Do corporately organized wine producers cope better with unfavorable weather conditions than private wine estates? Hedonic pricing models for South African wines

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Hedonic pricing models for South African wines

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American Association of Wine Economists

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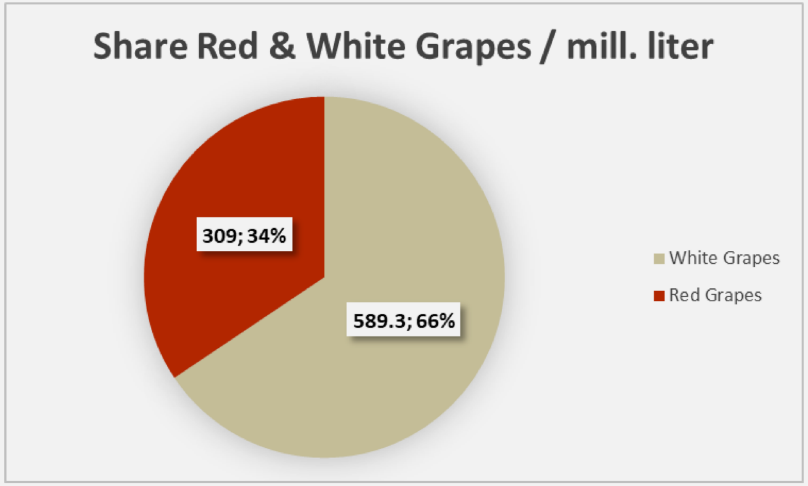
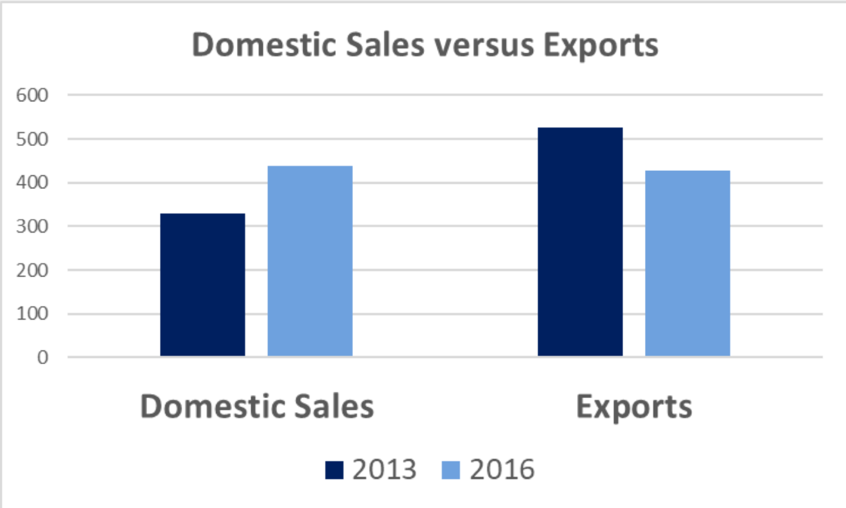
1. Wine Production in South Africa (Sawis 2016)



Wikipedia.com



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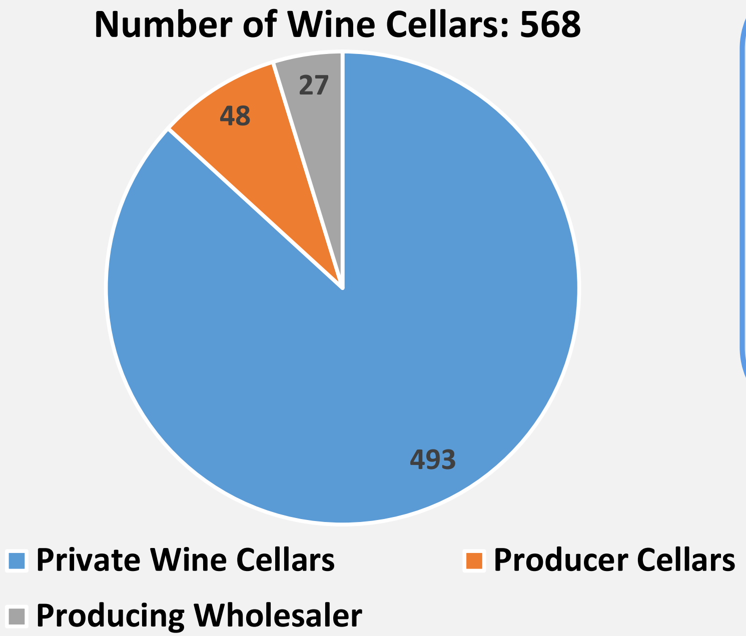


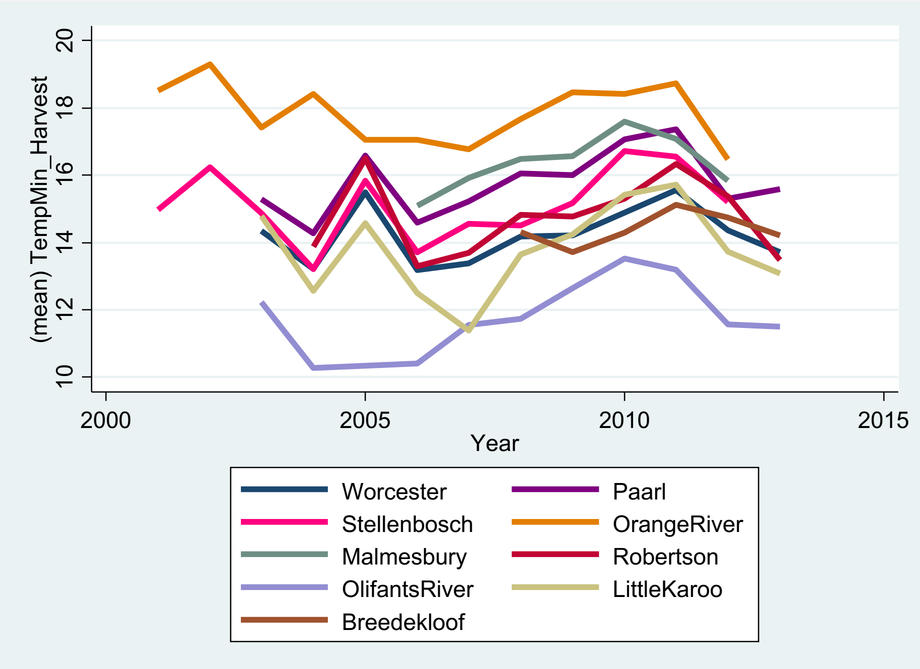
Private Wines cellars (Wine estates):
Wine is made and bottled there from grapes that are grown on own land. Grapes leave the farm only as a finished product.

Producers Cellars (corporately organized):
Independent grape farms belong to a cooperative, which the farmers own together. They process grapes into wine on a communal basis.

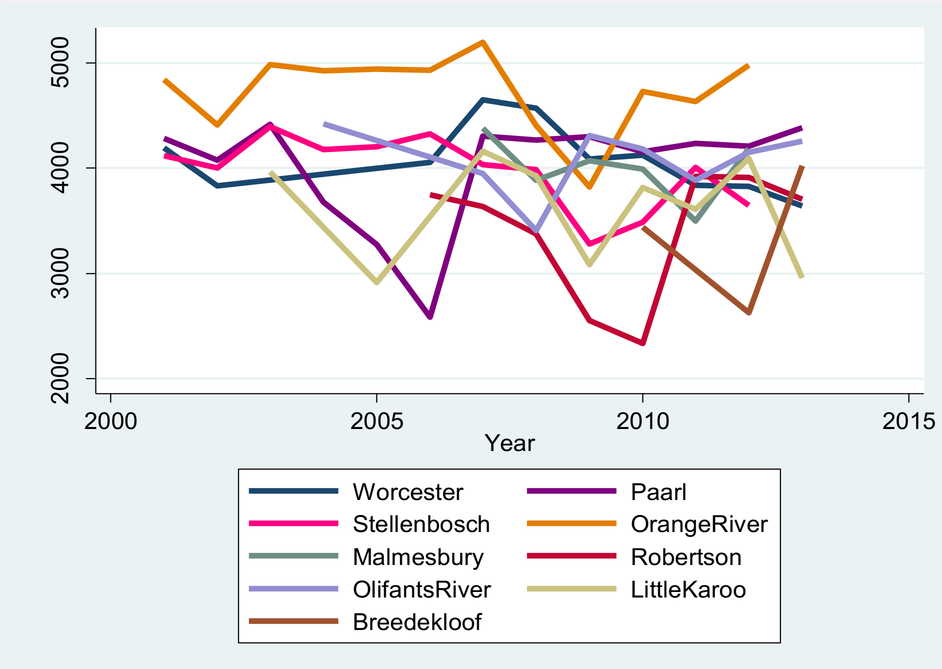
2. Weather in South Africa

- Wine production depends on weather conditions
- Weather conditions vary from year to year and differently in each wine region

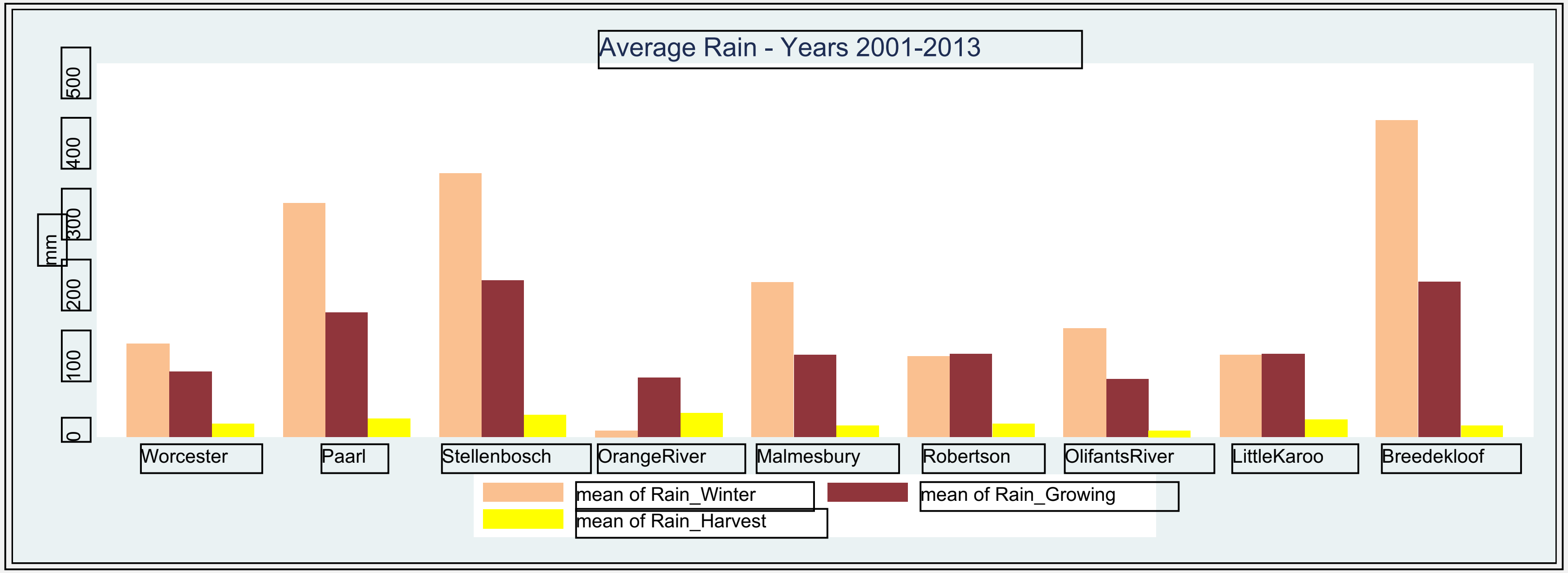
min. avg. Temp. harvest time



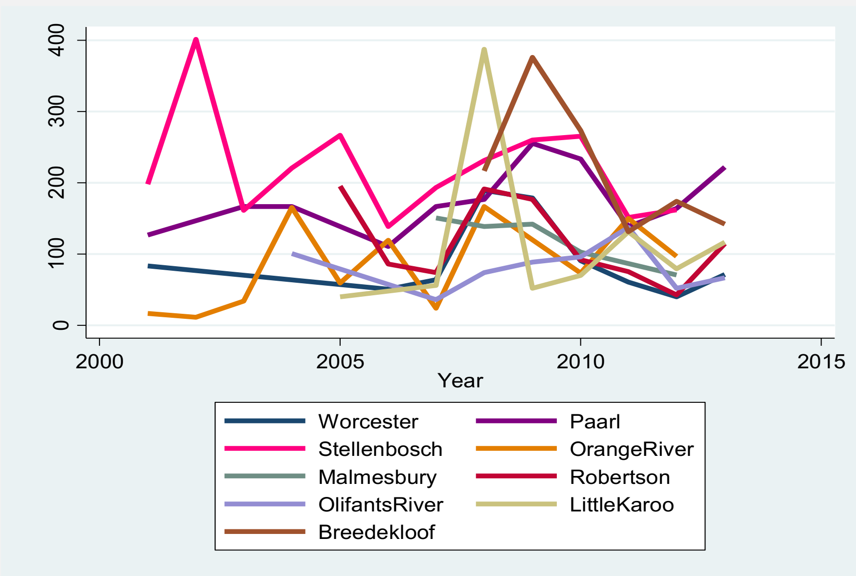
sum of radiation growing time



2. Weather in South Africa

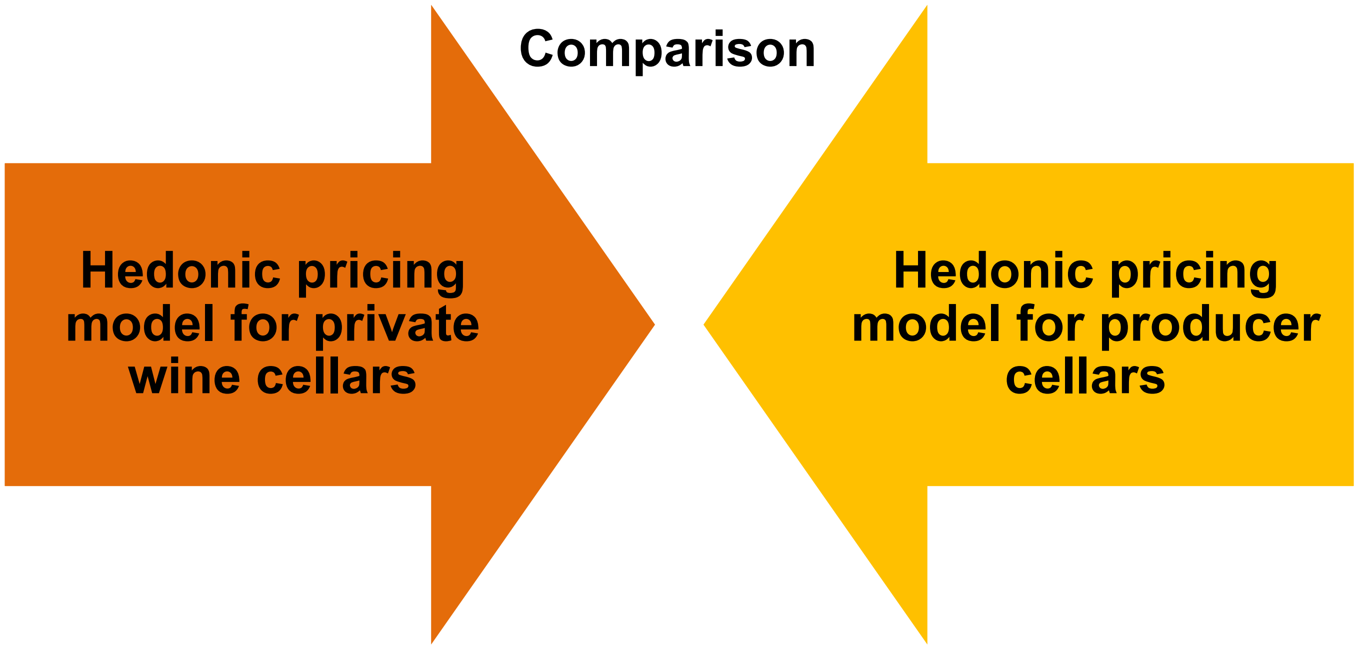


sum of rainfall in mm growing time



Research Question:
Do corporately organized wine producers (producer cellars) cope better with unfavorable weather conditions than private wine estates (cellars)?

Approach:



Hypothesis:
Weather variables have a higher importance for hedonic pricing functions of private wine cellars compared to producer cellars.

Literature:

- Hardly quantitative research on the impact of weather on SA wine prices.
- Bonnardot and Carey (2008) find an increase in temperatures
- Conradie et al. (2002), Bonnardot et al. (2005), White et al. (2006) and Deloire et al. (2009/10) suppose an important impact on the wine style
- Vink et al. (2012) stress, that single vineyard wines from small private estates will suffer more than bigger cooperatives.

4. Data (Years 2001 – 2011)

6 Wine Regions

Weather Data from ARC, Institute for Soil, Climate and Water (Stellenbosch)

6 different weather stations / daily data

Average temperature, temp-max, temp-min

Sum of precipitation (in mm), of radiation (MJ/m2).

Winter season:	June to August (year n-1)
Growing season:	September (year n-1) - 15 February
Harvest season:	16 February – 31 March

Data on prices, age of wine: Wine Searcher

- 2962 Observations, 84 producers (31 producer cellars, 53 private wine estates)

Data on wine and wine cellar characteristics: Platter's Guide on SA wines

- Production in tons, area in ha, age of wine cellar, private or producer cellar

4. Data (Years 2001 – 2011)

Descriptive Statistics

Producer Cellar (961 obs.)

Attributes	Mean	Std.Dev.	Min	Max
age of wine bottle	2.92	1.62	0.00	10.00
trend	4.11	1.04	1.00	5.00
ha	429.53	669.06	0.00	2500.00
tons	6582.10	8551.21	60.00	29000.00
Age of firm	38.21	29.05	2.00	131.00
established (firm)	1893.25	123.20	1682.00	2004.00
price bottle 0.75	104.02 Euro: (9.9)	81.82 (7.79)	46.27 (4.41)	804.00 (76.57)

Private Cellar (1781 observ.)

Attributes	Mean	Std.Dev.	Min	Max
age of wine bottle	2.78	1.54	0.00	9.00
trend	3.81	1.16	1.00	5.00
ha	119.55	91.93	0.00	350.00
tons	1125.82	995.47	30.00	5800.00
Age of firm	23.20	16.41	1.00	119.00
established (firm)	1860.02	138.25	1682.00	2004.00
price bottle 0.75	98.56 Euro: (9.39)	62.09 (5.91)	46.12 (4.39)	850.00 (80.95)

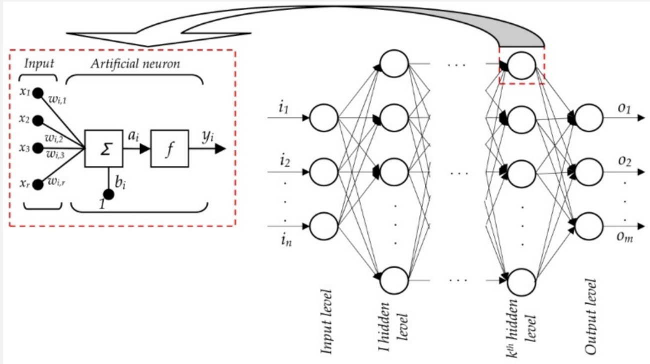
4. Data (Years 2001 – 2011)

Descriptive Statistics - Weather

Attributes	Mean	Std.Dev.	Min	Max
Temp_Winter	13.12	0.60	7.21	14.16
Temp_Growing	18.48	0.44	17.61	20.33
Temp_Harvest	21.91	0.94	19.67	25.07
TempMin_Winter	8.00	1.01	3.41	9.66
TempMin_Growing	12.50	0.48	10.53	14.00
TempMin_Harvest	15.12	1.01	13.18	18.07
TempMax_Winter	18.28	0.62	16.24	20.41
TempMax_Growing	24.46	0.69	22.71	27.09
TempMax_Harvest	28.67	1.03	26.13	32.14
Rain_Winter	345.75	125.60	0.00	568.50
Rain_Growing	308.33	102.80	76.00	1952.20
Rain_Harvest	32.98	28.85	2.10	435.50
Radiation_Winter	850.74	88.05	134.90	1096.98
Radiation_Growing	4204.61	554.71	141.60	5078.62
Radiation_Harvest	904.74	153.33	1.50	1133.40

5. Model and Results

- Model building based on ‘artificial neural networks‘ (ANN)
- Logarithmic price in Rand of a 0.75l bottle = dependent variable
- 27 independent variables
- 2 Models
  - 1 model for corporate cellars
  - 1 model for private cellars
  - 2 indicators for interpretation



5. Model and Results

We prefer ANN over OLS regression, because its highly non linear and succeeds in several ways.

Pros: robust to missing and data errors or collinearities, finds hidden relations, leads to more accurate models, more flexible, can cope with missing variables

Cons: use of ANN needs some experience, interpretation of model (black-box) can be more difficult without proper indicators.

Analyzes is based on two different indicators to interpret the ANN models:

1. **dependency matrix (DM) and scaled dependency factor (SDF)**
2. **average elasticity**

- **1. Dependency matrix (DM)** describes all dependencies between independent and dependent variables based on the **scaled dependency factor (SD)** as measure of influence between two variables

The Dependency-Factor $\overline{D}_{ik}$ is calculated from the partial derivates of the model:

$$\overline{D}_{ik} = \frac{\sum_{s=1}^{N} \left| \frac{\partial O_k^s}{\partial I_i^s} \right|}{N} \qquad \forall i, k \qquad (4)$$

The Scaled Dependecy-Factor $\overline{SD}_{ik}$ is the normalized dependency factor :

$$\overline{SD}_{ik} = \frac{\overline{D}_{ik}}{\max_j(\overline{D}_{jk})}$$

The Dependency-Matrix $\overline{\overline{DM}}$ is calculated as

$$\overline{\overline{DM}} = \begin{pmatrix} \frac{\overline{D}_{11}}{\max_j(\overline{D}_{j1})} & \cdots & \frac{\overline{D}_{1k}}{\max_j(\overline{D}_{jk})} \\ \cdots & \ddots & \cdots \\ \frac{\overline{D}_{i1}}{\max_j(\overline{D}_{j1})} & \cdots & \frac{\overline{D}_{ik}}{\max_j(\overline{D}_{jk})} \end{pmatrix} \qquad \forall j, k \quad \text{with } j \in \{1, .., N_I\} \; and \; k \in \{1, .., N_O\} \qquad (5)$$

whereas

O_k^s	: output value of training data set s of the k^{th} node in the output layer,
I_i^s	: input value of training data set s of the i^{th} node to the ANN,
N	: the total number of training data sets
s	: the training data set,
$\max_j(\overline{D}_{jk})$	: the maximum of all dependency factors of the k^{th} node in the output layer,
N_I	: the number of nodes in the input layer,
N_O	: the number of nodes in the output layer

2. average elasticity

- **for price**
- **and additionally for price for each region** (fixed effect)

Elasticity:

Point elasticity: $\varepsilon_{y,x} = \frac{\partial y}{\partial x}\frac{x}{y}$

Average (semi) elasticity: $\bar{\varepsilon}_y = \frac{1}{n}\sum_{i=0..n} \varepsilon_{y,xi}$

Interpretation equals the interpretation of a linear regression model:

1 unit change of independent variable causes a % change in dependent variable.

5. Model and Results

Comparing the model accuracy

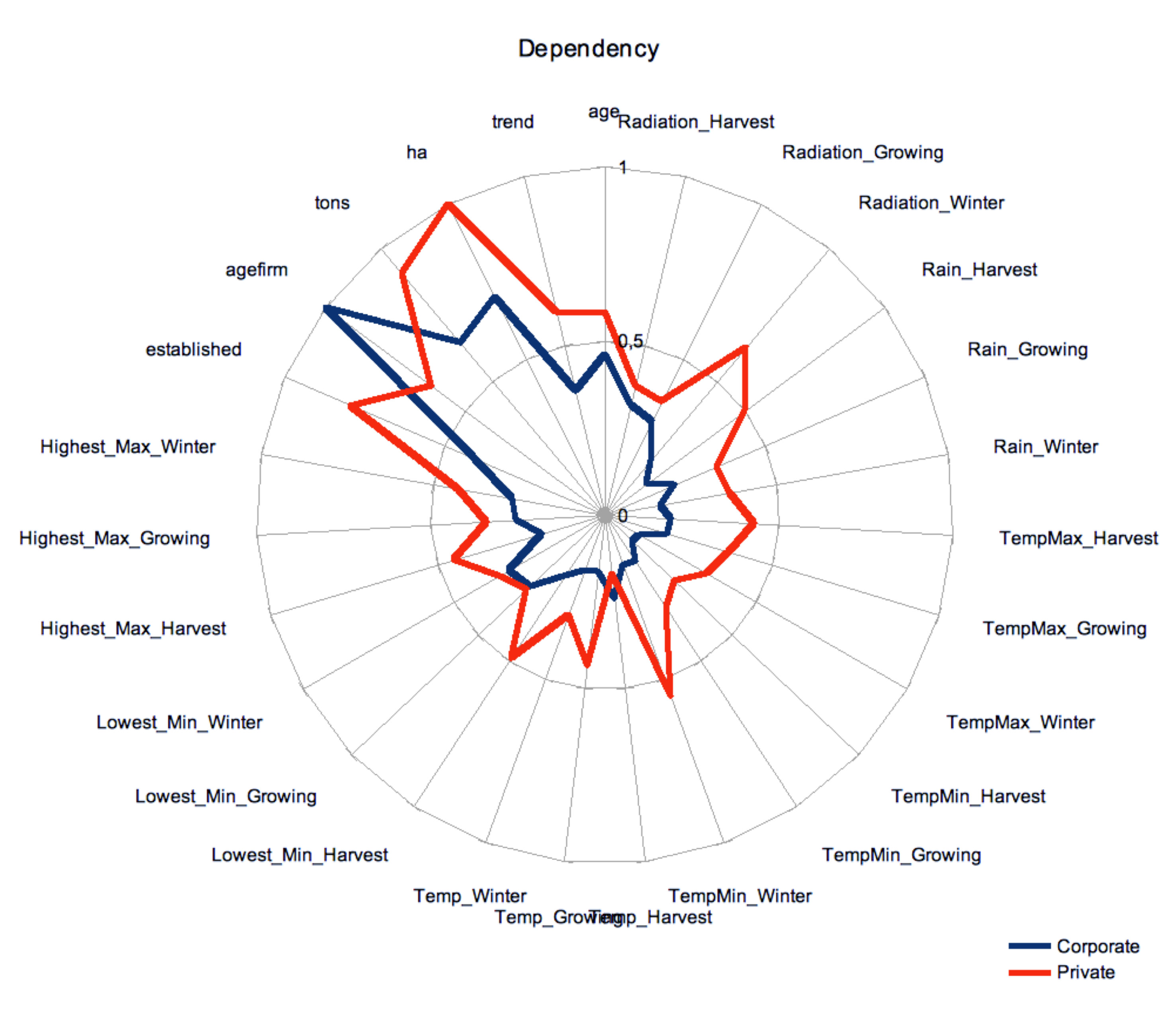
Coporate Cellars

Method	MSE	RMSE	MAE	R2
OLS	0.307	0.554	0.383	0.678
ANN	0.083	0.289	0.201	0.913

Private Wine Cellars

OLS	0.448	0.669	0.467	0.218
ANN	0.102	0.319	0.221	0.822

5. Model and Results



5. Model and Results

Dependecy Matrix

Independent Variable	Corporate	Private
Age of Wine	0,460	0,584
Trend	0,367	0,599
Ha	0,700*	1,000*
Tons	0,645*	0,905*
Agefirm	1,000*	0,622
Established	0,405	0,794*
Highest_Max_Winter	0,270	0,426
Highest_Max_Growing	0,254	0,341
Highest_Max_Harvest	0,190	0,451
Lowest_Min_Winter	0,319	0,348
Lowest_Min_Growing	0,297	0,311
Lowest_Min_Harvest	0,210	0,491
Temp_Winter	0,168	0,303
Temp_Growing	0,161	0,433
Temp_Harvest	0,242	0,170
TempMin_Winter	0,155	0,551
TempMin_Growing	0,159	0,319
TempMin_Harvest	0,110	0,276
TempMax_Winter	0,114	0,337
TempMax_Growing	0,188	0,372
TempMax_Harvest	0,190	0,430
Rain_Winter	0,163	0,362
Rain_Growing	0,219	0,348
Rain_Harvest	0,150	0,500
Radiation_Winter	0,204	0,628
Radiation_Growing	0,301	0,365
Radiation_Harvest	0,324	0,381

5. Model and Results

Producer Cellar Elasticity

independent Variable	avg.elast	OlifantsRiver	Paarl	Robertson	Stellenbosch
Age	-0,0029	-0,0059	-0,0027	-0,0029	-0,0025
Trend	-0,0052	-0,0127	-0,0032	-0,0035	-0,005
Ha*	**-0,3584**	2,9265	**-1,4614**	**-2,4792**	**-0,1227**
Tons*	**-3,8346**	**-61,9314**	3,3675	12,2091	0,9943
Agefirm*	**0,1033**	**0,4096**	**0,1029**	**0,0922**	**0,0495**
Established	-0,2703	-9,9736	2,4989	2,036	-0,255
Highest_Max_Winter	-0,0424	-0,2308	-0,0128	-0,0182	-0,0269
Highest_Max_Growing	0,0409	0,198	0,0156	0,0369	0,0265
Highest_Max_Harvest	0,0178	-0,0364	0,0165	0,0087	0,0294
Lowest_Min_Winter	0,0019	-0,0078	0,0016	-0,0012	0,0042
Lowest_Min_Growing	0,0020	-0,0057	0,0014	-0,0001	0,004
Lowest_Min_Harvest	0,0015	-0,0049	0,0016	0,0007	0,0027
Temp_Winter	-0,0078	-0,0619	-0,001	0,0028	-0,0028
Temp_Growing	0,0073	0,0588	-0,0003	0,0024	0,0026
Temp_Harvest	**0,0288**	**0,1435**	**0,01**	**0,0097**	**0,0202**
TempMin_Winter	-0,0067	-0,0362	-0,0022	0,0004	-0,0046
TempMin_Growing	-0,0081	-0,0273	-0,0063	-0,0022	-0,0063
TempMin_Harvest	0,0030	0,0295	-0,0004	0,0002	0,0004
TempMax_Winter	0,0119	0,0626	0,0057	0,0011	0,0073
TempMax_Growing	0,0324	0,1867	0,0141	0,0092	0,017
TempMax_Harvest	0,0259	0,1099	0,0106	0,0151	0,0201
Rain_Winter	-0,1485	-1,1372	-0,0259	-0,0233	-0,0494
Rain_Growing	0,2876	0,9496	0,129	0,0322	0,2816
Rain_Harvest	0,0032	0,0081	0,0085	0,0051	-0,0008
Radiation_Winter	**1,0273**	**5,6216**	**0,2224**	**0,3688**	**0,7011**
Radiation_Growing	**7,6988**	**41,0108**	**2,7328**	**1,9248**	**4,9845**
Radiation_Harvest	**1,4489**	**5,2973**	**0,757**	**0,5144**	**1,2288**

5. Model and Results

Private Cellar Elasticity

independent Variable	avg.elast	Malmesbury	Paarl	Robertson	Stellenbosch	Worcester
Age	-0,0032	0,0008	-0,0015	-0,0002	-0,0044	-0,0035
Trend	0,0035	0,0029	0,0053	-0,0002	0,0031	0,0049
Ha*	**0,1233**	**0,4189**	-0,104	-0,0995	**0,1811**	**0,8767**
Tons*	**-1,9924**	**-2,0869**	**-1,6161**	**-6,451**	**-1,5148**	**-3,2106**
Agefirm	0,0241	-0,003	-0,0024	0,0535	0,0324	0,019
Established*	**-2,6764**	**-0,93**	**-2,3054**	1,042	**-3,124**	**-5,6104**
Highest_Max_Winter	0,0408	0,0298	0,0277	0,0457	0,0452	0,0496
Highest_Max_Growing	0,0305	0,0155	0,0199	0,0259	0,0391	-0,0162
Highest_Max_Harvest	-0,0286	-0,0399	-0,0179	-0,0375	-0,0347	0,0169
Lowest_Min_Winter	0,0013	0,0014	-0,0001	-0,0005	0,0022	0,0004
Lowest_Min_Growing	0,0017	0,0004	0,0004	0,0001	0,0024	0,0012
Lowest_Min_Harvest	-0,0005	-0,0023	0,0035	-0,0007	-0,0033	0,0173
Temp_Winter	-0,002	0,0042	-0,0021	0,0033	-0,0022	-0,0102
Temp_Growing	0,0142	0,0126	0,0075	0,02	0,0192	-0,0276
Temp_Harvest	0,0056	-0,0019	0,0007	0,0051	0,0083	-0,0007
TempMin_Winter	-0,0127	-0,0052	-0,0102	-0,0059	-0,0151	-0,0073
TempMin_Growing	0,0106	0,0054	0,0037	0,0071	0,0139	0,0118
TempMin_Harvest	0,0021	-0,0051	0,0039	-0,0034	0,0031	-0,0087
TempMax_Winter	-0,0167	-0,0034	-0,0107	-0,0044	-0,0208	-0,0194
TempMax_Growing	-0,0163	-0,0013	-0,0102	0,0024	-0,0167	-0,0838
TempMax_Harvest	-0,0237	-0,0138	-0,0266	-0,008	-0,0263	-0,0015
Rain_Winter	-0,0347	0,0819	-0,0353	0,045	-0,0321	-0,2534
Rain_Growing	-0,2679	-0,2159	-0,165	0,0121	-0,3461	-0,2561
Rain_Harvest	-0,0243	0,0246	-0,0202	0,0006	-0,0322	0,0012
Radiation_Winter	**-1,4671**	**-0,9822**	**-1,3116**	**-1,5004**	**-1,5555**	**-1,2529**
Radiation_Growing	**4,3661**	**4,658**	**1,9434**	**4,4633**	**5,6377**	**0,0119**
Radiation_Harvest	**0,6037**	**-0,2592**	**0,0263**	**0,012**	**0,9597**	**0,2642**

6. Conclusions

1. The dependency matrix suggests that producer cellars depend less on (un)favorable weather conditions than private wine cellars.

2. Prices of private wine cellars react at least 2 times more sensitive on (un)favorable weather conditions.

3. Prices of private wine cellars depend in addition on

- *reputational parameters* like „established" – the older a wine cellar, the higher the prices,
- the „*amount of production* (tons)" - this is an important model variable, but has a negative impact on prices of private wine cellars, the
- „*production area* (ha)" – on average a positive impact, but the price impact differs between regions.

4. Prices of producer cellars depend

- *positively on the reputational parameter* „age of firm“ – the older a producer cellar, the higher the prices,
- on the „*amount of production* (tons)“ in a very ambigous way. It has a positive impact for nearly all wine regions but Olifants River, where the amount of production has a very strong negative impact
- on „*production area* (ha)“ – on average a negative impact, but the price impact differs between regions.

Suggestion:
Further investigation will be done on underlying data to interpret model results.

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Thank you for your attention!!!