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Economic issues and perspectives on innovation in new resistant grapevine varieties in France

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Abstract

The arrival in France of new varieties resistant to downy mildew and powdery mildew calls into question the aims of this "revolution" in a sector dominated by tradition. The proposed evaluation reviews the historical experience of cross-breeding programmes from an evolutionist standpoint before analysing the responses to the new technological paradigm of resistance to disease. Taking account of the time periods, dating their implementation and describing the opportunities open to winemakers, the paper revisits the scientific controversies, the institutional blockages to be eliminated, the means of recognition and the prospects.

Keywords: Innovation; Grapevine varieties; Environmental compliance

1. Introduction

Varietal innovation has long contributed to agricultural progress. An excellent example of this can be found in the winemaking sector, with the solutions provided by new hybrid varieties, both direct producers and rootstock, to the phylloxera crisis in the 19th century. In France, after the Second World War, plant breeding became the exclusive domain of public research. Launched in 1956, the programmes yielded some limited results, but their experience can be of use in analysing new programmes.

The major innovation of the past 15 years lies in the fact that varietal innovation is much more blatantly "pulled by technological demand" (demand pull) than pushed by supply (technology push). The choices of technological paradigms have not been the same in France as in the rest of Europe, and in particular Germany, Switzerland and Italy. The socio-economic evaluation of this major technological innovation is therefore based on understanding past technological trajectories as well as analysing the current technological supply, strategies adopted by stakeholders', including the value chain's pilot institutions, market characteristics and the qualitative foundations underpinning their definitions.

2. The evolutionist baseline and the innovation chain

The standard neoclassical approach is of no great help in understanding the technological dynamics. Consequently, we use the tools of evolutionist theory together with the systemic analysis of the innovation chains and the product chains.

The aim of evolutionist models is to explain how firms and their technology have developed over time and how the agent or process studied achieved this. The explanation includes random elements which renew or generate variations of the variables studied to which are added sorting and selection mechanisms. In the social sphere, these models comprise imperfect processes of learning and discovering by trial and error together with selection mechanisms. These models specify the determinants of adaptation (or fitness), thereby

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requiring the determination of the selection unit and the main mechanisms by which selection is made.

We revisit Giovani Dosi's two fundamental concepts: the technological paradigm and the technological trajectory. The technological paradigm represents what we are looking for, how, why and who conducts the research. The technological trajectory provides the economic dimension of the technological paradigm by combining the research programme and its economic evaluation by different stakeholders including firms, sectors or industry, the market, development agencies and economic policy makers.

The idea behind calling on Dosi's concepts is thus to invite the researcher studying a group of companies and a specific technology to explore the existence and describe the nature of this orientation. In a systemic and finalised approach, the complementary notion of innovation chain makes it possible to identify the stakeholders participating in a sector-based technological trajectory.

To understand the aims of this innovation, we conducted numerous interviews with French and foreign researchers involved in the development of this technological paradigm as well as the different institutions concerned at the stage of development.

3. A little history

From a historical standpoint, innovation in wine-growing plant material has focussed much more on sanitary and clonal selection from 1962 than plant breeding. This line of research has transformed the value chain by eradicating the main viral diseases and thus supplying the entire world with plants boasting unparalleled levels of productivity and quality. The new varieties produced by the cross-breeding programmes launched in 1956, at least in France, did not have this impact. From 1974, for the pioneering work of Alain Bouquet, and from the beginning of the new millennium for French viticulture research, the increasing demand of society for sustainable development and a reduction in the use of pesticides renewed the technological paradigms of plant breeding along with the attention paid by policy-makers and researchers to this road to progress that had been almost completely abandoned in France.

4. Social demand

Until recently, the range of pesticides available (fungicides and insecticides) ensured that winemakers enjoyed a high-quality harvest while protecting yields. It is only relatively recently that the wine-making sector has become aware of the need to reduce the use of pesticides. Winemakers and their workers have often been unaware of the risks to their health. The 2001 ban on the use of sodium arsenite (a carcinogenic product) in the wine-making sector to treat the main vine trunk disease (Esca) only served to confirm the general criticisms levelled at pesticides by ecologists. There were also some complaints relayed by the press with regard to a slight intoxication suffered by schoolchildren when the product was sprayed near their school. The data concerning the proportion of pesticides used by the wine-making sector in Europe have also heaped further disgrace on the sector.

The Ministry of Agriculture launched the Ecophyto 2018 plan with a view to satisfying this social demand, requiring a commitment from the stakeholders to reduce the use of pesticides across the country by 50%, if possible within a time frame of ten years. The fear of facing legal proceedings, as in the case of asbestos, for having failed to provide agricultural workers with sufficient protection against these risks further increased awareness within the sector, drawing operators' attention to all possible improvements in this sphere as well as the potential contributions of new resistant varieties. The reduced use of pesticides in the wine-making sector has therefore come to represent an essential social demand.

5. Plant breeding is a long process

In France in 1956, researchers at the INRA launched a plant breeding research programme. The aims of this programme were to create new varieties that were at least "equivalent" to existing varieties, in particular the predominant grape variety at that time, the Carignan, such that these varieties offered at least the same yield. Table wine yield was the main "cost divider", and thus a factor of income. The varieties had to be "grown upright", to avoid tying, and goblet-trained, a cheap pruning method broadly used in southern France. The grapes were to ripen earlier as in southern areas, the harvest took place two years out of five during or after the autumn rains, often leading to damage caused by grey mould (Botrytis cinerea). Furthermore, it would be a bonus if this variety were less susceptible to the most common diseases (downy mildew and powdery mildew). Finally, the organoleptic qualities were required to be equal too, if not better than, those demonstrated by the existing varieties.

The line of research adopted was that of intra-specific hybridisation. The main justification for this resulted from French legislation which had banned most inter-specific hybrid varieties resulting from post-phylloxera works producing wines deemed to be of insufficient quality. Furthermore, to emphasise this distinction, plant breeders described these varieties as "cross-breeds" and not hybrids.

This programme encountered variable success, but a series of new varieties appeared with differing dissemination rates. If we take the example of the Marselan, the original cross-breed (Cabernet × Grenache) was performed in 1961 with stage 2 comprising 12 seedlings reached in 1971 and stage 3 comprising 150 seedlings achieved in 1974. The micro-vinifications conducted from 1978 to 1982 recognised the high quality of this grape variety. Professional opinion was nevertheless negative, with the yield deemed too low. The INRA continued its experiments and succeeded in having the variety entered in the catalogue in 1991. Twenty-two years later, in 2013, this variety covers a surface area of 3,226 ha in Languedoc-Roussillon, representing 1.37% of the vineyards in this region. In 2013; the other four main varieties created exhibited dissemination rates of 0.93% (Caladoc), 0.21%

(Chasan) and 0.19% (Chenanson) in 2013 while the Aranel variety did not even appear in the statistics!

6. The causes underlying the failure

A combination of several explanations highlights the reasons for this failure. There are causes proper to the technological paradigm and others linked to the institutional environment framing the market conditions which had changed since the selection made 30 years previously and the registration in the catalogue.

Having chosen the cross-breeding approach, a decision which was entirely understandable in the economic and regulatory context of 1956, the researchers deprived themselves of the possibility to incorporate genes offering resistance to diseases or certain climate conditions which were absent from the vinifera species but present in other species of the Vitis genus. Researchers in other European countries adopted a different strategy (a different paradigm) by conducting inter-specific crossings followed by "back-crossing", or what modern-day geneticists refer to as "introgression". By reintroducing V. vinifera genes, they obtained varieties with a high percentage of V. vinifera genes after several periods ($\geq 99\%$), and thus wines offering vinifera quality, but with factors of resistance from the other Vitis species, except for phylloxera, although this problem was overcome by means of grafting. This line of research was followed in work conducted in Germany and Switzerland.

The economic conditions changed profoundly over 30 years. From a period of relative shortage at the creation of the common market, Europe was confronted by structural overproduction linked to the plantations of the 1960s, increased yields and most importantly the fall in wine consumption in all wine-producing countries. Policy focused on quality wines, local wines and registered designation of origin wines (AOC), characterised by a limited yield and use of the major grapes derived from the traditional varieties of the AOC regions which had become international standards.

Vine-training methods have changed considerably, due to both the use of these grape varieties from AOC regions and in particular the introduction of harvesting machines from 1972 onwards. Statistics from the Champagne region show that since 1981, global warming has gradually brought the harvest date forwards. The early ripening factor is consequently becoming less important.

The varietal wines market has gradually overtaken the table wine market in France since the beginning of the 1980s. This market was based on the reputation of the major varieties such as Cabernet-Sauvignon and Merlot for red wines and Chardonnay and Sauvignon for white wines. Marselan and Chasan were still unknown.

The French law of 6 May 1919, which defined the AOC, or registered designations of origin, was based on "local, fair and constant" practices. By definition, this does not include the new varieties. However, it is these wines (now classified as AOP, or protected designation of origin) which represent the best quality, reputation and valuation on the market.

It was even many years before the Pays d'Oc wines, which base their reputation on varietal wines, finally accepted these grape varieties in their classification. They were followed by the AOCs: Marselan has only been authorised in the Côtes du Rhône region since 2010, up to a maximum of 10%, while Caladoc is still subject to testing for this designation.

Indirectly, until 2015, the absence of plantation rights for table wines – wines without geographical indication – WwGI - was not conducive to the dissemination of this variety of grape in the category for which it was initially intended. This absence of plantation rights was compounded by the concomitant lack of subsidies for vineyard restructuring within the framework of the common organisation of the wine market.

More generally speaking, the natural renewal rate of French vines is 2.5%, with an average life of forty years. The choice of variety is a key decision for a long period. New varieties are competing with well-known varieties and new trends are slow to take root.

7. A return to inter-specific hybridisation in France

The practical question for present-day winemakers is thus one of choice: which variety of resistant vine should they plant? Three possibilities are open to them: to plant those that already exist, to wait a little and plant those that will be "arriving" or to wait a little longer and plant those that are currently being created.

Plant breeding is indeed a long process that used to take 20–30 years (cf. the example of Marselan) and now takes only 10 to 15 years thanks to marker-assisted selection. Crossings performed in year 1 are followed by early selection (2–3 years), then a study of the wine's resistance and quality (4–9 years) and finally the VATE tests assessing the agronomic, technological and environmental value (10–15 years), leading to the registration in the catalogue by the CTPS, the permanent technical selection committee – vines.

In France, the use of vine varieties is based on two procedures: (1) *registration in the national catalogue* or that of another member state of the European Union, which supervises the multiplication and distribution of plant material and (2) *classification*, which facilitates marketing.

Those winemakers interested therefore have access to foreign varieties, primarily German and Swiss. An inventory was conducted under the impetus of the Institut Coopératif du Vin. Published in 2013, the work describes 56 varieties exhibiting resistance, often partial, and the advantages of their wines.

A professional dynamic has gradually developed, driven by a winemaker who took a major risk eight years ago by planting ten of these varieties over an area covering thirty hectares without any subsidies or any guarantees that he would be able to continue selling his wines for more than 15 years if these varieties were not registered in the catalogue. His vines are visited, his wines tasted and the unions are urging the administrations to lift the restrictions.

The CTPS has introduced a new accelerated temporary classification procedure with the results subject to confirmation. In June 2016, the CTPS studied 14 cases of existing

foreign varieties, issuing a favourable opinion for the immediate and definitive classification of four varieties and the temporary classification of seven others while a further three raised a problem of denomination. Furthermore, eight traditional foreign varieties already registered in the French catalogue received a favourable opinion for immediate and definitive classification along with three traditional local varieties. Four new varieties developed by the INRA, currently undergoing the VATE process, were proposed for temporary classification.

The classification was the green light eagerly awaited by winemakers to begin plantations with a view to quickly expanding the referential and the acquisition of broader experience.

8. Why does the INRA appear to have taken a back seat?

As early as 1974, Alain BOUQUET, Director of Research at the INRA in Montpellier, revived the research programme by extracting genes from Muscadinia rotundifolia offering resistance to numerous parasites and diseases, including mildew and powdery mildew. He then applied the classic method of back-crossing with traditional high-quality vinifera varieties.

In the organisation of French wine genetics at the INRA, it was the team in Colmar which, in the year 2000, took over the work begun by Alain Bouquet in Montpellier and Jean-Pierre Doazan in Bordeaux. The ResDur programme (standing for RESistance DURable, or sustainable resistance) took over the new varieties created by Alain Bouquet with the resistances derived from Muscadinia, which it combined with German varieties, Regent and Bronner, which drew their resistance from American or Asian Vitis species.

The aim of this programme is to take account of the study results showing that combining several resistance genes – a process referred to as pyramiding – improves resistance and reduces the risk of it being circumvented.

The first crossings were conducted in three batches during the first ten years of the 21st century. The first crossings are now in the final VATE stage of selection, i.e. they are being tested for their agronomic, technological and environmental value. Twelve varieties are candidates and should be registered in the French catalogue in 2016. The other candidates should follow between 2020 and 2023.

The CTPS responded favourably to the pressure from the professionals by offering the possibility of already planting resistant varieties. However, the philosophy of the INRA is still to maintain the pyramiding system and only to disseminate varieties exhibiting polygenic resistance… despite the scientific controversies surrounding this subject.

9. The future arrival of Italian varieties

At the IGA – the Istituto di genomica applicata at the University of Udine – work began again at the beginning of the new millennium. Selection was based on the crossing of local or international varieties such as Tocai, Sauvignon blanc, Merlot and Cabernet Sauvignon, with German or Hungarian varieties already "introgressed" and known for their resistance: Bianca, Regent or 20-3.

Ten resistant varieties have thus been presented for registration in the Italian catalogue: Fleurtai, Soreli, Early Sauvignon, Petit Sauvignon, Sauvignon doré, Petit Merlot, Royal Merlot, Petit Cabernet, Royal Cabernet and Julius (see below for the debate concerning their names). In collaboration with the University of Udine, VCR (Vivai Cooperativi Rauscedo), the leading cooperative of nurseries in Italy, is testing the new varieties that are resistant to cold weather or fungal diseases (monogenic or polygenic). The VCR's experimental winery can vinify up to 400 micro-vintages per year and perform the oenological assessment of new selections. The new varieties are of the Chardonnay, Cabernet and Sangiovese type. Thirty four hybrids are in the process of being tested.

These varieties will compete with or complement the range of new varieties available to French winemakers. The development of contracts between the researchers and the nurseries is certainly favourable to a rapid dissemination process.

10. Partnerships for the creation of regional resistant varieties

Furthermore, in the longer term, six INRA-IFV-value chain programmes 2015–2030, funded by the wine-product interprofessional organisations, have been launched to promote oligogenic resistance stock obtained by the INRA and the IFV through absorption crossings with emblematic varieties in order to select new varieties complying with the ideotypes of the major French wine regions.

11. The war of names is not over

In this race to adopt new resistant varieties, having settled the question of the term "hybrid", the question is now raised of the new names adopted. The new Italian varieties are qualified by a double name, one of which is none other than the name of an outstanding and renowned variety, for example merlot kanthus, cabernet volos, sauvignon kretos, cabernet jura and cabernet cortis.

On the one hand, the authorities want to protect consumers and not mislead them. On the other hand, the experience of the new cross-bred varieties of the 1980s, rejected by the promoters of varietal wines, makes professional leaders aware of the interest of playing on this notoriety already acquired. The idea they would like to promote is that it is more or less the same variety or an equivalent variety to which has been added a resistance to fungal diseases.

12. Piwi – a labelling system

Recognition of these wines produced without pesticides is not included in the current labelling system for geographic indication wines or designation of origin wines. However, the pioneers have already found solutions to enhance the promotion of these wines by creating brands such as "Au creux du nid" as well as emphasising the PIWI label, standing for

Pilzwiderstandsfähig (resistant to fungal disease), and the gold medals awarded during the international PIWI competition.

13. Conclusion

The time lag between implementing the scientific paradigm and obtaining the prototype thirty years later no longer appears in the creation of resistant varieties, so high is the social demand. In one of its recent issues, the regional professional review of Côte du Rhône wines led with an article entitled "The revolution of resistant varieties has begun". We could add that it is well underway with regard to the supply of technology as the key moment of registration and classification has finally arrived. The conditions for the general adoption of these varieties are not yet all fulfilled. We are currently dealing with a turbulent innovation mechanism clearly described by the model of Klein and Rosenberg. Generations of varieties are arriving, offering a hyper-choice, and will be subject to tests in different contexts; the learning processes are at work. We are witnessing a scientific and technical revolution similar in scope to the biological solutions provided to the phylloxera crisis in the 19th century. Every winemaker with a plot to plant will be faced with these questions.

Will the choice of these varieties be decisive in the selection of companies who did not make it? Probably not in the short term but in the longer term, consumer preference for wines produced without pesticides and social pressure concerning environmental protection will be decisive.