case of China*
Boziac et al. (2014) - *Tails Curtailed: accounting for nonlinear dependence in pricing margin insurance for dairy farmers*
Bokusheva et al (2016). *Satellite-based vegetation health indices as a criteria for insuring against drought-related yield losses*

Cyr, D., Eyler, R., & Visser, M. (2013). *The Use of Copula Functions in Pricing Weather Contracts for the California Wine Industry*. Working paper. Brock University

Other Areas of Research with Copula Functions

Potential Use of Copula Function Analysis: Weather and the Niagara Region

Cyr, D., Eyler, R., & Visser, M. (2013). *The Use of Copula Functions in Pricing Weather Contracts for the California Wine Industry*. Working paper. Brock University

Cyr, D., Eyler, R. and Visser, M. (2012). Climate change and the time series and distributional properties of weather factors influencing California viticulture. *2012 Agricultural and Applied Economics Association Annual Meeting,* Seattle, Washington,

Cyr, D., Kusy, M. and Shaw, A.B. (2010). Climate change and the potential use of weather derivatives to hedge vineyard harvest rainfall risk in the Niagara region. ***Journal of Wine Research***, 21(2), 207-227.

Cyr, D., Kusy, M. and Shaw, A.B. (2009). Hedging the risks of vineyard injury with an OTC collar contract. *American Association of Wine Economists Annual Conference*, Reims, France, June.

Cyr, D., Kusy, M. and Shaw, A.B. (2008). Hedging adverse bioclimatic conditions employing a short condor contract, ***Journal of Wine Economics***. 3(2), 149-171.

Cyr, D., Kusy, M. and Shaw, A.B. (2008). The potential use of weather derivatives in the viticulture industry, ***Economia & Diritto Agroalimentare***. 13(3), 67-82.

Cyr, D. and Kusy M. (2007). Canadian ice wine production: a case for the use of weather derivatives, ***Journal of Wine Economics,*** 2(2), 145-167. Note: This paper is also posted on the *Weather Risk Management Association* website.

The End