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# Wine productivity per farm size: A maximum entropy application ☆

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**Abstract**

The size of a farm is one of the factors that influence its productivity, in an ambiguous relationship that is often discussed in the industrial economy. In Portugal, the Demarcated Douro Region (DDR) is characterized by very small farms. Usually, this trend is considered a limitating factor in the profitability of the wine farms. In order to assess the correctness of this sentence, the variation of wine productivity per land size, from 2010 to 2016, was studied in the DDR, considering its three distinctive areas: Baixo Corgo, Cima Corgo and Douro Superior. The farms were categorized in nine different size ranges; as these variables outnumber the available seven observations, the Generalized Maximum Entropy (GME) estimator was used, since it suits the need to solve an ill-conditioned problem. GME was applied with the MATLAB (MATrix LABoratory) software along with the Bootstrap technique. According to the simulations, larger farms (with an area greater than 20 ha) on Douro Superior and Cima Corgo reveal higher marginal productivity given the current state of the region. On the other hand, Baixo Corgo's results suggest that medium-sized farms (with area ranges between 2 and 5 ha) display higher marginal increments to the region wine productivity.


*Keywords:* Maximum-entropy; Wine productivity; Farm size

## 1. Introduction

Companies' size may influence their economic performance (Baumol, 1967) and it can also be a competitive advantage. In the agriculture sector, the farm size affects the performance or productivity of the farm, but this relationship is somewhat controversial (Townsend et al., 1998).

The vineyard activity has a strategic importance for the Portuguese and the European agriculture sector. According to 2016 data, Portugal is the 11th world wine producer, the 9th world exporter in value and the 5th largest European producer regarding production volume (OIV, 2017).

In Portugal, wine production has a great tradition, particularly in the Demarcated Douro Region (DDR), the first viticulture region to be delimited and regulated worldwide, in 1756. The DDR is located in the Northeast Portugal, in the Douro river basin, surrounded by mountains. Due to the heterogeneity of climatic, topographic and soil characteristics, this region produces superior quality wines, most of them with Protected Denomination of Origin (PDO), including the unique and worldwide famous fortified Port wine. The DDR is divided into three sub-regions: Baixo Corgo, Cima Corgo and Douro Superior (Magalhaes, 1998), with approximately 250,000 ha of total area, 45,000 ha of which are occupied by continuous vineyards. The harvest of 2016/17, constituted 22% of the Portuguese total wine production (1,336,612 hl), being the most representative wine region of the country (IVV, 2017a).

The portuguese viticulture sector, including the three sub-regions of the DDR, is embodied mostly by farms with less than 5 ha (see Fig. 1). In Portugal, around 63% of the farms

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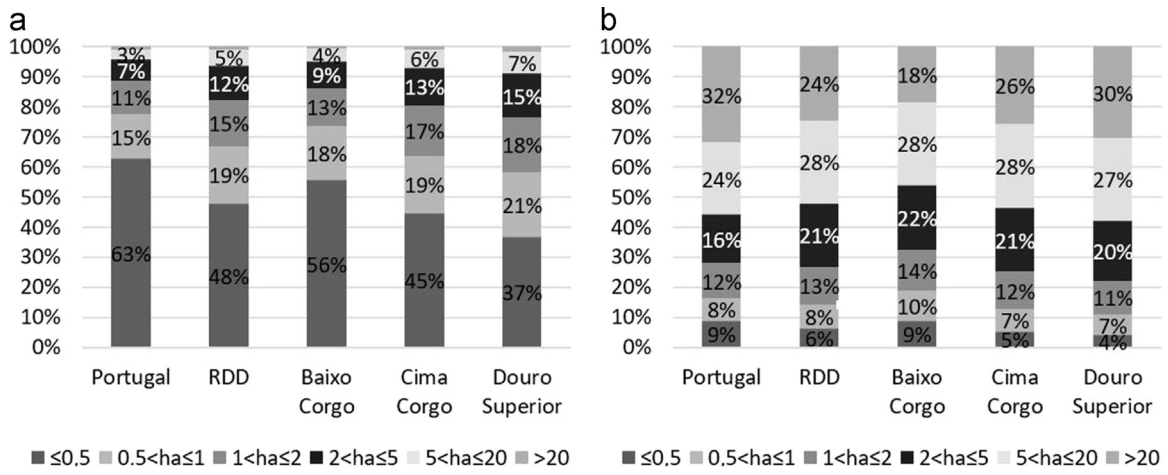


Fig. 1. Farm size in the viticulture sector of Portugal and DDR, in 2013, by classes of area. (a) Proportion of number of farms; (b) Proportion of farm area (Data from INE (2013) and IVDP (2010-2016a)).

have less than 0.5 ha, although they represent only 9% of the total area. Comparatively to the country, the DDR has fewer farms with less than 0.5 ha: 48% of farms, representing 6% of its total area. On the other hand, the farms with more than 20 ha constitute only 1% of the total number of farms, in Portugal and in the DDR, corresponding to 32% and 24% of their total area, respectively. Analysing the sub-regions of the DDR, the Baixo Corgo has the highest percentage of farms with an area between 0.5 and 5 ha, both in number and in total area, while the Douro Superior presents the lowest. Additionally, from 1989 to 2015, the total vineyard area of the DDR suffered a slight decrease (IVV, 2017b). This could be due to shrinking profit margins and to European Union (EU) regulations, which supported the farmers for uprooting their vineyards and imposed a limit on new plantations (Meloni and Swinnen, 2013).

This work aims to analyse the influence of farm size on wine production in the three sub-regions of the DDR (Baixo Corgo, Cima Corgo and Douro Superior), considering the land productivity. To attain this, we explore some Generalized Maximum Entropy (GME) estimators, using nine classes of size area for the referred sub-regions. The article is divided in four sections. The first section presents an overview of the DDR and a brief literature review regarding the influence of farm size on productivity. Section 2 introduces the available data and describes the chosen methodology, supported by relevant references and mathematical formulations. In the two subsequent Sections 3 and 4, the GME results are presented and analysed. Finally, Section 5 summarizes the main conclusions and makes suggestions for further improvement.

## 2. Theory and calculation

Sellers and Alampi-Sottini (2016) analysed the influence of farm size on the economic performance of Italian wineries, using profit, productivity and efficiency measures on a sample of 723 wineries for the year of 2013. The results showed that the size of the farm is positively correlated with all indicators of performance and the company may achieve the optimum size and higher efficiency, with increasing returns to scale, when the unitary costs are minimized (Sellers and Alampi-Sottini, 2016).

Other authors argue that the positive relationship between size and productivity is explained by the increasing returns to scale, which means that when a farm increases its size (input), the production (output) increases proportionally more (Diewert and Fox, 2010; Sheng et al., 2015).

In the agricultural sector, economies of scale are more commonly associated with mechanization, especially when linked to high-performance (Gleyses, 2007). The technological progress and the access to improvements can also explain why big farms are more productive, since they often have more capital available than small farms to invest in new technologies, which allow them to reach higher productivity levels (Hooper et al., 2002).

Another theory is that small farms may have more difficulties to conquer new emergent opportunities in the international market: when larger volumes of goods are required and the market competition increases, their low production capacity restrains a possible adjustment to these challenges (Commission, 2005; Sheng et al., 2015).

The positive relationship between the size and the performance or productivity of a company is not always confirmed. As observed by Marcus (1969) and by Capon et al. (1990), only some industries display that type of results. In addition, an inverse correlation between farm size and productivity has been detected (Berry and Cline, 1979), mainly concerning developing countries (Ghose, 1979; Chand et al., 2011; Chen et al., 2011). However, Ghose (1979) argues that the advances in technology are the main factor for the vanishing of this inverse correlation, while Townsend et al. (1998) showed that this relationship was weak and inconsistent.

The authors considered that the main mechanism contributing to the positive farm size and productivity relationship is the advantage of larger farms in obtaining financial and other non-labour inputs. In the viticulture sector, farm size increase may be a consequence of the elimination of small-scale producers (Kroll, 1987) or an effect of the growth of some farm holdings