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Is the New Wine World more efficient? Factors influencing technical efficiency of wine production

We have experienced the emergence of New World wine producing countries (the Americas, South Africa and Oceania) in the last 10-15 years as they have successfully increased their market share in European markets. In this paper we perform a two stage model on a panel of most of the major wine producing countries over the period 1995-2007. We estimate a Cobb-Douglas production function and technical inefficiency using stochastic frontier analysis. We show that there is a significant difference between the major Old and New World countries in terms of technical efficiency in favour of the latter group. The analysis supports our hypothesis that the more efficient functioning of the sector in the New Wine World can be one of the drivers of their success. Moreover, inefficiency is related to some macroeconomic factors such as the development of the financial system, the quality of human capital and per capita wine consumption.

Keywords: efficiency gap, wine production, New World, Old World, macroeconomic drivers

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Introduction

Wine making has a long tradition in Europe. However the first decade of the current Millennium saw the rise of new wine producing countries conquering the traditional markets of European wine producers. This group of countries, the so-called 'New Wine World', consists of those where wine production was not present before the arrival of Europeans, i.e. the Americas, South Africa and Oceania. In some of these countries, vineyards and wine making have only been present for a few decades.

The increase of the wine exports of these countries has considerably exceeded¹ that of the traditional wine producers (the so-called 'Old Wine World'). According to International Organisation of Vine and Wine (OIV) data, exports in 2009 as a percentage of 1996 for five of the largest wine producing New Wine World countries were as follows: United States: 300; Argentina: 144; Australia: 665; Chile: 538 and South Africa: 556. By contrast, the figures for the three major Old Wine World producing countries were: Italy: 123; France: 109 and Spain: 233. Amongst the Old Wine World producing countries the best performances over this period were recorded by the relatively small producers Austria (353) and Georgia (274).

This success of the 'New Wine World' countries is a widely discussed phenomenon among the stakeholders in the wine sector. Anderson (2005) gives a detailed and plausible overview of the success of these countries. However the economic causes are seldom analysed quantitatively in a greater depth. In this paper we use a macroeconomic approach to explain the recent emergence of the New Wine World by showing the relationship between some instrumental variables and the growth of wine exports via technical efficiency.

Technical efficiency in the wine sector

In general, estimations and investigations of technical efficiency in the wine sector use models based on micro data. On the one hand, this raises the level of precision, but on the other it evidently limits the scope of the results. Using stochastic frontier analysis, Conradie *et al.* (2006) estimated

the technical efficiency of two panels of wine grape growers (and another of organic table grape growers) in South Africa. They showed that efficiency is affected by labour quality, age and education of the farmer, location, the percentage of non-bearing vines and expenditure on electricity for irrigation.

Barros and Santos (2007) compared the efficiency of private companies and cooperatives in Portugal via data envelopment analysis. They concluded that "Portuguese wine cooperatives, on average, are more efficient than their private counterparts" (Barros and Santos, 2007, p.109). Carvalho *et al.* (2008) studied a sample of Portuguese vine growers of the Alentejo region that sell their grapes to cooperative wineries. The research was conducted over the period 2000-2005 and its aim was to estimate their technical efficiency using the stochastic production frontier method. Their results showed that "technical efficiency was time variant, there was room to improve technical efficiency of vineyard farms and technical efficiency increased with size, family entrepreneurship and farm profitability" (Carvalho *et al.*, 2008, p.5). However their final conclusion was that the better performance of wine cooperatives could lead to even more improvement of the grape producers' situation.

Moriera *et al.* (2011) used stochastic frontier analysis to estimate technical efficiency of Chilean wine grape growers via a sample of 38 suppliers of an association of high quality wineries. They demonstrated a strong relationship between certain vineyard training systems and the yields per hectare. The estimated returns to scale were quasi-constant. Using a translog stochastic production function Coelli and Sanders (2013) estimated the technical efficiency of wine grape growers in the Murray-Darling Basin in Australia on an unbalanced panel including 134 producers over four years. Their study revealed a significant potential improvement of efficiency and some evidence of increasing returns to scale.

In addition to the studies presented above, we can find more macro-focused analyses. Aparicio *et al.* (2013) investigated the Spanish wineries that produce wines with PDO².

¹ The difference is significant at a level of 4 per cent

² PDO: protected designation of origin. Wines with PDO bear the name of their place of origin (which is actually *the* PDO) and show quality and characteristics essentially or exclusively due to their place of origin.

They estimated revenue inefficiency decomposed to technical and allocative inefficiencies using data envelopment analysis. Their results showed that revenue efficiency was the most in the case of PDOs with specific wine products serving niche markets and without clear competition.

The paper is structured as follows. Next we elaborate our modelling framework, including the macroeconomic reasoning behind it, then we present and explain our results. In the last section we conclude.

Methodology

We used a two stage investigation procedure to estimate the technical inefficiency and to show its relationship to certain instrumental factors. Owing to the specification of our stochastic frontier model, inefficiency was estimated instead of efficiency. Given the macroeconomic focus of our study and the use of proxies, our paper concentrates on macro-level relationships.

We used a panel of 16 major wine producing countries over a period of 13 years (1995–2007), including 11 countries of the Old and 5 of the New Wine World. We have considered a country to be a major wine producer if its average annual wine production was more than 1 million hectolitres during the first decade of the current Millennium (Table 1). Owing to lack of data, a further seven countries were excluded from the sample.

Table 1: Main wine producing countries of the world and average annual wine production, 2000–2009.

Old Wine World		New Wine World	
Country	Production (000 hl)	Country	Production (000 hl)
Austria	2,522	Argentina	14,223
Bulgaria*	2,012	Australia	11,889
Croatia*	1,546	Brazil*	3,184
France	50,386	Chile	7,407
Georgia*	1,108	New Zealand	1,170
Germany	9,438	Rep. S. Africa*	8,648
Greece	3,688	USA	20,411
Hungary	3,762		
Italy	47,860		
Rep. Moldova*	2,106		
Portugal	6,844		
Romania	5,250		
Russia	5,258		
Spain	37,335		
Switzerland	1,092		
Ukraine*	2,253		

* Excluded from the sample used in this study owing to lack of data
Source: <http://www.oiv.int/oiv/info/frstatoivextracts2>

Table 2: Descriptive statistics for 16 wine producing countries over the 13 year period 1995–2007 (i.e. N=208).

Variable	Mean	Std. Dev.	Min	Max
Openness to international trade	58.35	22.98	20.00	169.94
Development of the financial system	86.62	45.39	10.96	182.14
Quality of human capital	9.97	1.61	6.45	13.22
Wine consumption	28.27	16.07	0.84	63.13
Old Wine World (dummy)	0.69	0.46	0.00	1.00
Inefficiency term	0.18	0.11	0.03	0.79

Unless specified below, the sources of data were as follows: area of vineyards, wine production, exports and imports: StatOIV extracts (<http://www.oiv.int/oiv/info/frstatoivextracts2>); agricultural capital stock: FAOSTAT (<http://faostat3.fao.org/faostat-gateway/go/to/download/I/CS/E>); all other indicators: World Bank database (<http://databank.worldbank.org/data/databases.aspx>).

Estimating inefficiency

In the first stage of our model we estimated the inefficiency. We applied panel data stochastic frontier analysis based on a Cobb–Douglas production function by regressing wine production against three inputs: land (area of vineyards), capital (agricultural capital stock) and labour force (employment in agriculture). We used agricultural machinery and agricultural employment as proxies for capital stock and employment in the wine sector as more detailed data were not available. Essentially, we followed a process developed by Belotti *et al.* (2012). Assuming a half normal distribution for the inefficiency term, our stochastic frontier model showed robust results. The estimation of the inefficiency terms via $E(u|\varepsilon)$ verified our assumption on the nature of half normal scattering.

Macroeconomic factors influencing the efficiency

In the second stage, we regressed the estimated inefficiency term against some instrumental variables describing macro-economic elements that we assumed would affect it. Our choice of variables was based mostly upon Bos *et al.* (2010), who applied a latent class model on the production function of 77 countries. They identified four factors that are assumed to be growth determinants by affecting factor accumulation, efficiency change and technical change. In our model we assumed that these variables are related with technical inefficiency and regressed them against the estimated inefficiency term. However, owing to lack of data we did not investigate the role of the share of the primary sector. In addition, we introduced two new factors that are specific to the wine sector: per capita wine consumption and belonging either to the Old or the New Wine World. Table 2 shows the descriptive statistics of these variables.

Openness to international trade

One can assume that countries that are more open to international trade are more competitive and thus more efficient from the technical point of view as well. Previous studies of micro data confirm the positive relationship between technical efficiency and openness to international trade. Tybout *et al.* (1991) considered the example of the Chilean industrial sector and found that technical efficiency improved significantly following a drastic trade liberalisation in the 1970s. Gökçekuş (1995) came to the same conclusion following the study of the Turkish rubber industry in a period of a crucial change in the country's trade policy. The study of the Peruvian trade policy reforms and the plant level efficiency by Alam and Morrison (2000) confirmed these findings.

From a panel of Bangladesh manufacturing sector Hosain and Karunaratne (2004) found that involvement in competition with international supply (both export orientation

and import substitution) increased technical efficiency. Sotnikov (1998) estimated a 20 per cent decrease of technical inefficiency on average on a panel of 75 Russian agricultural regions. The results showed that efficiency gains were larger in regions with more liberalised trade while the effect of technological change was negligible.

Bos *et al.* (2010) argued that on the macro level this factor has a role in increasing allocative efficiency, contributes to adaptation to international market trends and the implementation of foreign knowledge and technology. Moreover, Edwards (1998) demonstrated that more open economies show faster total factor productivity growth. Ben-David and Loewy (1998) proved that trade liberalisation helped to close the income gap between countries and contributed to growth, while Frankel and Romer (1999) found that income correlates positively with trade.

Openness is measured as the sum of exports and imports compared to the Gross Domestic Product (GDP). Data were retrieved from the World Bank database.

Development of the financial system

The basic assumption is that the more developed the financial system is, the more efficient the allocation and use of capital will be. Bos *et al.* (2010) based this assumption on two factors: (a) the evaluation of investment decisions and (b) the increase of risk sharing (thus allowing the investment in riskier yet more productive technologies). Theory suggests that a more efficient allocation of capital presumes an efficient use of this input and thus results in higher level of technical efficiency.

This factor is measured by the amount of deposits held in the financial system compared to the GDP, and these data were retrieved from the database of Beck *et al.* (2009).

Human capital

We assume that the quality of human capital has a positive effect on technical efficiency. Briefly, the more educated people are, the better they will perform. This factor sums the potential effectiveness and learning abilities of the workforce of a given population. While Bos *et al.* (2010) advocates that human capital may be directly related to efficiency on a macro level, some other studies from the literature of agricultural economics confirm this using micro data. Bos *et al.* (2010) stipulates that human capital “can affect efficiency through absorption of existing advance technologies” (p.116). This effect is fostered by the influence of human capital on innovation, managerial decisions and the use of inputs.

Huffman (1977) showed that, for a sample of US Corn Belt farmers, investment in education improved allocative efficiency. Furthermore, Mathijs and Vranken (2001) estimated technical efficiency using data envelopment analysis and found that it was positively related to human capital (age and education). Davidsson and Honig (2003) show that some aspects of human capital have a positive effect on firm performance on a sample of newly established enterprises. An additional set of studies found a positive effect of human capital on total factor productivity (Engelbrecht, 1997; Maudos *et al.*, 1999; Miller and Upadhyay, 2000; Del Barrio-Castro *et al.*, 2002).

The quality of human capital is measured by the average years of education of the population that is at least 25 years old. Data were retrieved from the World Bank database. As data were only available for every fifth year, we estimated the missing values by interpolation, assuming that the change of the indicator was linear.

The tradition of wine

The tradition of wine is measured by the per capita consumption of wine. We assume that the permanent presence of wine in a country's culture increases the technical efficiency. Wine can only be made of grapes and grape production is only possible in a geographically limited zone. Traditionally, wine has mostly been consumed relatively close to its place of origin. In addition, the place of origin may have a significant effect on wine quality. All in all, an important portion of the vine production and wine-making know-how can inevitably be considered a “knowledge of the particular circumstances of time and place” (Hayek, 1945, p.521) that is spread mainly in traditional wine regions. Moreover, if the consumption of wine is high, so is the supply. Thus, competition is high, which results in low marginal costs. Operating in a highly competitive context presumes higher efficiency.

Evidently, the tradition of wine is higher in *traditional* wine producing countries. As a result the given variable can incorporate the factors that improve the competitiveness of Old Wine World countries.

Belonging to the Old or New Wine World

Our main hypothesis is that the New Wine World countries are more efficient than the Old Wine World countries. The belonging to one of the wine worlds is represented by a dummy variable in our models.

Results

The production function

The estimated parameters of the Cobb-Douglas production function listed in Table 3 illustrate the percentage change in the quantity of wine produced (independent variable) that would result if the independent variable were to change by 1 per cent. The quantity of wine production is significantly and positively related to the area of vineyards. However, the relationship between the production and the two other inputs (capital stock and employment) is negative. We think that these inputs were probably not used in an efficient way.

Table 3: Estimated parameters of the Cobb-Douglas production function (respective p-values are indicated in parentheses). Dependent variable: log wine production.

Vineyard area (log)	0.7271 (0.000)
Agricultural employment (log)	-0.1808 (0.036)
Net agricultural capital stock (log)	-0.6702 (0.000)

Factors affecting inefficiency

In the second step we regressed the previously estimated inefficiency terms against the instrumental variables described above (Table 4). We applied random effect (RE) and fixed effect (FE) panel regression estimations. For both type of models we have three variants: (1) all instruments are taken into consideration; (2) given that *openness to international trade* was proved not to be significant, we excluded it in the second model; and (3) because of the possible multicollinearity in the third model we did not include the *human capital* variable. Consequently we have six permutations.

The quality of human capital was ignored in model 3 due to the relatively high level of its correlation with per capita wine consumption ($r = -0.6805$) but the variance inflation factors (VIF) and the coefficients of these models suggested that regression coefficients are not influenced by multicollinearity to a significant extent. We assume that the reason for the correlation of these variables may be related to their actual trends: while school attainment was increasing, per capita wine consumption showed a constant decrease during the period in question (in the countries observed).

The results show that the estimated inefficiency term is significantly related to these factors – the sole exception is the openness to international trade. Additionally, we demonstrated that the direction of the relationship is as expected in all cases. The relatively low values of the coefficients are due to the range of the dependent variable.

More importantly, the Old Wine World dummy is significant (and positive) in all relevant models (dummy variables – due to model design – are omitted from fixed-effects models per definition), therefore a significant difference between the technical efficiency of Old and New Wine World countries is shown. As the mean value of the inefficiency term is 0.1766, the coefficients of the Old Wine World dummy ranging between 0.0343 and 0.0370 could represent a notable difference. This supports our hypothesis that the emergence of the New Wine World countries might be due to their higher production efficiency. However, wine traditions may decrease this difference.

Finally, the values of the different R^2 indicators suggest that our models tend to explain differences between the countries involved better rather than their internal changes.

Concluding remarks and limitation of validity

Our study focused on macroeconomic elements that affect the technical efficiency of the wine sector in the major producing countries. We learned from our analysis that the more developed financial system improves the technical efficiency. This is very much in line with the earlier empirical finding of Bos *et al.*, 2010, who claimed that effective financial systems via optimal allocation of assets increase efficiency.

The literature suggests that more educated people can absorb and apply new knowledge and more complicated technologies and thus increase the technical efficiency of production. Our results underline the importance and significance of this factor. The tradition of wine – measured by wine consumption, which on average is more than two times higher in the Old Wine World countries – helps in bridging the efficiency gap between the groups.

The openness to international trade was not significant in our analysis. As previous literature suggests, firms operate at increased technical efficiency in countries that are open to international trade. Involving indices more specific to the wine sector may prove to be useful.

However, due to the partial lack of specific data we were forced to use some proxies when estimating the wine production function. In addition we had to focus on data about the *volume* of wine production instead of the *value*. These conditions limit the scope of our results; however our findings were not in contradiction with the previous empirical experiences.

This paper did not take into account the possible role of agricultural policies on inefficiency. However, in the Old Wine World wine policies are often claimed to be responsible for the decreasing competitiveness of the sector (in particular in the European Union).

Table 4: Estimated parameters of six models of factors affecting technical inefficiency (*p-values* in parenthesis).

Model type	RE-1	RE-2	RE-3	FE-1	FE-2	FE-3
Openness to international trade	-0.000118 (0.755)			0.000038 (0.964)		
Development of the financial system	-0.000315 (0.094)	-0.000266 (0.076)	-0.003905 (0.032)	-0.002552 (0.001)	-0.002548 (0.001)	-0.003259 (0.000)
Quality of human capital	-0.012645 (0.057)	-0.012729 (0.054)		-0.037970 (0.105)	-0.037414 (0.059)	
Wine consumption	-0.002207 (0.003)	-0.002186 (0.003)	-0.001295 (0.027)	-0.013977 (0.000)	-0.013985 (0.000)	-0.013299 (0.000)
Old Wine World (dummy)	0.036881 (0.084)	0.034296 (0.080)	0.036983 (0.060)	omitted	omitted	omitted
Constant	0.373845 (0.000)	0.369991 (0.000)	0.221572 (0.000)	1.169103 (0.000)	1.16571 (0.000)	0.834798 (0.000)
R^2 within	0.1551	0.1630	0.1591	0.1779	0.1779	0.1622
R^2 between	0.4689	0.4825	0.4960	0.3579	0.3564	0.3325
R^2 overall	0.0760	0.0755	0.0587	0.0491	0.0489	0.0403

The dependent variable is the estimated inefficiency term

Model types: RE: random effect and FE: fixed effect panel regression estimation; 1: all instruments taken into consideration; 2: openness to international trade excluded; 3 human capital excluded

As the wine sectors usually have a relatively small share even in the agriculture of biggest wine producing countries it is hard to collect data on the use of inputs. Moreover, the high level of product differentiation makes estimations on prices more difficult and less reliable in the wine sector. Thus, one faces substantial difficulties when trying to take the value into account instead of the volume.

We observed a high level of correlation between the quality of human capital and the per capita wine consumption (which, however, does not seem to influence regression coefficients). We assume that this is only the result of the actual set of countries investigated and would disappear if the panel was changed. Therefore the inclusion of more countries should improve our results for this reason as well.

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