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What Is the Future of the Wine-Grape Industry in Veneto? Evidence from a Micro-Macro Prediction Model

Laura Onofri [a], Federica Bianchin [b], Vasco Boatto [c], Maikol Furlani [d], Francesco Pecci [e] and Federico Perali [f]

Abstract

This article presents a micro-macro integrated model/framework for the disaggregated quantitative assessment of the impacts of various shocks generated in five socio-economic and climate-driven simulations on the wine-grape sector in Veneto, Italy. (JEL Classifications: C01, C67, Q12, Q54)

Keywords: ASAM, input-output, marginal product of land, socio-economic/climate scenarios.

I. Introduction

Veneto is an Italian region, located in the northeast of the country, known for wines such as *Prosecco, Amarone, Recioto, Soave,* and *Valpollicella*. Currently, more than 30% (about €2b) of Veneto agri-food exports relate to wine and other beverages. The sparkling wine industry (i.e., mainly *Prosecco*) has exhibited enormous growth rates

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[a] Department of Land, Environment, Agriculture and Forestry, University of Padua, Via dell'Università 16 - 35020 Legnaro (PD); e-mail: laura.onofri@unipd.it.
[b] Department of Land, Environment, Agriculture and Forestry, University of Padua, Via dell'Università 16 - 35020 Legnaro (PD); e-mail: fed.bianchin@gmail.com.
[c] Department of Land, Environment, Agriculture and Forestry, University of Padua, Via dell'Università 16 - 35020 Legnaro (PD); e-mail: vasco.boatto@unipd.it.
[d] Economics Living Lab, Spin Off University of Verona, Via Cantarane 24 - 37129 Verona (VR); e-mail: maikol.furlani@econlivlab.eu.
[e] Economics Living Lab, Spin Off University of Verona, Via Cantarane 24 - 37129 Verona (VR); e-mail: francesco.pecci@econlivlab.eu.
[f] Department of Economics, University of Verona, Via Cantarane 24 - 37129 Verona (VR); e-mail: federico.perali@univr.it.

(31.4% in 2015) and represents almost one-third of the overall Veneto wine export value.

In the future, the viticultural sector in Veneto, and in many other Italian regions, will face new challenges and uncertainties caused by factors such as climatic changes, water scarcity, land degradation, globalization, and changing markets due to changing demographics, trade policies, and economic growth.

"What is the future for the wine grape industry in Veneto?"

In this article, we attempt to address this question by creating a short-term micro-macro prediction methodology that applies to the Veneto region. We first analyze the production structure by estimating the marginal productivity of various viticultural inputs. We then simulate changes in land use, according to different socio-economic and climate scenarios, downscaled for Veneto in 2030. We use the simulations in order to compute the (micro-based) monetary value of the shock and use those figures to simulate the impacts on the Veneto economy.

The article is organized as follows. Section II introduces the data and methods. Section III presents selected results and Section IV concludes.

II. Methodological Framework

In our setting, farms make profit maximizing production choices in a standard neo-classical fashion accounting for the stochastic impact of climate change on production plans, as in Equation (1)

$$Max\, \pi = \{f\,(Q, p, C) | Q = g(i_1, .., i_n) + v + u\}. \tag{1}$$

The terms v and u represent distinct error components. The random vector v is iid and captures unobserved heterogeneity related to both different degrees of exposures to climate shocks and farm specific capacities to adapt to climate changes. The farm maximizes profits π depending on produced quantity Q, output price p, and production costs C given the stochastic technological constraint combining n production inputs. Climate change affects decisions also by influencing output and input prices, that, in our cross-sectional set-up, are maintained unaffected. Different "states of the world" associated with a climatic shock thus act through the stochastic component of the technology and place constraints on both the input and output possibility frontier due to climate-induced changes in agronomic conditions. Uncertainty stemming from climate change affects both the relative factor productivity and, for fixed but allocable factors such as land or family labor, the mix of best uses. The outcome of the microsimulations of the forecasted climate change scenarios for each production sector is aggregated at the macro level. The macro simulations use the Veneto Social Accounting Matrix (SAM) spatially differentiated into mountains, hills, and planes to account for the significantly different climate impacts in each geographic area. The macro analysis estimates the impact of each scenario on each productive sector and the regional economy.

A. Inputs' Marginal Productivity

We model agricultural production functions to measure the marginal productivity of each factor used in the production of wine grapes and its marginal impact on wine grapes production. We use translog specifications, as in Equation (2). The Veneto agricultural total output q (in logs) depends on a log-log combination of n production inputs, the m interactions of n production inputs, and an error term.

$$\ln q = \beta_0 + \sum_{n=1}^{N} \beta_n \ln x_n + \frac{1}{2} \sum_{n=1}^{N} \sum_{m=1}^{N} \beta_{nm} \ln x_n \ln x_m + u \quad (2)$$

The first step provides a picture of the technological efficiency and productivity of each input used for producing wine grapes in Veneto. It also assesses potential wine grape production changes when production inputs (e.g., land) change[1] and it allows attaching a monetary value to those variations.

B. Prediction Methodology and Microeconomic Shocks Computations

Assuming that the estimated marginal productivity of inputs does not change in the near future, we are mainly interested in knowing by how much the total use of land will vary due to climate-induced changes. We obtain the information about the likely climate scenarios for the Veneto region from the UNIVE-CREA Report (2017). This study follows the assumptions and methodology adopted by the International Panel on Climate Change Report (IPCC, 2000). The UNIVE-CREA Report shows how the IPCC future socio-economic-climate scenarios have been scaled down to the Veneto region. It consists of a narrative description (storyline) and a series of quantitative estimates that show the evolution of some of the fundamental elements of society such as gross domestic product (GDP) and demographic growth over the course of the 21st century. The report assumes that:

1. The changes in the use of the land input depend on the occurrence of different socio-economic-climate scenarios that assume a distinctly different direction for future developments.
2. The occurrence of each scenario depends on a wide range of key "future" characteristics such as demographic change, economic development, and human

[1] Because the econometric model is assumed to hold for all observations, it also holds that: $y_0 = x_0'\beta + \varepsilon_0$, where ε_0 satisfies the same properties as all other error terms. The obvious predictor for y_0 is $\bar{y}_0 = x_0'b$. As $E\{b\} = \beta$ it can be verified that this is an unbiased predictor. The different assumed values for x_0' are then multiplied by the pooled oridinary least squares (OLS) estimated coefficients for land marginal productivities (Verbeek, 2004).

capital change, among others. Such characteristics affect emissions that in turn affect temperature and climate change.

The UNIVE-CREA Report prospects five main scenarios for Veneto in 2030. The report assumes that Veneto will adapt to the international trends, emission levels, and temperature changes as estimated by the IPCC report. The scenarios are summarized in Table 1.

C. Impacts on the Veneto Economy

The shock computed at the micro level is then aggregated at the macro level to generate the exogenous shocks for the SAM analysis (Adelman and Robinson, 1989). Such exercise allows computing the impacts of climate-driven changes on wine grape production on the Veneto economy. Input-output (I-O)/SAM methodology shows how (and how much) the changes (shocks) computed under point (2) propagate in the Veneto Region economy.

In particular, the SAM is constructed starting from the Veneto Supply Use Table, disaggregated for agricultural and agri-food sectors using the technology coefficients of the Italian Symmetric Input Output table realized by Istituto di Servizi per il Mercato Agricolo Alimentare (ISMEA). The SAM is balanced using the RAS method. The environmental satellite account is derived at the regional level using the coefficients from the World Input Output Database (WIOD), by downscaling national aggregated matrices. We have linked the traditional SAM to satellite accounts, obtaining an augmented social accounting matrix (ASAM) for the Veneto Region. We have enlarged the matrix by adding insights on data and information on employment, environmental, and other socio-economic data.

In developing a SAM multiplier model, we distinguished between endogenous and exogenous accounts. The former reflects the purpose of the analysis while the latter include those accounts that can be used as policy instruments (for instance, regional administration), those generating long-term effects (e.g., capital account), and those that cannot be influenced by policy interventions. Exogenous shocks have been modeled on the basis of the scenarios described in Table 2.

III. Selected Results

A. Microeconomic Estimates of Inputs' Marginal Products

We use a rich dataset (RICA, *Rete di Informazione Contabile Agricola*) that contains 9,220 farm budgets observed in the period 2009–2012. The dataset also contains information on the farms' produced output and on the use of production inputs. Table 3 reports some descriptive statistics for selected variables.

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Table 1
Synthesis of UNIVE-CREA Scenarios

Selected Sectors	*A Sustainable World (1)*	*Business as Usual BAU Scenario Baseline (2)*	*A Fragmented World (3)*	*An Unequal World (4)*	*A Wealthier World (5)*
Population	+0/10%	–	+10/20%	–0/10%	–0/10%
Economic growth	+0/10%	–	–0/10%	+0/20%	+10/30%
Agricultural land use change	20/30%		0/–20%	0/10%	0/5%
Human development	++	–	–	+/–	+
Environment concern	++	–	–	+/–	–
Rural/agricultural development	++	–	–	+/–	+/–
Natural resources protection	++	–	–	–	–

Note: – Decrease, + – Increase or Decrease, + Increase, ++ Significant Increase.

Source: UNIVE-CREA Report (2017).

Table 2
The SAM Framework

	Endogenous Accounts				*Total*	*Exogenous Accounts*	*Total*
	(1)	*(2)*	*(3)*	*(4)*		*(5)*	
(1) Sectors	T_{ij}		T_{ih}		N_1	X_1	Y_1
(2) Factors	T_{fj}				N_2	X_2	Y_2
(3) Households		T_{fh}	T_{hh}		N_3	X_3	Y_3
(4) Firms					N_4	X_4	Y_4
(5) Exogenous	E					V	Y_X
TOTAL	Y_1	Y_2	Y_3	Y_4		Y_X	

Table 4 presents selected estimates of the translog production functions and the inputs' marginal productivity.

Land is the most productive input. Each input has a significant positive impact on production. Marginal returns are diminishing for labor and increasing for land. The direct impact of irrigation is only marginally significant. Quadratic and interaction terms are not significantly different from zero with the exception of the negative relation between grape production and the combination of land size and irrigation. This is interesting because it shows that irrigation, traditionally not adopted in small vineyards, is not used to increase production at the expenses of quality. Rather it is adopted as a means to cope with the greater uncertainty associated with climate

Table 3
Descriptive Statistics

Variable	*Mean*	*Standard Deviation*	*Minimum*	*Maximum*
Wine grape quantity	1,046.106	2,527.952	0	28,444
Machinery	675.6204	3,782.912	0	104,000
Labor	1,971.898	5,490.362	0	136,000
Land	7.4	18.53	0.04	229.93
Water	196.30	133.9	0	400
Electricity	338.833	3,076.795	0	64,900
Seeds	113.5998	1,213.871	0	25,280
Fertilizers	1,517.427	4,334.785	0	45,330

Note: Grape produced quantity is measured in quintals; machinery in hours of use; labor in hours of work; land in hectares; water in cubic meters; electricity in kilowatts; composts and seeds in quintals.

Table 4
Pooled OLS Estimates of Marginal Input Productivities

Explanatory Variables	*Translog Production Function*
(Log)labor	0.57***
(Log)water	0.17*
(Log)land	1.43***
(Log)labor^2	0.08
(Log)water^2	0.04
(Log)land^2	0.01
(Log)labor*land	−0.01
(Log)labor*water	0.01
(Log)land*water	−0.07*
Constant	6.89***
R-squared	0.78

change mainly used in prolonged dry periods during critical stages of the production cycle.

We then compute the value of the marginal productivity of the inputs and scale the value to fit the UNIVE-CREA scenarios. We have computed the value by multiplying the total produced quantity under each scenario times the 2030 price of wine grapes per quintal. Following a study conducted by the Dipartimento Territorio e Sistemi Agroforestali (TESAF) observatory on wine grapes prices (TESAF, 2014) monitoring the wine grapes prices' trends, we did not observe significant changes in real prices that remained stable during the last 30 years. Therefore, we have assumed that wine grapes prices do not change in the near future.

B. Macroeconomic Simulations

Table 5 displays the macro baseline scenario, the business as usual (BAU) starting point, where no climate-driven changes in production input occur (Business as

Table 5
Baseline Scenario

	BASELINE SCENARIO - VENETO SAM	*Total Resources/ Use*	*% on Total Activities*
Activities	Agriculture, mountain	194	0.06
	Agriculture, hill	1,036	0.34
	Agriculture, plain	3,588	1.18
	Fishing	210	0.07
	Mining and quarrying	315	0.10
	Food products, beverages, and tobacco	13,431	4.43
	Textile, clothing, leather, and accessories	15,439	5.10
	Timber industry	2,580	0.85
	Paper printing and recording	5,592	1.85
	Manufacture of coke and refined petroleum products	1,603	0.53
	Manufacture of chemicals and chemical products	6,075	2.00
	Production of pharmaceuticals, medicinal chemical and botanical	1,283	0.42
	Manufacture of rubber and plastics	5,059	1.67
	Other products in the processing of non-metallic mineral	5,395	1.78
	Manufacture of basic metals and processing of metal products	22,068	7.28
	Manufacture of computer, electronic, and optical	2,432	0.80
	Manufacture of electrical equipment	7,826	2.58
	Manufacture of machinery and equipment n.e.c.	16,595	5.48
	Manufacture of transport equipment	3,819	1.26
	Other manufacturing, repair, and installation of machines	13,524	4.46
	Supply of electricity, gas, steam, and air conditioning	4,989	1.65
	Water supply; sewerage, waste treatment	3,407	1.12
	Construction	21,428	7.07
	Wholesale and retail trade, repair of motor vehicles and motorcycles	31,136	10.28
	Transportation and storage	15,894	5.25
	Accommodation and food services	12,309	4.06
	Publishing, audiovisual, and broadcasting activities	1,469	0.48
	Telecommunications	2,972	0.98
	IT services and other information services	3,968	1.31
	Financial and insurance activities	10,610	3.50
	Real estate activities	19,178	6.33
	Legal, accounting, management consulting, architecture	8,501	2.81
	Scientific research and development	3,879	1.28
	Other service activities	5,642	1.86
	Public administration and defense; compulsory social security	8,084	2.67
	Education	5,437	1.79
	Health and social work	10,198	3.37
	Arts, entertainment, and recreation	1,798	0.59
	Other service activities	4,041	1.33
Value added	Wages and salaries	44,453	
	Social contributions load employers	16,928	
	Mixed income, net operating income, depreciation, and amortization	68,876	
	Net indirect taxes on production	14,066	

Continued

Table 5
Continued

	BASELINE SCENARIO - VENETO SAM	*Total Resources/ Use*	*% on Total Activities*
Institutions	Households	182,762	
	Local and national PA	25,289	
	Private social institutions	703	
Capital	Capital	68,352	
Rest of the world	Interregional	58,048	
	Rest of Italy and rest of the world	50,605	

Table 6
Selected Micro-Macro Results: Wine Grape Sector

Scenario UNIVE-CREA	*Agricultural Cultivated Land Use Change in %*	*Effect of Land Variation on Wine Grape Production*	*Value of Variation on Sector (in mill €)*	*Impact on the Veneto Economy (in million €)*	*% Impact on the Veneto Economy*
Scenario 1 Sustainable world	20/30%	42.9%	+352	+1767	+0.37
Scenario 2 Business as usual BAU (baseline)	—	—	—	—	—
Scenario 3 Fragmented world	0/–20%	–28.6%	–234	–1175	–0.25
Scenario 4 Unequal world	0/10%	14.3%	+117	+587	+0.12
Scenario 5 Wealthier world	0/5%	7.15%	+58.5	+294	+0.06

Usual BAU). The table reports the value added of the sector and the percentage impact on the Veneto economy.

Table 6 presents selected results of the application of the micro-macro model and reports the impact of the micro-estimates/scenario-based variations of wine grapes production on the regional economy in 2030.

Results vary according to the selected scenario. It is worth highlighting that the percentage impact on the regional economy is relatively small, spanning from a minimum of 0.06% increase compared to the baseline (under Scenario 5) to a maximum of 0.37% (in Scenario 1), where the impact and the gain is around six times larger than in Scenario 5. The percentage impact on the regional wine sector is more relevant. It spans from a minimum of around 3% increase compared to the baseline (under Scenario 5) to a maximum of around 20% increase with respect to the baseline (in Scenario 1). Interestingly, investing in a more sustainable world

(Scenario 1) is the most beneficial scenario for Veneto agriculture and the grape sector, in particular. The large increase in land use devoted to viticulture, compared to the other scenarios, is mainly due to the increasing shift of viticulture from the plains to the hills as a result of climate change.

IV. Conclusions

In this article, we have applied a micro-macro integrated model for the quantitative assessment of the impacts and shocks generated by socio-economic and climate driven changes. Selected results show that investing in a more sustainable agriculture may generate the highest benefits to viticulture and the wine industry at large.

The model/framework can be extended for future research. For instance, one can replicate the same exercise by looking at how variations in other important inputs (for instance water) affect the wine grape production under different scenarios, and how this, in turn, affects the Veneto economy.

A final caveat highlights that our projections are conditional scenarios based on specific (or implicit) assumptions about the macroeconomic milieu, agricultural and trade policies, weather, and international developments, among others. The projections are not intended to be a forecast of what the future will be, but are instead a description of what could be expected to happen under very specific assumptions and circumstances.

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