How are vineyards management strategies and climate-related conditions affecting economic performance? A case study of Chilean wine grape growers.

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Background

- Growers decide between alternative management strategies that have direct consequences on competitiveness and so in the ability to remain in the industry
- Wine grape growing has shown important improvements in the last decades, with strong changes in technology adoption and cultivation approaches
- New world producers use modern management strategies and are offering high quality and quantity, making the business more aggressive than before
- Modern management strategies may reshape the relationship between production factors and economic outcomes, however, little is known about their effects.

… A better understanding of the factors affecting vineyards' economic performance, including production factors along with management strategies is needed to foster competitiveness

The aim of this study is:

a) to evaluate the impact on the economic performance of four management strategies

b) to identify (monetized) production functions of wine growers

a)	Training system	(tendone vs. vertical structures)
b)	Wine grape destiny	(reserve vs. varietal wines)
c)	Irrigation method	(pressurized vs. gravity irrigation)
d)	Mechanized harvest	(mechanized vs. hand-picked).

Different scope and nature: structural/fixed decisions flexible/alternative decisions.

a)	Land	(ha)
b)	Fertilizers	(expenditure)
c)	Fungicides	(expenditure)
d)	Herb.-insect.-acar.	(expenditure)
e)	Labor	(expenditure)
f)	Age	(years)

This study uses the case of Chile, a country that has experienced rapid development of its export-oriented wine industry in recent decades.

Between 1990 and 2015:

- *vineyard plantations doubled*
- *wine production increased fivefold*
- *wine export volume grew from 22 to 1,445 million liters.*

Study area and study unit

- The study area is located in the Central South part of Chile including the O´Higgins, and Maule regions (33° 50' and 36° 33' S)
  - 73% of the total planted area of vineyards
  - Mediterranean climate, with a rainy winter (600 and 700 mm annually)

- 336 farmers from irrigated lands belonging to three wine valleys were surveyed
  - Stratified random sample across 16 municipalities, based on the relative number of vineyards
  - The questionnaire collected detailed economic and agronomic information for the main variety grown in the vineyard (e.g., planted area, yield, grape price, inputs, labor, input/labor prices)
  - The dataset was complemented with climatic variables from Geographic Inf. Syst. (GIS) using the vineyards' georreference: specific data on precipitation, chilling hours, and evapotranspiration

Vineyards location and descriptive stats

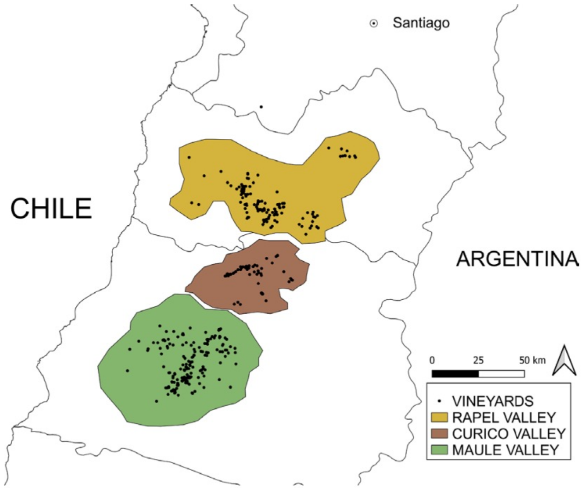

Figure 1. Map of the study area and locations of the vineyards included in the sample (black dots).

Table 1. Variable description and summary statistics of variables used in models of vineyard production for three wine grape growing areas of Chile (data at the plot level for the main grape variety of the vineyard; N= 336).

	Variable	Description	Mean	S.D.	Median	Min	Max
DV	TVP	Total value product (1,000 USD)	65.60	104.47	29.36	0.60	1213.76
Production factors	Land	Planted area (hectares)	16.74	20.28	9.90	1.00	140.00
	Fertilizers	Fertilizer expenditure (1,000 USD)	4.34	7.36	1.70	0.00	52.95
	Fungicides	Fungicide expenditure (1,000 USD)	2.89	5.63	0.99	0.00	51.38
	Agrochem.	Expenditure in agrochemicals to control insects, spiders and weeds (1,000 USD)	5.99	17.29	1.52	0.00	201.38
	Labor	Labor expenditure (1,000 USD)	16.49	21.05	8.13	0.28	137.61
Vineyards' attributes	Grape Color	Grape color (red=1; white=0)	0.82	0.38	1	0	1
	Vineyard age	Age of planting (years)	29.84	26.28	19	4	116
	Rapel valley	Rapel valley (yes=1; no= 0).	0.35	0.48	0	0	1
	Curicó valley	Curicó valley (yes=1; no= 0, excluded category in models)	0.20	0.40	0	0	1
	Maule valley	Maule valley (yes=1; no= 0).	0.45	0.50	0	0	1
Management strategies	Irrig. method	Irrigation method (pressurized= 1; gravity= 0)	0.39	0.49	0	0	1
	Mech. harv.	Machinery use for harvest (yes= 1; no= 0)	0.17	0.38	0	0	1
	Training syst.	Training system (tendone=1; vertical=0)	0.18	0.39	0	0	1
	Grape Dest	Grape destination (reserve=1; varietal=0)	0.11	0.32	0	0	1
Climatic conditions	Evapotransp.	Cumulative evapotranspiration from Dec-15 to Feb-16 (mm)	456	21	461	408	512
	Precipitation	Cumulative precipitation from Dec-15 to Feb-16 (mm)	22.81	7.23	24	8	45
	Chilling hours	Cumulative chilling hours in 2016 (hours)	1,287	303	1,380	750	1,830

Vineyards location and descriptive stats

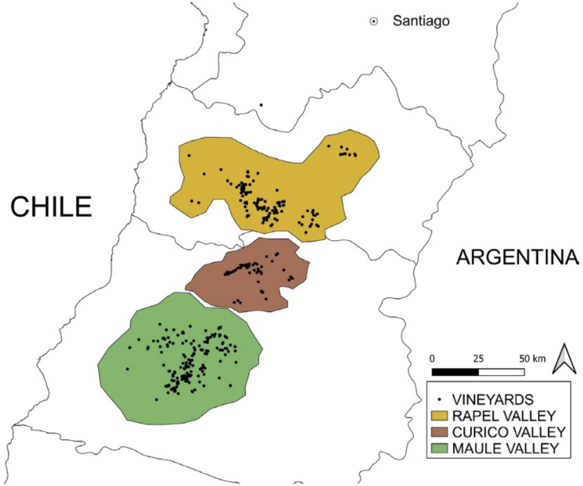

Figure 1. Map of the study area and locations of the vineyards included in the sample (black dots).

Table A.3. Mean comparison of grape price, yield and climate-related variables across valleys.

Variable	Rapel		Curicó		Maule	
Grape Price (USD kg^{-1})	0.30	a	0.25	b	0.22	b
Vineyard yield (ton ha^{-1})	17.42	a	15.22	a	12.63	b
Precipitation (mm)	15.24	a	27.16	b	26.65	b
Evapotranspiration (mm)	464.28	a	453.27	b	450.06	b
Chilling hours (hours)	1009.13	a	1542.43	b	1395.87	c

* Different letters within the same row means statistically significant differences ($p< 0.05$).

Method

For the main variety grown in the vineyard, a log-log regression model of total value product (TVP) was estimated

The explanatory variables were:

- **Production factors (land, inputs, labor)**
- **Vineyards' attributes (grape color, vineyard age, wine valley)**
- **Management strategies (irrigation method, mechanized harvest, training system, grape destination)**
- **Climate-related conditions (evapotranspiration, precipitation, chilling hours)**

From this model –which controls simultaneously for important and diverse determinants of yields–, we predicted the TVP functions for land, fertilizers, fungicides, agrochem., labor, and the age of vines.

Results for land and fertilizers

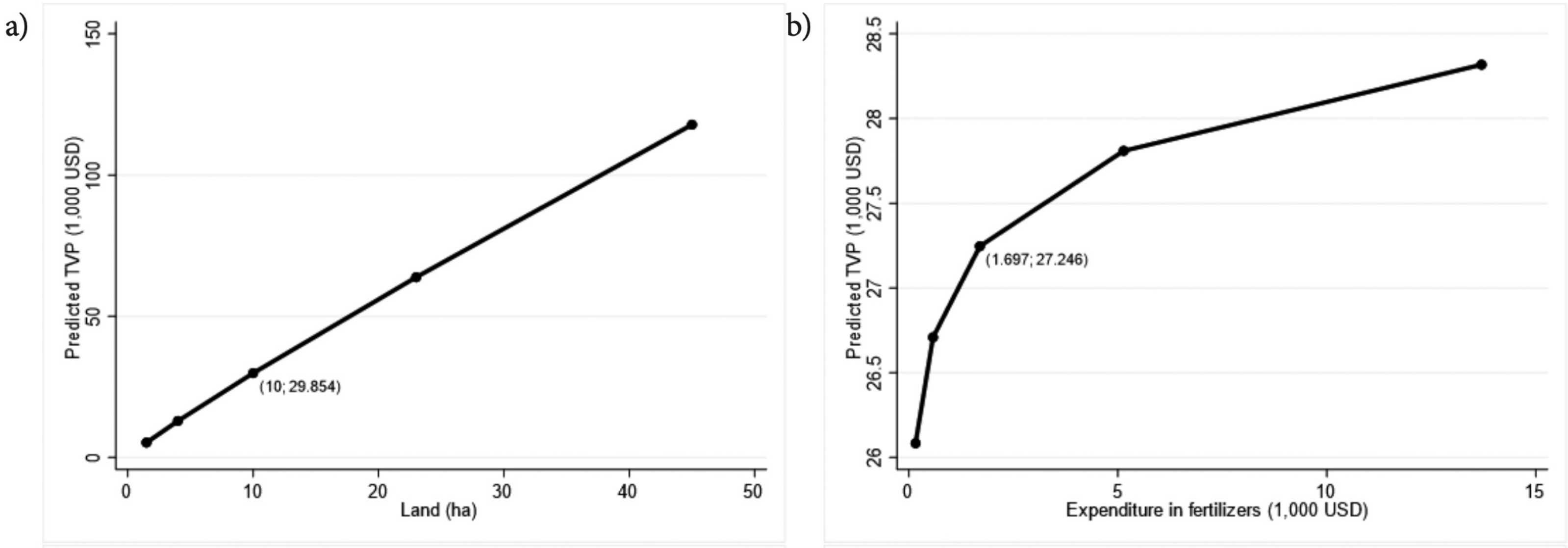

Figure 1. Total value product functions from a sample of 336 Chilean wine grape growers for: a) Land, and b) Expenditure in fertilizers. In each graph there are plotted five data points that, from left to right, correspond to the 10th, 25th, 50th, 75th, and 90th percentiles. Coordinates (X, Y) are median values in the X axe and the associated values in Y.

Results for fungicides and other agrochem.

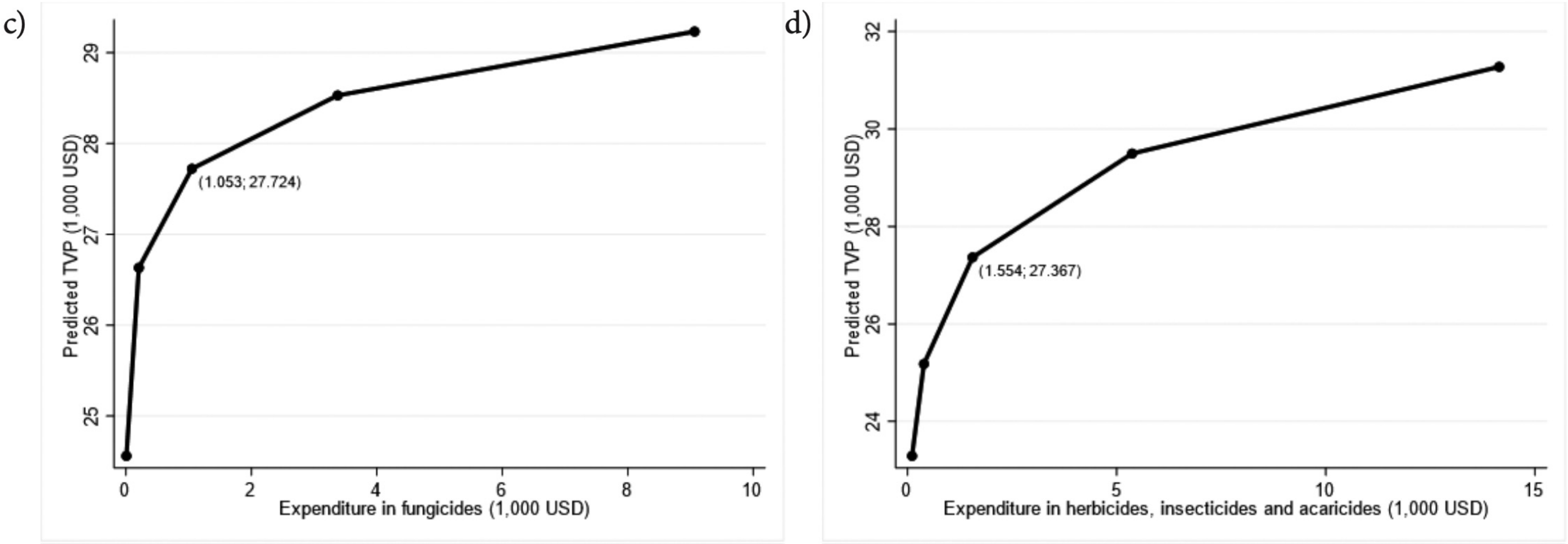

Figure 2. Total value product functions from a sample of 336 Chilean wine grape growers for: c) Expenditure in fungicides, and d) Expenditure in herbicides-insecticides-acaricides. In each graph there are plotted five data points that, from left to right, correspond to the 10th, 25th, 50th, 75th, and 90th percentiles. Coordinates (X, Y) are median values in the X axe and the associated values in Y.

Results for labor and age of vines

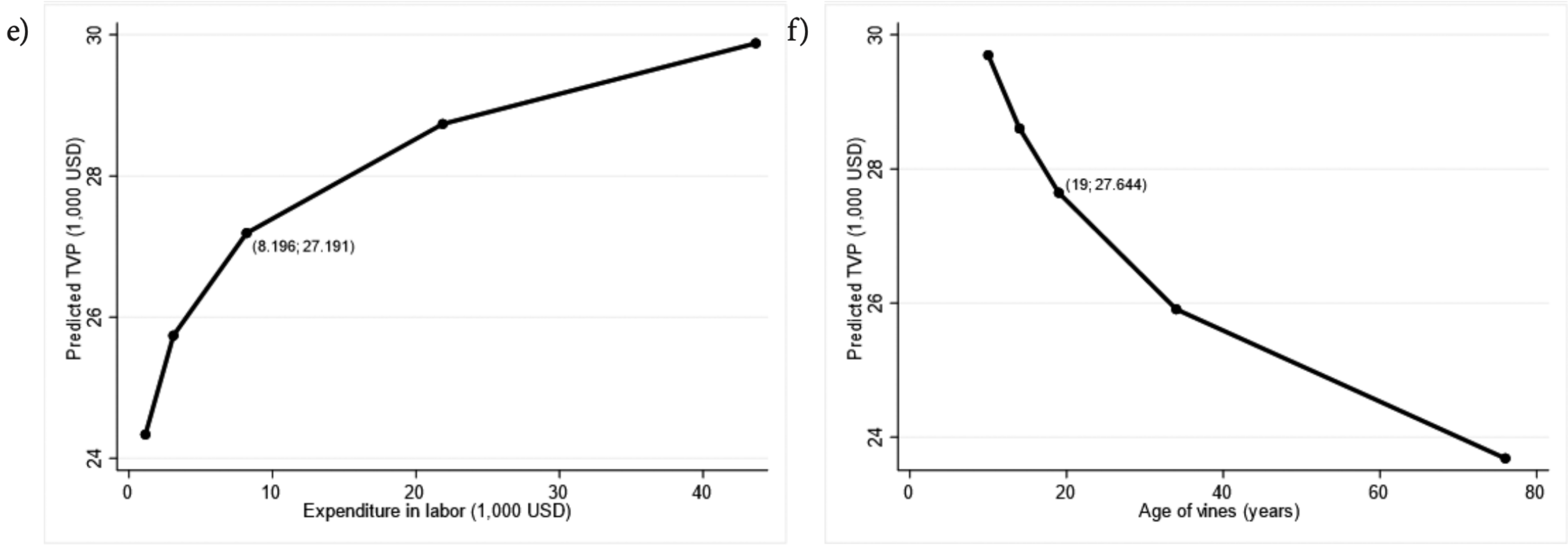

Figure 3. Total value product functions from a sample of 336 Chilean wine grape growers for: e) Expenditure in labor, and f) Age of vines. In each graph there are plotted five data points that, from left to right, correspond to the 10th, 25th, 50th, 75th, and 90th percentiles. Coordinates (X, Y) are median values in the X axe and the associated values in Y.

Results of the Econometric analysis

It shows a statistically significant contribution of cultivation techniques but no of technologies

Table 2. Cobb-Douglas estimates for total value product of Chilean wine grape growers under four alternative models (N=336).

Variable	Model A: Production factors		Model B: A + Vineyards' attributes		Model C: B + Management strategies		Model D: C + Climatic conditions	
	Coeff.[a]		Coeff.[a]		Coeff.[a]		Coeff.[a]	
Ln Land	0.603	***	0.806	***	0.913	***	0.917	***
Ln Fertilizers	0.033		0.018		0.018		0.020	
Ln Fungicides	0.049	***	0.028	**	0.025	**	0.022	**
Ln Agrochem	0.110	***	0.066	**	0.060	**	0.054	**
Ln Labor	0.274	***	0.156	***	0.056		0.050	
Grape Color			-0.381	***	-0.384	***	-0.371	***
Vineyard age			-0.163	***	-0.112	***	-0.109	***
Rapel valley			0.262	***	0.246	***	0.137	
Maule valley			-0.189	**	-0.168	**	-0.161	**
Irrig method					0.088		0.117	*
Mech harvest					-0.018		-0.019	
Training system					0.492	***	0.513	***
Grape Dest					0.227	**	0.222	**
Ln Evapotransp							0.066	
Ln Precipitation							-0.275	**
Ln Chilling hours							0.123	
Constant	1.394	***	2.011	***	1.674	***	1.246	
Obs (N)	336		336		336		336	
Adjusted R^2	0.831		0.864		0.880		0.876	
BIC	635.687		587.499		567.751		580.637	

[a] Significance: ***=1%; **=5%; *=10%.

Concluding remarks (1/2)

- An interesting contribution of this study is the identification of TVP functions for:
  - Land
  - Fertilizers
  - Fungicides
  - Other agrochemicals
  - Labor
  - Age of vines

We controlled simultaneously for different production factors and conditions

- Production Factors
- Vineyard characteristics.
- Grower characteristics.
- Technologies
- Techniques
- Weather

Thus, we disentangle the role of a diversity of factors affecting viticultural production and estimate their impact on growers' TVP

Concluding remarks (2/2)

- Higher economic performance is expressed by vineyards using:
  - Tendone training systems,
  - Growing white varieties,
  - Producing reserve quality grapes,
  - Having younger aged vines.
- The results are based on a diverse, comprehensive, and relatively large dataset (compared to experiments).
- These results have direct implications for both wine-grape growers and sectorial policymakers aiming to improve the competitiveness of viticultural production, representing valuable information to develop a strategy for the primary sector.

Thanks!

Any question?

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Extra

Table A.2. Vineyards' characterization by training system and grape destination.

	Training system				Grape destination			
	Vertical		Tendone		Varietal		Reserve	
Variable	N	Mean	N	Mean	N	Mean	N	Mean
Grape price (USD kg-1)	275	0.260	61	0.229	298	0.235	38	0.409
Yield (ton ha-1)	275	12.609	61	26.000	298	15.554	38	11.011
Planted area (ha)	275	17.297	61	14.249	298	16.644	38	17.527
Fertilizer expenditure (1,000 USD)	275	4.228	61	4.818	298	4.468	38	3.291
Fungicide expenditure (1,000 USD)	275	3.111	61	1.904	298	2.807	38	3.560
Expenditure in agrochemicals to control insects, spiders and weeds (1,000 USD)	275	6.453	61	3.883	298	5.674	38	8.435
Labor expenditure (1,000 USD)	275	15.680	61	20.116	298	16.226	38	18.521
Expenditure in pruning/mooring (1,000 USD)	270	4.616	61	7.181	295	5.174	36	4.392
Expenditure in harvesting (1,000 USD)	265	5.789	60	10.373	287	6.567	38	7.154
Expenditure in desprouting (1,000 USD)	232	1.722	47	1.355	247	1.645	32	1.777
Expenditure in thinning of shoots (1,000 USD)	217	0.895	26	0.489	214	0.858	29	0.808
Expenditure in physical weed control (1,000 USD)	200	0.985	52	0.953	229	0.971	23	1.048
Expenditure in other labors (1,000 USD)	167	4.436	27	1.508	167	3.665	27	6.276
Grape color (red=1; white=0)	275	0.829	61	0.803	298	0.829	38	0.789
Age of planting (years)	275	32.335	61	18.574	298	29.658	38	31.237
Irrigation method (pressurized= 1; gravity= 0)	275	0.378	61	0.459	298	0.396	38	0.368
Machinery use for harvest (yes= 1; no= 0)	275	0.200	61	0.033	298	0.178	38	0.105
Training system (tendone=1; vertical=0)	275	-	61	-	298	0.201	38	0.026
Grape destination (reserve=1; varietal=0)	275	0.135	61	0.016	298	-	38	-