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Predicting wine quality from terrain characteristics with regression trees

Prédire la qualité du vin, à partir d'analyse de régression sur les caractéristiques des terrains

Reiner Schwarz

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Résumés

Français English

On utilise une précédente étude cartographique sur les caractéristiques des terrains de l'espace du Rhinegau allemand. On essaye d'évaluer la qualité relative du Riesling d'après des facteurs de localisation à l'aide d'une classification et d'un

arbre de régression (CART). La validité des résultats suppose que la qualité supplante la quantité, que le niveau des prix ou les méthodes de vinification ne sont pas pris en compte. L'étude montre que CART est un outil statistique valable, sans restriction quant à la nature des données.

A former cartographic study on terrain characteristics of the German Rhinegau is reviewed. An attempt is made to predict relative quality of the Riesling from local site factors usings **C**lassifcation **A**nd **R**egression **T**rees (= **CART**). Valid results suppose quantity to be ruled out by quality, ignoring any price ratio of vine cultivation. The study demonstrates that CART is a valuable statistical tool without restrictions by data types.

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Entrées d’index

Mots-clés :

qualité du vin, caractéristique du terroir, régression sur variables qualitatives, CART, écologie viticole, Rheingau

Keywords :

wine quality, terrain characteristic, regression classification, statistics, agriculture
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Plan

Texte intégral

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The Problem

1Within one area of vine cultivation of a uniform macroclimate it has been known for a long time that wine quality depends on terrain characteristics. Vine growers

and vine experts know by experience which wine quality can be expected at a site. With this knowledge the French Institut National des Apellations d'Origine (I.N.A.O.) is able to fix cartographically the terroirs according to wine quality. The most important specific habitat characteristics are known to be altitude, substratum, radiation exposition, slope, local wind influence and danger of frost. Asking the question of a geographer, according to which logic a specific wine quality traces back to terrain characteristics, even now the valuation of DICKENSON & SALT (1982, p.169) is true: "...no methodology has yet been produced for satisfactorily correlating micro-environment characteristics with those of the end product. Everyone says there is a relationship, but no one understands why."

Fundamental Principles

2Beeing harvested from an area, wine relates to a region not representing uniform terrain conditions and in its quality the cellarer's art participates as well. In order to rate wine quality to a local site it is only the must quality that can be measured directly. Must quality also depends from measures taken by the wine grower in order to balance quality against quantity in an economically reasonable way. The question under study needs to relate unambiguously must quality to wine quality. This can be achieved by assuming that wine growers and cellarers optimize their product with respect to quality regardless with expense. Then, quality solely depends on stage of maturity and content of grape body which can be fairly well measured as density of must in degrees Oechsle by aerometer or polarimeter.

- 1 The French *terroir* denotes a synopsis of all local factors of the area under cultivation that are r (...)

3We must be conscient, however, that this quality optimizing assumption is only valid for answering questions relating to terrain analysis. For an economic geographical study of viticulture such an imagination would be inadmissable. This idea is subject of a controverse discussion dividing wine experts into two opposing parties. On the one hand there are wine experts and wine authors like JOHNSON (1994) who exclusively orientate themselves towards wine quality. Again and again they state that wine quality can be traced back in the long run to quality of habitat and therefore they would be able to fix it cartographically. Obviously, this is also the French I.N.A.O.'s opinion. Those "regionalists" are characterized by their supposition of optimizing behaviour with respect to quality instead of economy. On the other hand, there are the viticulture experts who are conscient about the importance of costs and the substitution ratio of quality to quantity. They concede a quality judgement only to the final product and not already to the *terroir*1. Such is the point of view of economical geographers who consider cost structure and market ratio. The German wine legislation, as well, is clearly based on these thoughts and not on a fault egalitarian

perception of democracy as supposed by JOHNSON (1994, p.144).

- 2 Without, however, citing it by a bibliographical reference

4For correlating wine quality to habitat conditions we clearly have to take the same point of view as the regionalists. DICKENSON & SALT (1982) refer to "The World Atlas of Wine" by JOHNSON (1971) commenting on the Rhinegau study by *Hessisches Landesamt für Bodenforschung* at Wiesbaden. GOULD (1973, p.148) as well, underlines in his review of JOHNSON's work (1971) the reproduction of the resultant maps of the Rhinegau study from a geographical point of view. Still in his new edition of "Neuer Weinatlas", JOHNSON (1994, p.144) presents the Rhinegau study as the probably most profound one ever having been dedicated to wine quality2.. This study (ZAKOSEK et al. 1967) refers to the Hessian viticulture area in all which consists mainly of the Rhinegau, situated at the west and south exposed side of the Taunus towards the Rhine, between Wiesbaden and the Rhine gap. It represents the most distinguished historical innovative centre of the German viticulture. In the 17th century already, the adaption from red wine, usual up to then, to white wine production started for evading the too powerful competition of French wines on the Cologne market. During the 18th century the Riesling succeeded with the use as optimum vine variety. It gets particularly precious when the overripe grapes become infested by Botrytis disease which as a special late vintage (Spätlese) was discovered in 1775 at Johannisberg Castle.

5The Rhinegau study emphasizes the most important terrain characteristics influen-cing decisively the dependent variable of must quality.

- possible radiation input due to relief as a measure
- absolute altitude as a measure for heat,
- changing assimilates into growth and maturity
- relative wind velocity as a measure of cooling air influence
- soil type for supply of necessary humidity, nutrients, and heat in the root region
- danger of late frost due to terrain conditions.

6All these distinctive features have been carefully mapped in many years and published as an atlas bound of single maps drawn to a scale of 1:50 000 (ZAKOSEK et al. 1967). The result of the study does not go beyond a pile of thematical maps each of a single variable. With this the data base is given indeed, but the relation of single characteristics to habitat quality remains obscure.

7The problem of rating could not even allusively be solved by means of mere

conventional study of the single maps because the ordinally scaled characteristics are actually perpendicular or even contradicting each other. In this way, altitude is opposite to radiation exposition extending in gradient direction. Lower absolute altitude means greater heat, but at the same time, also because of the cold air stream on the valley floor, greater danger of late frost. The low relative wind velocities on the valley floor, on the other hand, are favourable, whereas this habitat is unfavourable regarding the radiation input due to the shadow of higher slopes.

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The Approach

8It is our goal to state an intelligible rule by means of which habitat quality can be estimated from its single characteristics and then testing it critically. Hereby habitat quality has been measured by density of must in degrees Oechsle simultaneously at the same date shortly before the first picking of grapes. Even if vintages might turn out quite differently, grades among habitats of a region stay invariant.

- 3 The study of HOFFMANN (1988) shows in which "labyrinth" of problems on gets by estimating faults in (...)

9Principally, must quality regarded at the habitat could be predicted by simulating the physiology of vine by means of dynamic system modelling. Such models have been developed and successfully used by CRESPIN (1986) and by LEBERRE & UVIETTA (1989). They need a dynamic driver variable for which it would be difficult to translate the static habitat characteristics into a dynamic series of microclimatic data for driving such a model. In particular we would be very uncertain about which faults should be attributed to which part of model. That is why we should walk on the direct way of a simple black-box model3.

10Under these conditions, there is a suggestion that a linear multivariant model should be able to predict the relative must quality from habitat characteristics. Two reasons, however, prevent the problem from being satisfactorily solved in this way. Soil type exists only at the categorical data level. Consequently, there are no interpretable calculations possible. Additionally, the interaction of predictor variables cannot be imagined to be additive. The logical coherence of any characteristics is rather a conditional one. Heat and soil characteristics can become efficient not until sufficient assimilation products are available by radiation input. On the contrary, growth is presupposed for sufficient leaf surface to absorb luminous energy. On the other hand, the available assimilation product should be invested in grape ripeness not in mere vegetative growth.

- 4 =Classification And Regression Trees. "Classification" refers to a categorical "regression", on the (...)

11For such a conditional logical coherence, logically flexible models for data analysis have been developed in the USA in the last years under the name of CART4.. It makes usage of the enormous data processing capacity of modern computers, and is also available now on personal computers (STEINBERG & COLLA 1992). Step by step all possible rules are played through for best separation of the objects into two subsets. Hierarchical repetition of this procedure produces a classification tree where every ramification is defined by a decision rule. When at each end of a branch there is only one single object which cannot be ramified any more, the decision tree is pruned back according to the desired modelling simplification. Thus, we get an optimum logical decision structure for predicting the category of the dependent variable. Joint to this are test methods for critical examination of the model results corresponding to its misclas-sification behaviour.

The Result

12As a data basis for predicting the quality of vine habitat from terrain characteristics the ones in question have been extracted from atlas maps 1 : 50.000 of the Rhinegau study of *Hessisches Landesamt für Bodenforschung* (ZAKOSEK et al. 1967) by an identically positioned millimetre-overlay screen. Due to its unequal distribution the dependent variable has only little information content. Therefore has it been advisable to reduce its seven map levels to the three categories "very good" (G=1), "middle" (G=2) and "little" (G=3). All data refer to only one vine type, the Riesling.

13The fidelity of the model is measured as misclassification rate referring to a random test sample. Balancing misclassification against reasonable simplicity, from a series of attempts a model of ten final nodes is resulting. A random sample of 1.123 points is divided up according to the delineated graph. This reads as follows: The relatively seldom highest quality grade (G=1) can be reached only on soils that are rich in sceletal matter, dry, lime-free, poor of bases, and poor of nutritive material. Wherever this supposition is given, the radiation input decides if best habitat quality is possible (G=1).

14With a higher offer of radiation (S=1,2) best habitat quality (G=1) is always given if the absolute altitude is below 200 m. At an absolute altitude between 200 and 250 m only those habitats with the highest radiation input (S=1) are optimum, whereas the ones with less radiation (S=2) are already ranged into the lowest quality grade (G=3). Furthermore, habitats of the lowest radiation grade (S=4) on soils of group B=1 and B=2 are also generally found in the lowest quality grade (G=3). At a little higher radiation input (S=3) on these soils, only strongly late-frost-dangered habitats and such above 100 m belong to the lowest quality grade

(G=3), the others belong to the medium (G=2). On other soils the highest quality grade (G=1) cannot be reached. There, simply the altitude is decisive. Above 200 m habitat quality of lower degree (G=3), below 200 m quality of medium grade (G=2) can be expected.

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Interpretation

- 5 This is an effect well-known in vegetation geography that corresponds to bunch and cusshion plants. (...)

15To begin with, it is to be noticed that the relative wind influence has diasappeared among the predicting variables. This seems to be in contradiction to the knowledge that the autonomous radiation climate is influenced unfavourably by fresher air of the atmosphere5.. Here, wind screening by alignment and the distance of vine rows might be decisive . The study of HORNEY (1975) shows that in Rhinegau E- and NE-wind directions dominate during radiation weather conditions. By aligning vine rows N-S, these winds, detrimental particularly for heat budget, are mostly eliminated while irra-diation on soil about noon is only little disturbed.

16The fundamental role of soil type seems mysterious at the fist glance. It occurs at all such models in the same way, no matter if they are more detailled i.e. having more nodes, or if they are simpler. Obviously, must quality at soil type B=1 or B=2 reacts particularly sensitive on microclimatic variants. All in all, those soils are little productive because of their dryness and poorness of nutrients. These characteristics however are favourable for a high must density of the relatively few grapes. Stony soils show good thermal conductivity. While having a relatively low nocturnal heat flux to the air, it shows a positive heat balance during warm seasons. Combined with the little water storage capacity above the withering point, such soils can heat up quickly at radiation input.

17Under such conditions the possible chemical transformations because of shortage of nutrients do not lead to an increasing vegetative growth at the cost of the fruit. For producing pure sugar, there is no need of plant nutrients but only carbon out of the air. High sugar content provides grapes from deterioration by becoming overripe and helps rotting on the vine favourably by Botrytis cinerea. With this the presupposition is given for producing the quite particularly precious late vintage Spätlese and extra quality wines.

18Soil characteristics favourable for quality only develop their effect under good radiation conditions at W- to SE-exposition, high slope gradient, and low horizontal shading, and where absolute altitude is below 200 m. Only optimum

radiation conditions can compensate an absolute altitude up to 250 m. Higher absolute altitude means lower air temperatures, and according to a rule of thumb every 100 m higher mean a loss of 6 3 degrees Oechsle. Since on soil types 3 to 7 no very good quality can be reached at any rate, simply the criterion of an altitude of 200 m is decisive for medium (G=2) or low (G=3) quality. This may be true of those radiation privileged parts of the terrain that are normally used for vintage.

19If radiation and heat can be of such importance the question arises why white wines of the Rhinegau overtop Mediterranean competition in spite of its site near the northern border of vintage. This question has often been asked and the answer points to the more subtle characteristics of quality, to aroma, flavour, delicate fragrancess and fruit-acid that white wines produced in Mediterranean climate do not have at a corre-sponding rate. This however traces back to the macroclimatic conditions which are concerned with Rhinegau entirely. Certainly there are also many different variants of taste within this cultivated area. Yet, they cannot be exactly coordinated with each of the single terrain points because of the mixture occurring during wine production. This is why the dependencies from terrain conditions of these wine quality dimensions must remain obscure.

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Notes

1 The French *terroir* denotes a synopsis of all local factors of the area under cultivation that are relevant to wine quality

2 Without, however, citing it by a bibliographical reference

3 The study of HOFFMANN (1988) shows in which "labyrinth" of problems on gets by estimating faults intending to estimate must qualify by multiple regression out of quantitative data of time and space at the same time

4 =Classification And Regression Trees. "Classification" refers to a categorical "regression", on the other hand to a numerical dependant variable. In both cases it is a matter of dependence analysis. Thus, in the title of this essay "tree regression" as a standard term was chosen. (comp. BREIMANN et al. 1984)

5 This is an effect well-known in vegetation geography that corresponds to bunch and cusshion plants. ENDLICHER & FITZHARRIS (1995) point out that vineyards

of New Zealand can only be found on the wind-protected east side of the isle.

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