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A spatial micro-econometric approach to estimating climate change impacts on wine firm performance: A case study from Moldavia region, Romania

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ABSTRACT

This article proposes a micro-econometric approach to assess climate change impacts on wine industry performance in the Moldavia region of Romania. In the assessment we consider the spatial variability of wine-growing micro-areas and employ a small scale for the analysis. Results show that vineyard revenue is influenced by a local effect. Spatial differences among municipalities are highlighted and are driven by vineyard locations and distance from urban areas. Differences at the local scale reflect the presence of structural and environmental constraints. Findings demonstrate that climate change impacts vary significantly among simulated scenarios. The simulated increase in temperature should compensate for the negative effect caused by rainfall changes. Results also suggest that winegrowers should benefit from climate change, although this will depend on the vineyard's location. Potential policy measures designed to remove local constraints and to capitalise on the positive effects of climate change are discussed.

1. Introduction

The wine industry is strongly influenced by climate change. Evidence of this phenomenon is provided by extensive and worldwide empirical literature (for a review, see Ashenfelter and Storchmann, 2014). Adopting different methods and scales of analysis, scholars have demonstrated that climate affects vineyard yields (Adams et al., 2003; Lobell et al., 2006; Fraga et al., 2014), wine quality (Jones et al., 2005; Storchmann, 2005; de Orduna, 2010; Alston et al., 2011) and wine prices (Ashenfelter et al., 1995; Jones and Storchmann, 2001; Lecocq and Visser, 2006; Chevet et al., 2011; Storchmann, 2012). Some studies have considered effects on winegrowers' profitability in terms of net revenue or profit (Haeger and Storchmann, 2006; Ashenfelter and Storchmann, 2010a; Ashenfelter and Storchmann, 2010b; Marinoni et al., 2012). Other studies have shown that climate change impacts on grapevines are highly heterogeneous across varieties (Bindi et al., 1996; Webb et al., 2008; Fraga et al., 2015) and regions (Jones, 2007; Fraga et al., 2012).

Europe encompasses the largest vineyard area in the world (International Organization of Vine and Wine — OIV, 2012). Large-scale analyses have demonstrated that climate change effects in Europe are spatially variable: water deficits and severe dry conditions are expected to decrease wine quality and increase annual fluctuations in yields in the Mediterranean zone. Conversely, in Central and Northern Europe, warming conditions are forecast for the future, and this should improve wine quality (Seguin and Garcia de Cortazar, 2005; Fraga et al., 2013a, 2013b).

The spatial variability of climate change effects in the wine industry is recognisable also at the local scale. Jones et al. (2005) pointed out that effective adaptation strategies require that the effects of micro-climate changes on vine growing are taken into account. This implies the adoption of a finer scale of resolution in simulations of future climate conditions. The micro-climatic and meso-climatic characteristics of a given winemaking zone are considered key factors of wine production performance (Carbonneau, 2003). Moreover, soil chemistry and structure, as well as vineyard management practices, are factors varying also at a local scale and there is evidence that they influence significantly wine performance (Winkler et al., 1974; Mackenzie and Christy, 2005). Studies assessing climate change effects on grapevine cultivation generally employ a global (Jones et al., 2005) or regional scale of analysis (Moriondo et al., 2011; Marinoni et al., 2012), although Wilbanks and Kates (1999) pointed out that small-scale domains are the most suitable for examining climate change consequences for agriculture. Observations at a small scale provide more detailed information than those at a large scale (Wilbanks, 2006) and results obtained by considering two different scales of analysis can dramatically differ.

The assessment of climate change effects on agriculture is essential for defining suitable adaptation strategies, and the choice of an appropriate scale of analysis is crucial. In many cases the results obtained at a specific scale are unfortunately used for the implementation of policy measures at different and mismatched scales (Association of American Geographers — AAG, 2003).

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This article aims to fill the abovementioned literature gaps by proposing a micro-scale econometric approach that considers the role of spatial variability in vine growing environments.

The study aims to: (i) highlight the importance of spatial variability at a local scale; (ii) produce robust estimates of climate change effects on wine performance for use in development of policy adaptation measures at a local level; (iii) provide empirical evidence of climate change effects in an un-investigated wine-growing area (the Moldavia region of Romania), which could benefit from climate change (Fraga et al., 2012; Baduca Campeanu et al., 2012).

The rest of the paper is articulated as follows. Section 2 explains materials and methods; results are reported and discussed in Section 3. Section 4 concludes.

2. Materials and methods

2.1. Methodological framework

The model proposed in this study stems from the 'Ricardian approach' (Mendelsohn et al., 1994), which is one of the mostly used micro-econometric methods to assess the long-time climate change impacts on agriculture. The Ricardian approach uses a cross-sectional analysis to estimate the relationship between economic performance, measured in term of land values or net revenues per hectare,[1] and the climate, portrayed in terms of climate 'normals'. Climate 'normal' is defined for convention as the arithmetic average of a climate variable over a 30-year interval (World Meteorological Organization — WMO, 1989). By simulating changes of the climate scenarios and projecting into the future this relationship, the Ricardian approach measures the economic impact on agriculture in terms of farm outcome variations. According to Mendelsohn et al. (2010), this approach shows at least three advantages: "*it is relatively easy to estimate, yields geographically precise values, and captures adaptation*" (page 154).

However, in some circumstances the latter aspect can represent a weakness. Ricardian cross-sectional analyses consider the economic performance of all cropping and breeding activities. More specifically, they consider the adaptation strategies promoted by farmers in response to changes in economic and environmental conditions that involve the shifting among cropping and breeding activities. Adaptation strategies are treated as a 'black box' and detailed information on strategies is missed (Mendelsohn et al., 2007, 2010). Moreover, the Ricardian approach concerns the whole agricultural sector and not a specific industry, even if some recent studies estimate an industry-specific Ricardian model using survey data of farms growing or breeding particular species (De Salvo et al., 2013; Dall'erba and Dominguez, 2015). Further, the Ricardian approach cannot take some relevant phenomena into account, such as the effect of variables that do not vary across space, the effects of year-to-year change in weather, the change in climate variation or extreme events, and future climate scenarios that have no analogue with past climate envelopes (Deschênes and Greenstone, 2007; Mendelsohn and Dinar, 2009; Mendelsohn et al., 2010). Finally, Ricardian analyses generally consider spatial variability of climate change impacts only at regional or national level, and not at lower scales of analysis.

The Ricardian approach is suitable to estimate impacts on wine firm performance caused by long-time variations of climate. However, to make the analysis industry-specific, to assess climate change effects at a lower (vineyard) scale, and to treat the spatial variability of climate change impacts, it is necessary to modify the Ricardian model specification. The model proposed by this study differs from the traditional Ricardian model in the following aspects. Firstly, it concerns only wine-growing activities. That means that it is industry-specific, and it suitable to capture differences between vine growing environments and production systems within specific wine regions. Secondly, it is formulated according to a micro-scale (vineyard) analysis perspective. It considers the spatial variability in vineyard profitability through the estimation of a fixed component effect, which is municipality-specific, and captures the heterogeneity due to unobserved variables. Finally, the model uses as dependent variable the gross revenue instead of net revenue or land value. The latter variables cannot be evaluated at the vineyard scale. In fact, net revenue requires an assessment of fixed costs, which can be easily quantified only at the farm level, and land value information is available only as the average for counties or larger regions, or for a few specific plots of land that are for sale.

2.2. Model specification

In this study, according to the Ricardian approach, the dependent variable measures the economic performance at vineyard level, and 'control' and 'climate' are included as explanatory variables. Control variables include winegrower and farm characteristics, which are constant at farm level. Climate 'normals' simulate the local meso-scale climatic context.

The following econometric model is specified:

$$Y_{ifm} = \beta_{0m} + \beta_{1f} * edu_f + \beta_{2f} * age_f + \beta_{3f} * CC\_perc_f + \beta_{4f} * winem_f + \beta_{5f} * tec\_lev_f + \beta_{6m} * f(temp_m) + \beta_{7m} * g(prec_m) + \varepsilon_{ifm} \quad (1)$$

where:

- Y_{ifm} is gross revenue (€/ha) for the *i*th vineyard of the *f*th farm located in the *m*th municipality;
- β_{0m} is a constant term (e.g., fixed effect) specified at the municipality level (m);
- edu_f is winegrower education level;
- age_f is winegrower age;
- CC_perc_f is winegrower perception of climate change effects on farm performance;
- $winem_f$ is the processing of grapes;
- tec_lev_f is farm technological level;
- $temp_m$ is average temperature;
- $prec_m$ is total precipitation;
- ε_{ifm} is an error term.

The gross revenue represents the average value for three consecutive years (2010–12).[2] It is calculated by multiplying grape yield by the corresponding price. Given that each vineyard is cultivated with a single variety,[3] the model implicitly captures the variability in revenue due to grape variety as a 'black box'. Moreover, the use of revenue as a dependent variable allows the model to consider the effects of climate change on both grape quantity and quality. In fact, price is determined by market equilibrium conditions and it is an adjustment factor of vineyard yield based on market willingness to pay for the quantity and quality of grapes.

The average temperature ($temp_m$) and total precipitation ($prec_m$) for the period 1982–2012 were considered. These variables are measured at the municipality level (m). No a priori assumption was made about the functional form of the relationship between the vineyard revenue

[1] In some cases the economic performance is measured in a representative year. In other cases an average among two years or more is used to remove year effect.

[2] Following the example of Mendelsohn et al. (2007), we combine more years of data and measure the dependent variable as an average for three years in order to make the analysis robust with respect to the presence of year effect.

[3] In this study, a vineyard is defined as a continuous portion of land, located in a particular municipality, managed by a specific winegrower, and cultivated with a particular grape variety.