How big is the 'lemons' problem? Historical evidence from French appellation wines

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Abstract

This paper provides an empirical measure of the economic surplus loss arising from the failure of a competitive market to supply quality in the presence of asymmetric information. When consumers cannot observe product characteristics at the time of purchase, incentives for atomistic producers to supply quality may be suppressed. We use variation in wine prices across administrative districts around the enactment of pioneering regulations aimed at resolving asymmetric information problems in the French wine market to identify related welfare losses. Difference-in-differences results indicate large potential losses from the quality-related market failure, suggesting an important role for credible certification schemes.

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In his seminal paper "The market for lemons: quality uncertainty and the market mechanism," George Akerlof formalized the notion that a consumer's inability to ascertain objective quality differences in products may "drive the good product out of the market," resulting in a socially undesirable outcome (Akerlof, 1970). The idea behind Akerlof's paper is that if buyers cannot distinguish good products from bad, they will tend to value a product as having average quality. If sellers of the good product have reservation prices that, despite being lower than buyers' valuation of it, lie above buyers' valuation of the average-quality product, they cannot profitably trade with them. In equilibrium, the bad product is sold yet the good product remains in the hands of sellers, despite having higher social value in those of potential buyers.

At the time of its publication, Akerlof's piece was famously dismissed by some economists as either trivial or wrong.[1] Half a century later, no economist would argue that Akerlof's description of the quality-related market failure was conceptually wrong. Nonetheless, its relevance might still be debated, and indeed empirical evidence of the existence of lemons' markets, let alone of their welfare significance, is scant.[2] The present paper argues that Akerlof's quality-related market failure may indeed have greater empirical relevance than previously acknowledged.

[1] See, for instance, https://en.wikipedia.org/wiki/The_Market_for_Lemons.

[2] This lack of hard evidence may partially explain why, in many developed countries and in several supranational authorities, political support for public regulations aimed at resolving asymmetric

We start by highlighting the fact that, in addition to its clear potential to suppress trade—illustrated in Akerlof's paper in the context of an exchange economy—asymmetric information about product quality can also deter *production*. Intuitively, if buyers cannot tell quality differences at the time of purchase, and quality is costly to supply, atomistic producers have no incentive to supply it. The resulting market equilibrium may involve an exchange of goods, yet there may be forgone gains from producing—and trading—higher-quality goods instead.

We argue that such a lack of incentives to supply quality was at play in the French wine market during the decades preceding the adoption of a 1935 law aimed at codifying production rules and implementing official controls for fine wines benefiting from a reputable geographical appellation—like *bordeaux* or *bourgogne*. We show that this pioneering law, the first of its kind to be adopted in the world and the enduring template for any regulation pertaining to geographical designations, profoundly and durably changed the nature of the French wine market. Our analysis, which involves a careful counterfactual comparison of district-level wine prices before and after the reform, also reveals the extent of the market failure preceding its adoption, something that existing studies, even those providing empirical evidence of a lemons' effect, have been unable to deliver.

In a sense, the French wine market is the setting *by excellence* to study the effects of quality-related market inefficiencies. Wine is a highly differentiated product, with the area of origin potentially playing a salient role in signaling quality. Yet it is difficult for the average consumer to know quality at the time of purchase, even with a geographical indication. Incentives to free-ride on a region's reputation are large as production is atomistic and costs per hectoliter vary according to the varietal planted, the type of terrain (due to the varying opportunity costs of land for alternative crops), or the techniques used to turn grapes into wine. Without clear labeling rules, it is easy to plant high-yielding but low-quality grapes on bad terrains and resort to subpar wine production techniques while claiming a heretofore reputable origin. And indeed the history of wine production—and France is no exception—is riddled with anecdotes of such profitable behavior. Economists should hardly

information about product quality, say through process and product composition rules, has been weak, especially relative to that granted to rules pertaining to product safety. This is perhaps no clearer than in Codex Alimentarius, a joint FAO/WHO program aimed at adopting food standards applicable for international trade, and in the ongoing debate about the opportunity to protect "place names" for wines and other food products. For many years, disagreements with respect to the appropriate protection to be granted to geographical indications have spoiled bilateral trade negotiations between the US and the EU. See, for instance Josling (2006) and Congressional Research Service (2016).

be surprised. Whether these well-documented anecdotes add up to economically meaningful effects, and if so, whether some form of government intervention may be effective at correcting them, is perhaps a more debatable proposition, which the present paper aims to address.

To that effect, we assemble a long panel of yearly average wine prices at the level of the department—a French administrative unit roughly the size of a US county—to identify the extent of the quality-related market failure. Following a difference-in-differences strategy, we regress the departmental price of wine on the share of a department's vineyards eligible for recognition under *appellation d'origine contrôlée* (hereafter AOC), the official designation for appellation wines created by the 1935 Law.[3] For departments with AOC recognition, this share becomes nonzero in the years following the enactment of the 1935 Law. Because it took time for the administration to define the 213 appellations present during our sample period, this measure of eligibility does not go from zero to its final value within a year, but instead grows as more appellations are being recognized over time. The fact that departments have varying shares of vineyards eligible for an AOC (many having shares equal to zero, others one, and many others in between) and the temporal roll-out of the reform allow us to flexibly control for potentially confounding factors through year fixed effects differentiated by broad wine region (*vignoble*). We also control for wine production to capture swings in wine prices arising from weather shocks and the possibility that the reform may have reduced wine output.

Our main results imply that the market price of appellation wine in France increased significantly due to AOC recognition, by a value roughly equal to 44% of the average price of wine. This figure suggests that appellation wines for which production was ultimately regulated had been produced at an inefficiently low quality prior to regulation, consistent with historical accounts of widespread abuse in the appellation wine market in the decades leading to the reform. Importantly, we do not find any evidence that the reform decreased wine production, which implies that the price increase cannot be attributed to a reduction in the quantity of wine sold. We are also able to reject a competing hypothesis according to which the price increase was the result of the *déclassification* of wines, that is, the denial of

[3]There were several legislative attempts to define appellation wines prior to 1935. None of them included official controls or a systematic definition of production requirements. In many cases, definitions merely included broad geographical delimitations, which encouraged free-riding on other important aspects of quality provision within the delimitated zones, and led to a worsening, not an improvement, of the asymmetric information problem (Capus, 1947).

an appellation label for wines sold under an appellation prior to the reform.

At the end of our study period, the share of vineyards eligible for AOC recognition was 31.6%.[4] Together with our estimated price effect, this figure implies a welfare loss of close to 14% due to asymmetric information. This is a *gross* welfare loss in the sense that it does not account for the added cost of quality-enhancing practices required for wines sold under the AOC label. While these cost increases could be substantial, the fact that a large share of eligible producers decided to durably abide by the rules of controlled appellations—as opposed to producing cheaper, ordinary wines—clearly suggests that the policy was beneficial to wine producers, and welfare-enhancing.

The paper is organized as follows. Section 1 provides some historical institutional background. In Section 2, we formalize the asymmetric information problem in the context of endogenous quality provision using a simple model of vertical differentiation. (Alternative models are presented in Appendices.) Importantly, we highlight how the model can be brought to the data and key parameters estimated to derive meaningful gross welfare effects using available average price data. Section 3 exposes our identification strategy, the construction of our dataset, and our empirical results, including a series of robustness checks. Section 4 concludes.

1 Historical and institutional background

The AOC system was created by a 1935 French law as the outcome of a longstanding debate on the recognition and preservation of premium quality wine-producing areas, known as appellations. Two issues were particularly debated: (i) the geographic borders of these areas and (ii) the set of eligible vineyard and wine-making practices. The search for a consensus on these questions caused a series of regulatory trials and errors throughout the 20^{th} century that led to the coexistence of a set of certifications of origin, the AOC being the one lying at the top of the hierarchy.

Before any regulation on wine appellations was adopted, France's most renown vineyards (*vignobles*, meant here as potentially large sets of parcels), whose place names were already used to identify the wines produced therein, suffered from problems of free-riding and malpractice. These problems became widespread

[4]Not all vineyards eligible for AOC recognition claimed the AOC label, but our 44% appreciation estimate is an average that includes eligible wines not claiming an AOC.

during the acute production shortage of the late 19th century.[5] This crisis generated strong incentives among wine producers to increase production while lowering quality.[6] Malpractice was so prevalent that in 1889, French authorities had to pass a law defining wine as the exclusive produce of grape juice fermentation. During this episode, quality vineyards were especially harmed since the general trend was to produce lower quality wines at higher yields. Furthermore, at the time there existed no legal definition of appellation wines. Unsurprisingly, counterfeiting was common as famous names were often usurped by producers located in other wine regions, or were used without consideration for the production techniques and attendant wine characteristics that had brought reputation to the place.

In 1905, the first general law on the prevention of fraud and falsification in France was adopted. Although the scope of the law was much broader than the protection of wine appellations, it provided for a mechanism by which the French administration would take on the task of delineating the geographical limits of each wine appellation.[7] Those boundaries were to be defined by administrative decrees. A few appellations were thus delimited, starting with the *champagne* appellation in 1908, followed by *banyuls*, *cognac* and *armagnac*. The administration then delimited *clairette de Die* in 1910 and *bordeaux* in 1911 (Humbert, 2011). However, this top-down definition of appellation regions was unsatisfactory to many stakeholders. They led to the Champagne riots, as producers in excluded regions felt they had been wrongly denied the appellation. Administrative delineations also failed in the Bordeaux region. In addition to generating political unrest, administrative delineations had a fundamental weakness: they established a legal right to utilize a place name solely based on communal delimitations, irrespective of the type of terrain, grape varietal, or production practices. Not surprisingly then, unscrupulous producers located in eligible regions started to use famous names to identify mediocre wines. This situation raised concerns among higher-quality producers, who wished for precise eligibility conditions for appellation wines (Capus, 1947).

A 1919 law removed the authority to define appellation wines from the administration, and instead gave it to the courts. Any stakeholder who thought they were being hurt by the abusive use of a place name could file a lawsuit. Courts were

[5] In the 1860s, a pest imported from America called phylloxera started to ravage French vineyards, eventually causing production to be cut by half between 1875 and 1890.

[6] A common way to increase volume while maintaining the alcohol content of wine was to add sugar to the must and dilute wine with water. Another way was to fabricate wine from raisins.

[7] This task was defined in a 1908 amendment to the 1905 Law.

given the right to not only define geographical boundaries but also to take account of local, loyal, and constant uses. Unfortunately, most judges refrained from defining production practices, and in effect, for most appellations the court only specified geographical boundaries.[8] As a result, in the early 1930s most appellations only had requirements pertaining to the eligible area. This period also saw a rise in the number of new appellations claimed by producers as a way to escape the stringent production controls applicable to ordinary wines starting in 1931 with the *Statut Viticole*. This situation led to what is known as the "appellation scandal," that is, the proliferation of unwarranted appellations, which further eroded the reputation of historical, legitimate appellations.

The 1935 Law introduces a new category of so-called "controlled origin appellations" (*appellations d'origine contrôlée*, or AOC), without—at first—eliminating the existing appellations. These new appellations are to be defined by decree, but unlike the early administrative delimitations, the decree merely sanctions a set of production requirements, including detailed geographical boundaries at the parcel level, that emanate from a committee composed, by order of importance, of representatives of local wine associations and wholesalers, members of Parliament, and representatives of the administration—the CNAO, *Comité national des appellations d'origine*. As such, the definition of the requirements applicable to each AOC is left to a technical body of experts that includes representatives of each wine region.[9] In contrast to existing appellations, now referred to as "plain appellations" (*appellations simples*), AOCs are subject to official control, including tasting requirements. Wines are eligible for an AOC if they are grown in the eligible region, according to the specified practices, and meet a set of criteria pertaining to, e.g., alcohol content. The AOC is not compulsory in the sense that producers may elect to sell their wines as ordinary wines, or under a plain appellation (without control) if they can claim one. Typical requirements for an AOC, beyond geographical area and terrain, are the grape varietal, the specification of a maximum yield per hectare, and minimum levels for alcohol and sugar contents.[10]

[8] Another law passed in 1927 explicitly allowed judgments to include a list of specific grape varieties in the definition an appellation, but this precision was left optional, and very few judges resorted to it.

[9] The CNAO was initially financed by a tax on the sales of AOC wines of 2 francs per hectoliter. Its agents were sent to carefully delimit each AOC at the parcel level and to control the production conditions.

[10] In the late 1920s, some appellation wines were produced at very high yields, between 120 and 200 hectoliters per hectare but with only 7% of alcohol content in volume (Capus, 1947). The minimum

Soon after the 1935 Law, many appellations were officially recognized by an AOC decree: 77 AOCs were created in 1936 and 58 others in 1937. These new AOCs did not exactly replace the former appellations of the same names: both an AOC and a plain appellation could coexist under the same name in the same region. For instance, after the creation of the *bordeaux* AOC in 1936, Bordeaux wines that did not meet the strict requirements of the AOC could still be sold under the plain appellation. This coexistence of both plain and controlled appellations, known as the "double appellation regime," although arguably confusing, was necessary to garner political support for the new system as it allowed producers willing to claim the AOC to transition to the new requirements. However, it was soon to be abolished. A first law passed in 1938 allowed the CNAO to forbid the use of a plain appellation at the request of the most representative local producer organization. This option was immediately adopted in many small, upper-quality regions, and by the end of 1939, half of the AOCs had gotten rid of their plain appellation counterparts. However, large regional appellations like *bordeaux* and *bourgogne* survived the creation of their AOC counterpart as no consensus was found in their respective local unions in favor of abolition. This situation was put an end in 1942 when a new law granted the CNAO the right to unilaterally suppress a plain appellation wherever an AOC also existed under the same name. All remaining duplicate appellations were eliminated the next year. Thus, the only surviving plain appellations were those for which no AOC had yet been created. The AOC label quickly became the standard for premium quality wines and by 1940 the production of AOC wines already exceeded that of plain appellation wines (Humbert, 2011).

By 1940, 151 different AOCs had already been created, a testimony to the large amount of regulatory work undertaken by the CNAO.[11] Nonetheless, the CNAO was led to reject several AOC requests, as some less-known vineyards were found too heterogeneous and therefore unfit to bear the AOC label.[12] Note that AOC delineations are not mutually exclusive: a given parcel may be eligible for several appellations. For instance, a parcel located on appropriate terrain in the commune named Pauillac is eligible for the following appellations: *bordeaux*, *bordeaux*

alcohol content for AOC wines was typically set to between 10% and 15%, and the maximum yield between 20 and 50 hectoliters per hectare. These figures are still current standards for AOC wines.

[11] The 300^{th} wine AOC was created in 2015. The concept of AOC has been extended in 1990 to all agricultural products such as cheese, fruits, or olive oil, and is now in use in all the European Union.

[12] The examination of an application included a tasting session and an assessment of the reputation of the wines produced in the candidate region (Humbert, 2011).

supérieur, *haut-médoc*, and *pauillac*.

In 1949, a new intermediary quality label called VDQS (*vin délimité de qualité supérieure*) was introduced to reward the best non-AOC vineyards. Three different certifications of origin then coexisted for a few years: plain appellation, VDQS and AOC. The first two remained smaller in volume, whereas the AOC label established itself as the standard certification for premium quality wine.[13] From the years following the 1935 Law to the year 1969 that marks the end of our observation period, AOC wines represented on average between 10 and 15% of total French wine production.

2 A model of a lemons market with endogenous quality

We model wine production at the level of a French department. Vineyard acreage is assumed to be inelastic, and we further assume that yields are fixed (they may vary across space, but are constant across time). As we show in the empirical section, these assumptions, though perhaps unexpected, appear warranted by our data. Since there are no quantity effects, we can focus on the impact of regulation on wine quality.

For simplicity, we assume that there are two broad categories of wines, (i) ordinary wines grown in places where climate and soils can only yield mediocre wine, and (ii) appellation wines grown in places endowed with beneficial natural factors such as climate and soils (called *terroir*), the effect of which may or may not be further enhanced by appropriate production practices, such as varietal choice, harvesting techniques, etc. The second category of wine is distinguished from the first at wholesale and retail by the use of a place name referring to the *terroir* from which the wine originates. In a department, there may be more than one appellation. In our model, ordinary wines have a fixed quality, are produced at a constant marginal cost, and cannot be enhanced through costly practices.[14] In contrast, appellation wines may be enhanced through production practices that increase the unit cost of production.

[13] In the 1950s and throughout the 1960s, the production of VDQS wines only represented between one third and one half of the production of AOC wines (Humbert, 2011). The production of plain appellation wines also remained about half that of AOC wines. The plain appellation and VDQS labels were abandoned in 1973 and 2011, respectively.

[14] Technically, we could allow for the possibility of quality enhancement, but the free-rider problem would prevent any producer from profitably adopting them.

We further assume that there are many identical consumers, each with unit demand for wine, and that there are more consumers than units of wine produced.[15] Therefore, wines are sold at a price equal to their consumer valuation, and some consumers are not served. The consumer valuation of ordinary wines is denoted p_0, and that of appellation wines (that bear the name of the *terroir* they are produced in) have valuation p_1 when no costly production practices are used.

Note that before any regulation on production practices is enacted, a market equilibrium cannot involve any costly practices for appellation wines. The reason is that a single producer engaging in such practices would have an incentive to shirk since consumers cannot tell quality differences among appellation wines at the time of purchase, and there are many wines claiming the same appellation.[16] We assume that $p_1 \geq p_0$, that is, appellation wines cannot be of lower quality than ordinary wines.

We denote by s_1 the share of appellation wine produced and by $s_0 = 1 - s_1$ the share of ordinary wine produced. Although appellation and ordinary wines may be sold at different prices (the case $p_1 > p_0$) since appellation wines are distinguishable by their place name, in the data we only observe the average price of wine, $p_m \equiv p_0 s_0 + p_1 s_1 = p_0 + s_1(p_1 - p_0)$.

Upon enactment of the 1935 Law and subsequent decrees, the use of a place name is restricted, for wines bearing the AOC label, to wines produced according to certain practices that provide higher quality. In contrast, for plain appellations no specific production techniques are mandated, and therefore no explicit control is necessary. The 1935 Law therefore creates a difference between two types of appellations, plain appellations and AOCs, that may sell at different prices.

We would expect the 1935 Law to leave unaffected consumers' valuations of ordinary wines and plain appellations. In contrast, wines sold under the AOC label, which were previously sold as plain appellations, may have higher valuation after the reform, say $p_2 \geq p_1$, because producers of AOC wines abide by additional production requirements that supposedly increase wine quality. After regulation, denoting by s_2 the share of AOC wine (with $s_2 \leq s_1$), we can write the average price

[15] This assumption may seem at odds with the observation that in some years, there may exist production surpluses, leading to very low wine prices. Our model is a "one shot" representation of a multi-year market equilibrium where production is inelastic and not subject to weather shocks.

[16] One implicit assumption is that individual producers of appellation wines cannot reliably signal quality to consumers, perhaps because of the sheer number of producers in a given appellation region, which makes it very difficult for a single producer to create a reputation beyond the collective reputation of the appellation.

of wine in a department as

$$\begin{aligned} p_m &= (1-s_1)p_0 + (s_1-s_2)p_1 + s_2 p_2 \\ &= \underbrace{p_0 + s_1(p_1 - p_0)}_{\text{independent of regulation}} + s_2(p_2 - p_1) \end{aligned} \tag{1}$$

The first two terms in Equation (1) depend only on a department's appellation share and exogenous characteristics, while the last term depends on the extent of regulation. The effect of the reform on the department's wine price is $\Delta p_m \equiv s_2(p_2 - p_1)$. If all appellations in a department become eligible for an AOC, then $s_2 = s_1$. More generally, we expect $s_2 \leq s_1$, because in practice not all appellations were deemed worthy of control.[17]

We are interested in an empirical measure of the value $p_2 - p_1$, which captures consumers' valuation of the quality of an appellation wine that fails to be incentivized under asymmetric information. We estimate Equation (1) using yearly panel data at the department level over a long period of time beginning prior to the 1935 Law and ending several decades after it, once all the main AOC wines have been defined. Our empirical strategy involves absorbing the first two terms of Equation (1) in a department fixed effect and capturing the last term by using as a regressor the share of a department's wine production eligible for AOC in a given year. This regressor assumes the value of zero before the reform and then increases to the value s_2 as decrees are enacted that regulate more and more AOCs. The coefficient on this regressor, say π, can directly be interpreted as the increase in consumers' valuation of an appellation wine due to the reform, that is, the quality-enhancing practices that the reform leads producers to adopt. The product of the coefficient π by the quantity of AOC wine directly translates into a partial (or gross) welfare increase:

$$\Delta \text{GW} = Q s_2 (p_2 - p_1) \tag{2}$$

where Q denotes total wine output and $p_2 - p_1$ is given by the estimate of π. In our model with perfectly elastic demand for wines of a certain (known) quality and perfectly inelastic supply, all welfare accrues to producers. Our measure of welfare improvement is partial because it does not account for the cost of quality-enhancing

[17] We could have further differentiated the valuations of plain appellations and AOC wines before the reform, based on the idea that wines eligible for an AOC likely benefit from different natural factors than those only worthy of a plain appellation. This refinement would complicate the model without adding anything to our argument or the interpretation of our regression coefficients.

practices adopted on the share s_2 of production.[18]

[Figure 1 about here.]

Figure 1 depicts the gross and net welfare losses from asymmetric information, in the case where $s_2 = \frac{s_1}{2}$, that is, only half of appellation wine production is deemed worthy of an AOC. Total wine output is normalized to one. Since the price of ordinary wines does not change with regulation, only the market for appellation wine is depicted. The net welfare loss from asymmetric information, which is resolved by regulation, is the difference between the area shaded in blue (which represents the welfare from the trade of regulated wine under full information) and the area shaded in green (the welfare from the trade of this wine under asymmetric information). The gross welfare loss only relates to differences in consumer valuations (or market prices) and is given by the sum of the areas shaded in blue and yellow. The red dot depicts the equilibrium price of appellation wine under asymmetric information.

Note that Equation (2) can also be used to derive the relative change in gross welfare

$$\frac{\Delta \text{GW}}{\text{GW}} = \frac{Q s_2 (p_2 - p_1)}{Q\left[(1 - s_1)p_0 + s_1 p_1\right]} = \frac{\Delta p_m}{p_m} \approx \Delta \log p_m \tag{3}$$

where $\Delta \log p_m$ represents the change in the department's log average price attributable to regulation. Thus, a fixed-effects panel regression of $\log p_m$ on the share of a department's wine production eligible for a controlled appellation (with appropriate covariates to control for confounding factors) will yield the partial derivative $\frac{\partial \log p_m}{\partial s_2}$, which multiplied by the ultimate share of production eligible

[18] A legitimate concern is that not all wines eligible for AOC recognition end up being sold as AOC wines. For instance, some producers choose not to submit their production to official control and instead continue supplying baseline quality valued at p_1 because the associated costs would make AOC production unprofitable for them. The coefficient π should then be interpreted as the average valuation difference for eligible wines, accounting for the fact that some remain plain appellations. Formally, denote by $0 \leq \sigma \leq 1$ the share of eligible wine actually sold under AOC, and call p_3 the price of AOC wine. Then, $p_m = (1 - s_1)p_0 + (s_1 - s_2\sigma)p_1 + s_2\sigma p_3 = p_0 + s_1(p_1 - p_0) + s_2\sigma(p_3 - p_1)$, $\Delta p_m = s_2\sigma(p_3 - p_1)$, and $\Delta \text{GW} = Q s_2 \sigma (p_3 - p_1)$. Therefore, the coefficient on the eligible share, π, can still be used for welfare inference. If, in addition, a share $1 - \sigma$ of wines eligible for AOC recognition end up being sold as ordinary wines rather than plain appellations, perhaps because no plain appellation applies to them after the reform, the average valuation for ordinary wine will increase to $\bar{p}_0 = \frac{(1-s_1)p_0 + s_2(1-\sigma)p_1}{1 - s_1 + s_2(1-\sigma)}$, so that the average wine price will still be $p_m = (1 - s_1)p_0 + s_2(1 - \sigma)p_1 + (s_1 - s_2)p_1 + s_2\sigma p_3 = p_0 + s_1(p_1 - p_0) + s_2\sigma(p_3 - p_1)$. This case is functionally similar to the previous one.

after the reform becomes a predictor of $\Delta \log p_m$ and thus of $\frac{\Delta GW}{GW}$.[19]

Before moving to the empirical part of this study we wish to make two remarks. First, the mere observation that the price of eligible appellations rose after the reform—assuming we could observe appellation wine prices, which we do not—would not be sufficient to conclude that the reform had had any effect on wine quality or welfare. Indeed, such a finding could be the result of the market moving from a pooling equilibrium where all qualities are sold at the average valuation to a separating equilibrium where each quality is sold at its own valuation p_0, p_1, or p_2. Although such an equilibrium shift would have obvious distributional impacts, efficiency would not be affected as long as qualities were exogenously determined and unaffected by the reform. It is thus important to estimate the effect of the reform on *average* wine prices—which we do observe—to test the welfare-enhancing character of the reform. Intuitively, the fact that the average wine price is found to increase with the share of vineyards eligible for AOC recognition establishes the wealth-creating effect of the reform.[20]

Second, the derivation of ΔGW in Equation (2) assumed that all consumers have identical tastes. In Appendix A, we formally derive the expected welfare effects from wine regulation in a model where consumers have different tastes for quality. Importantly, we show that the gross welfare measure ΔGW derived above constitutes a lower bound to the gross welfare change when consumers are heterogenous in their valuation of quality.

[19] Note that in that case, we can interpret the coefficient on s_2 as the price premium relative to the average price of wine. This is because $\log p_m = \log\left(p_0 + s_1(p_1 - p_0) + s_2(p_2 - p_1)\right)$, and thus $\frac{\partial \log p_m}{\partial s_2} = \frac{p_2 - p_1}{p_m}$.

[20] If consumers are heterogenous with respect to their taste for quality, then, as we show formally in Appendix A.2 the average price of wine will rise without any quality changes if some wine previously sold under an appellation becomes ineligible and is sold as ordinary wine (there is historical evidence of such *déclassification* at least in the Bordeaux region). We show that in that case, welfare would also increase as quality-valuing consumers are able to select into consumption of a higher-quality appellation wine. Empirically however, we are able to reject *déclassification* as a driver of the increase in the price of wine thanks to the rollout of the reform, which temporarily allowed producers to continue using a place name even if they did not meet the production requirements set forth in the decree. See Section 3.3.3.

3 Empirical analysis

3.1 Identification strategy

We exploit quasi-random variation in the timing of the decrees taken in application of the 1935 Law. Most decrees were taken during the years 1936 and 1937, although several were adopted later, including those pertaining to the Alsace region in 1962. Importantly, the reform affected wine-producing departments very unevenly: many had no AOC recognition, some full AOC recognition, and many had only a share of vineyards declared eligible for AOC status. This cross-sectional variation provides us with both an extensive and an intensive margin of treatment and allows us to control for common shocks to wine prices through year fixed effects.

One legitimate concern when assessing the effect of a program or rule on outcomes is that implementation is not exogenous, i.e., rules happen to be implemented concurrently with other factors affecting the outcome. For instance, if appellation decrees happen to be enacted at the same time that demand factors, say expanding export markets, are affecting appellation wine prices, then the effect of foreign demand might be mistakenly attributed to regulation. Our strategy to control for such potentially confounding factors is to further differentiate the year fixed effects by *vignoble*, that is, the broad geographical area that defines wines, such as "Loire" or "Midi." We define these *vignobles* so that each of them makes sense from a regional and viticultural standpoint. In fact, we largely follow the classification adopted by INAO, making sure that each *vignoble* is large enough to include at least a couple of departments, our cross-sectional units of analysis. Our model includes 16 *vignobles* and 81 departments.

Given the limited geographical span of our *vignobles*, we believe it is unlikely that remaining unobservables correlated with the AOC share within a *vignoble*-year could be confounding the effect of regulation. Controlling for *vignoble*-by-year fixed effects means that our identification relies on differences, within a *vignoble*, on the share of vineyards eligible for an AOC in a given year following the reform. Such differences arise from different shares of a department's territory being eligible for a given appellation and, to a lesser extent, from different dates of adoption of decrees for different appellations. For instance, if two departments in the same *vignoble* are only eligible for one and the same appellation, they will nonetheless participate in identification as long as they have different shares of vineyards eligible for that

appellation. Conversely, if two departments in the same *vignoble* have the same share eligible, but this share relates to two distinct appellations with decrees taken at different dates, they will participate in identification as well. Assuming for a moment that decree adoption does cause an increase in wine prices, we would expect departments in a given *vignoble* with larger shares of vineyards eligible to have higher price increments upon AOC recognition, and we would also expect eligible departments in a *vignoble* to experience price increases sooner if their decrees are enacted sooner.

Formally, our preferred specification can be spelled out as follows:

$$p_{it} = \alpha_i + \gamma_{vt} + \boldsymbol{\beta}'\mathbf{s}_{it} + \boldsymbol{\delta}'\mathbf{x}_{it} + \epsilon_{it} \tag{4}$$

where i denotes a department, t denotes a year, v denotes the unique *vignoble* to which department i belongs, p_{it} is the average price of wine in department i in year t, α_i is a department fixed effect, γ_{vt} is a *vignoble*-by-year fixed effect, $\mathbf{x}_{it}$ is a vector if quantity controls, and $\mathbf{s}_{it}$ is a vector of treatment variables capturing the extent of AOC recognition in department i in year t. For instance, the vector $\mathbf{s}_{it}$ may include the share of a department's vineyard acreage eligible in year t for one or more and two or more controlled appellations. The vector $\boldsymbol{\beta}$ captures the effects of interest. Our identifying assumption is thus that within a *vignoble*, treated and untreated departments would have followed parallel price movements if not for the AOC reform. We provide support for this assumption before presenting our main results.

Because our specification includes fine *vignoble*-by-year fixed effects, we do not allow for time correlation of the error term when computing standard errors. However, because weather shocks, which affect wine quality, are likely correlated over space, we allow for the error term to be spatially correlated. We report two types of standard errors: (i) standard errors that allow for arbitrary spatial correlation within a *vignoble*, and (ii) Conley-type standard errors that allow for spatial correlation across neighboring departments up to the fourth order (Conley, 1999).[21] In each case, our standard errors allow for heteroskedasticity across years (but again no serial correlation).

[21]The Conley errors are to spatial data what Newey-West errors would be to time-series data. Indeed, we apply the Newey-West weighting scheme to neighboring relationships when calculating our standard errors.

3.2 Data

Our dataset combines several data sources. Departmental wine prices and vineyard areas come from France's *Statistique agricole annuelle*, a yearly publication of the Ministry of Agriculture available in print for the historical period 1907-1969.

Construction of the main regressor, the share of vineyards in a department eligible for a controlled appellation at a given time, required assembling several other information sources. The first one is the set of governmental decrees taken in application of the 1935 Law to define each AOC. These decrees provide information on the area eligible for an appellation, typically by stating which *communes* are eligible for a given appellation (this area may cross departmental boundaries). Historical records of which communal parcels are eligible for an appellation are kept in the cadastral archives of each of France's 34,000 communes and are usually not part of the decree itself. Since it is not reasonable to visit each commune to reconstruct the historical record of eligible parcels (which may have changed over time), we make use of a recent effort by France's *Institut national de l'origine et de la qualité* (INAO) to map out eligible parcels using GIS tools. A series of shape files is available that covers a large share of France's current controlled appellations (exceptions include *champagne* or *vins doux*). We select appellations that existed during the period of investigation (i.e., we exclude newer AOCs). Because we know from the decrees which communes were historically covered for a given appellation, we also get rid of areas located in communes that were not included in the appellation during our period of investigation. For those AOCs that existed but are not part of the INAO data, and for those AOCs that are covered but for which we find no area in a commune we know was eligible historically (likely because it was later removed from the AOC delimitation), we select the entire surface of the commune (all parcels included). Because eligible parcels often include land not actually in vineyards (for instance they may include hedgerows or access roads), we cross these delimitations with a raster file created from satellite imagery that shows pixels actually in vineyards in the years 1990, 2000, 2006, or 2012. These are the only years for which such information is available. We cross the two files by first rasterizing the INAO shape file and then overlaying it over the satellite images.

For AOCs that are covered by the INAO shape files, the resulting raster file therefore indicates the pixels that are eligible for an AOC as of 2016 while having been grown in vines in at least one of the four years for which we have explicit land

use data. For the few appellations not covered by the INAO file, or for communes within covered appellations that are no longer eligible, the resulting file indicates all pixels within an eligible commune that are planted in vineyards in at least one the years 1990, 2000, 2006, or 2012. The areas of these pixels are then summed up across departments' administrative boundaries.

To construct the AOC eligible share at the level of the French department, we divide the area covered by pixels eligible for at least one AOC (while being grown in vineyards) in a department by the maximum of the area planted in vineyards during the period 1907–1969, which comes directly from the historical record in the *Statistique agricole annuelle*. This calculated share represent our best guess at the true historical share of vineyards eligible. Similarly, we construct the departmental share of vineyards eligible for, say, three or more AOCs, by only selecting pixels that appear in three or more AOC delineations.

3.3 Results

Before we turn to our main regression results, we present simple suggestive evidence that AOC recognition positively affected the trajectory of wine prices at the departmental level.

3.3.1 Suggestive evidence

Figure 2 plots a time-series of average real wine prices across two categories of departments: those with high eventual AOC share (defined as those with an eligible share of AOC vineyards larger than 25% by 1969) and those with low eventual AOC share (defined as those with an eligible share lower than 2.5%). Departments with an intermediate share (there are 9 of them) are not represented.

[Figure 2 about here.]

The figure suggests that before the reform the two categories of departments had very similar prices, while after the reform (whose implementation started with the first set of decrees published during 1936) average prices started to diverge between the two groups, with higher values in departments with high eventual AOC share. The figure admittedly provides visual evidence of the "parallel trends" assumption

inherent in difference-in-differences designs.[22] What the figure does not capture, but our main regression will, is any differential price trends *within* the two broad categories defined here according to the AOC eligible share and the behavior of prices in departments with intermediate share (that is, the intensive margin of treatment along the AOC share dimension), as well as the fact that recognition did not happen simultaneously in all treated departments (the intensive margin of treatment along the time dimension).

[Figure 3 about here.]

Figure 3 depicts trends in real wine prices over the period 1910 to 1965 at the departmental level, using changes in 25-year averages from the endpoints of the period to compute the relative increase in price. It also depicts the share of vineyards eligible for AOC recognition by department as of 1965. Qualitatively, Figure 3 tells a similar story as the previous figure: price trends over the period 1910-1965 appear to be stronger in departments with higher AOC shares.

[Table 1 about here.]

One may be worried that departments with eventually high shares of AOC recognition may have been on a steeper price trend for reasons unrelated to regulation. To investigate this possibility, we compare two simple price trend regressions based on different subsamples of years: 1907–1936 (pre-regulation) and 1927–1956 (pre-post-regulation), where price trends are computed using 10-year averages from the endpoints of each period and are expressed in relative terms. The results are reported in Table 1. Column (1) of the table reports the coefficient on the AOC eligible share (by 1956) from a regression of the price trend calculated over the period 1927–1956. Column (2) controls for *vignoble* to purge the regression of effects common to all departments located in the same wine region. In both columns, the coefficient on the AOC share is highly significant, suggesting that AOC eligibility had a positive effect on price trends, even after controlling for *vignoble* effects. In contrast, columns (3) and (4) show that if we focus on price trends over the pre-regulation period, the AOC share does not have any explanatory power, that is, eventual AOC eligibility (as of 1956) is irrelevant to explaining price trends prior to

[22] Average prices in the 9 departments with an intermediate eventual AOC share do not contradict this story: prices in those departments were consistently below those in non-AOC departments before the reform, and caught up after it.

regulation. Finally, columns (5) and (6) show that AOC eligibility also had no clear effect on wine output, suggesting that the effects of regulation on price trends were not the result of a reduction in volumes.

3.3.2 Panel analysis

The results from the estimation of Equation (4) appear in Tables 2–5. Each table uses a different window of time to identify the effects of AOC recognition, from the widest (1907–1969, the entire data set) to the narrowest (1931–1940). Because it takes time for wines to (re-)establish a reputation, even after regulations have been adopted, we do not believe it makes sense to look at much narrower windows of time. Some results for narrower windows are provided in Section 3.3.3 when we discuss the elimination of the "double appellation" regime.

[Table 2 about here.]

We do not necessarily expect coefficient estimates to be stable across periods. One basic reason is that as periods change, so does the set of appellations that are recognized in the sample. For instance, appellations in the Alsace region were recognized relatively late (1962). Because AOC recognition may carry different price premia in different regions, our coefficient estimate, which captures an average effect, may vary according to the period used. Despite this consideration, our results suggest a relatively consistent effect across time: AOC recognition did increase the price of wine, even after conditioning on quantity produced, by a non-negligible factor.

[Table 3 about here.]

Our tables report two different effects: that of the share of vineyards eligible for one AOC or more (regressor AOC Share1), and, in some regressions, that of the share of vineyards eligible for five AOCs or more (regressor AOC Share5). The share of vineyards eligible for one or more (resp. five or more) AOCs is 31.6% (resp. 3.1%) across all departments. All tables suggest a sharp gradient with respect to the number of designations that a vineyard may claim. For instance, columns (7)–(10) of Table 2 indicate that eligibility for one to four appellations carries a price premium equal to about 40% of the average price of wine, while eligibility for five or more appellations carries a price premium equal to about 170% of the average price of wine (the sum of the coefficients on the two regressors).

[Table 4 about here.]

[Table 5 about here.]

Our identifying assumption is that conditional on *vignoble*-year effects and quantity, there are no unobserved determinants of price correlated with the AOC share. One could be concerned however that departments eligible for AOC recognition were on a different price trajectory than control departments. Although our *vignoble*-year effects control for trends common to all departments within a *vignoble*, the relatively long period used makes it plausible that factors that would have systematically propped up prices in treated departments after the reform, even if temporary, could be confounding the effect of regulation. For instance, an increasing taste of foreign markets for *bordeaux* wine happening after the reform could affect identification since the share eligible for the *bordeaux* AOC increased from zero to almost one within a single year. To rule out such possibility, we limit the sample to the post-1937 period: by that date, the most important AOCs had already been defined, so that the residual variation in the share eligible, conditional on the departmental fixed effects, comes from later rounds of AOC recognition, notably that of Alsatian wines. Results are displayed in Table 6. Although the estimate is less precise, the effect of the AOC share remains large and statistically significant.

[Table 6 about here.]

3.3.3 Ruling out alternative explanations

The results of Section 3.3.2 suggest a clear effect of AOC recognition on the departmental wine price. Whether the increase in wine price was indeed related to quality enhancements that failed to be incentivized prior to the reform remains to be established. Perhaps one of the biggest threats to identifying whether the AOC reform had any effect on the supply of quality is its potential for affecting the volumes of wine produced. There are at least two potential effects to consider: first, the reform could have reduced overall wine acreage and/or yields in regulated areas, and therefore the quantity of wine produced. Second, the reform could have reshuffled volumes of wines away from the appellation market into the ordinary wine market.

Acreage and yield effects

It is difficult to imagine how overall acreages could have been affected because the reform did not force producers to uproot existing vineyards, they merely placed conditions on the use of certain names in the sale of wines. One could easily expect, however, that maximum yields specified in many appellation decrees may have resulted in yield (and therefore production) reductions. In fact, we do not detect any such effects on acreage or yield in the data.

[Table 7 about here.]

Instead, regressions reported in Table 7 show that the share of AOC recognition had a positive and significant effect on acreage planted, irrespective of the window of time selected for the regression. This is consistent with the common view (confirmed by Figure 4) that wine acreage decreased more in non-AOC regions than in AOC-regions over time. Table 7 also shows that there is no clear effect of AOC recognition on yield. Estimates are small with fluctuating signs according to the period used for estimation. Importantly, there is no clear effect when focussing on the period immediately before and immediately after the reform. Although many AOC decrees specify maximum yields, it thus appears that reducing yield was not the principal channel through which quality improvements were achieved. The only statistically significant effect is found when including the last decade, but the effect of AOC recognition is positive, not negative. This effect would be consistent with the idea of differential technical progress across AOC and non-AOC regions, with plausibly more effort directed towards improving cultivation in prestigious regions.

[Figure 4 about here.]

Reshuffling effect

The second main effect that the reform could potentially have had on wine quantities is redistributive. It is conceivable that a large volume of wine that used to be sold under appellation before the reform was later denied the appellation status and had to be sold either under a less prestigious name or as ordinary wine (an effect known as *déclassification*). If consumers are homogenous with respect to their taste for quality, such movements of wines from one category of wine to another should leave the average price of wine at the department level unchanged as consumers update their valuations of ordinary and appellation wines based on the

average quality present in each segment of the market. In that case the reshuffling effect should not confound our finding that average prices increased due to AOC recognition through an increase in the quality of AOC wines.

[Table 8 about here.]

However, as we formally show in Appendix A.2, if consumers are heterogenous with respect to their taste for quality, average price will increase as a result of the *déclassification* of wines. We also show that welfare will increase as well, although the relationship between the relative increase in price and the relative increase in welfare is less straightforward than in the case where the price increase is solely due to an increase in the quality of AOC wines. Thankfully, a unique feature of the reform allows us to rule out *déclassification* as a significant driver of the price increase, so our coefficient estimates retain their nice welfare interpretation.

During the years 1936 to 1942 included, appellation names could still be utilized by producers even if a decree had been enacted and the wine produced did not meet the criteria for the AOC. This system was known as the "double appellation" regime and was maintained for a couple of years in order to let producers familiarize themselves with the reform. We address the possibility that reshuffling could be driving our price effects by comparing estimates of the effect of the AOC eligible share right before and right after the double appellation regime was abolished. Estimates of the effects of the share of AOC eligible are shown in Table 8. The estimates are similar before and after the interdiction. This suggests that forbidding the use of the name for non-AOC wine did not further increase average price, as would be implied in a model with heterogenous consumers if significant quantities of wines had been suddenly forced out of the appellation. This implies that either consumer heterogeneity was small and did not play a major role, or that the volume of wines forced out of the use of an appellation was not large enough to cause changes in the average price.

Other robustness checks

Table 9 provides results for samples that exclude (i) the years 1945–1947, during which there was a sharp increase in wine prices in AOC departments (e.g., Gironde), and (ii) the four departments of the Champagne region.

[Table 9 about here.]

Results without Champagne departments make sense. Unlike other wine regions, Champagne does not have sub-regional appellations, therefore the vast majority of eligible vineyards in Champagne departments are only eligible for one appellation, *champagne*. Despite this fact, *champagne* is perhaps the most prestigious of all wine appellations and the one that commands the highest prices. To the extent that *champagne* benefited relatively more than other appellations from AOC recognition, which is plausible, its effect would solely be captured by the AOC Share1 regressor. Including Champagne departments in estimation would then tend to pull the estimate on the AOC Share 1 towards a slightly higher value than when these departments are omitted. As the effect on AOC Share1 is being pulled up by Champagne departments, the coefficient on AOC Share5 is decreased as a larger share of the effect is already been captured by AOC Share1.

4 Discussion

References

Akerlof, G. A. (1970). The Market for 'Lemons': Quality Uncertainty and the Market Mechanism. *The Quarterly Journal of Economics*, 84(3):488–500.

Capus, J. (1947). *La Genèse des Appellations Contrôlées*. INAO, France.

Congressional Research Service (2016). Geographical Indications in the Transatlantic Trade and Investment Partnership (T-TIP) Negotiations. CRS report prepared for Members and Committees of Congress, Washington, D.C.

Conley, T. G. (1999). GMM estimation with cross sectional dependence. *Journal of Econometrics*, 92(1):1–45.

Humbert, F. (2011). *L'INAO, de ses origines à la fin des années 1960: genèse et évolutions du système des vins d'AOC*. PhD thesis, Université de Bourgogne, France.

Josling, T. (2006). The War on *Terroir*: Geographical Indications as a Transatlantic Trade Conflict. *Journal of Agricultural Economics*, 57(3):337–363.

Mussa, M. and Rosen, S. (1978). Monopoly and product quality. *Journal of Economic Theory*, 18(2):301–317.

For Online Publication: Appendices

A Models with heterogenous consumers

We consider a Mussa-Rosen model of vertical differentiation (Mussa and Rosen, 1978) whereby consumer tastes are parameterized by an index $\theta \in [0,1]$ and $F(\theta)$ denotes the c.d.f. of θ. Each consumer consumes at most one unit of wine. The mass of consumers is set to $M > Q$, where Q denotes the fixed quantity of wine produced, including ordinary and appellation wine. Therefore, some consumers are not served in equilibrium. When consuming wine of quality μ sold at price p, a consumer of type θ enjoys utility $U^\theta(\mu, p) = \bar{u} + \theta\mu - p$, where $\bar{u} > 0$, and zero if the consumer purchases nothing.

A.1 Model with quality enhancement

This model is an alternative to the model presented in Section 2 whereby consumers are allowed to differ in their taste for quality. As in the main text, we assume that the effect of the reform is to increase the quality of a share of wine production previously sold under an appellation.

Wine quality is denoted $\mu_0 = 0$ for ordinary wine, $\mu_1 \geq \mu_0$ for an appellation that does not end up being controlled (i.e., a simple appellation), and $\mu_2 \geq \mu_1$ for an appellation that is controlled.

Given that $M > Q$, the equilibrium price of ordinary wine must be equal to $\bar{u}$ ($p_0 = \bar{u}$) so that low-θ consumers are indifferent between purchasing nothing and purchasing ordinary wine.

Denote by $\tilde{\theta}$ the index of the consumer indifferent between purchasing ordinary wine and appellation wine. It must be that $\tilde{\theta} = \frac{p_1 - p_0}{\mu_1} = \frac{p_1 - \bar{u}}{\mu_1}$. Similarly, denoting by $\hat{\theta}$ the index of the consumer indifferent between purchasing uncontrolled and controlled appellation wine, we have $\hat{\theta} = \frac{p_2 - p_1}{\mu_2 - \mu_1}$. Market clearing implies that $M \int_{\tilde{\theta}}^{1} dF(\theta) = Qs_1$ and $M \int_{\hat{\theta}}^{1} dF(\theta) = Qs_2$ under full information. Under asymmetric information, all appellation wine has quality μ_1 and only the first market-clearing condition applies.

The relationship $M \int_{\tilde{\theta}}^{1} dF(\theta) = Qs_1$ determines $\tilde{\theta}$ given the exogenous values of Q, M, and s_1, and given $\tilde{\theta} = \frac{p_1 - \bar{u}}{\mu_1}$ it further determines p_1, which is then independent of the information regime. Similarly, the relationships $M \int_{\hat{\theta}}^{1} dF(\theta) = Qs_2$ and $\hat{\theta} = \frac{p_2 - p_1}{\mu_2 - \mu_1}$ determine $\hat{\theta}$ and p_2 under full information.

The increase in gross welfare (ignoring the additional costs of quality provision) when moving from the asymmetric to the full information scenario is simply the added gross utility of consumers with value index between $\hat{\theta}$ and 1, that is, those with the highest tastes for quality who end up purchasing the controlled appellation

wine:

$$\begin{aligned}
\Delta GW &= M \int_{\hat{\theta}}^{1} (\mu_2 - \mu_1)\theta dF(\theta) \\
&= M(\mu_2 - \mu_1) \int_{\hat{\theta}}^{1} \theta dF(\theta) \\
&= Qs_2(\mu_2 - \mu_1) \times \frac{\int_{\hat{\theta}}^{1} \theta dF(\theta)}{\int_{\hat{\theta}}^{1} dF(\theta)} \\
&= Qs_2(p_2 - p_1) \times \frac{\int_{\hat{\theta}}^{1} \theta dF(\theta)}{\hat{\theta} \int_{\hat{\theta}}^{1} dF(\theta)}.
\end{aligned}$$

Since $\frac{\int_{\hat{\theta}}^{1} \theta dF(\theta)}{\hat{\theta} \int_{\hat{\theta}}^{1} dF(\theta)} > 1$, it is clear that the gross welfare measure $Qs_2(p_2 - p_1)$ that holds with perfectly elastic demands (see Section 2) represents a lower bound to the gross welfare increase in the more general model.

[Figure 5 about here.]

Figure 5 illustrates the gross welfare calculation in the special case where $s_1 = 0.50$, $s_2 = 0.25$, $M = \frac{3}{2}Q$ and consumer taste parameters are uniformly distributed on $[0, 1]$. In this case, market clearing implies that $\tilde{\theta} = \frac{2}{3}$ and $\hat{\theta} = \frac{5}{6}$. Setting $\bar{u} = 1$, $\mu_1 = 1$, and $\mu_2 = 2$, we obtain the equilibrium prices $p_1 = \frac{5}{3}$ and $p_2 = \frac{5}{2}$. In the figure, blue lines are used to represent consumer utility (net of the price paid) as a function of the taste parameter. Black lines represent the resulting gross welfare (ignoring supply costs) in equilibrium. Dashed lines depict utility and gross welfare for high θ consumers under asymmetric information. The shaded area represents the increase in gross welfare resulting from regulation.

A.2 Pure adverse selection model

A competing explanation as to why the average price rises after the reform, besides an increase in quality, is that the quantity of wine sold under appellation decreases as some wines are subject to declassification (keeping constant the total quantity of wine sold). Indeed, wines previously sold under an appellation and that did not meet the requirements for the appellation once it becomes controlled had to be sold either under a less prestigious appellation, if available, or as ordinary wine. If massive quantities of wines previously sold under appellation were redirected to the ordinary wine market due to the reform, the average price could change without any change in quality.

Here we thus assume that wine quality (and quantity) are fixed. We denote by $\mu_0 = 0$ the quality of ordinary wines, and by μ_1 the quality of "true" appellation

wines. The share of appellation wines is s_1, but some of the ordinary wine is sold under appellation. The share of wine sold under appellation is thus $s_2 > s_1$. Therefore, the average quality of appellation wine is $\bar{\mu}_1 = \frac{\mu_1 s_1 + \mu_0(s_2 - s_1)}{s_2} = \frac{\mu_1 s_1}{s_2}$. We assume the reform reduces the share of appellation wines by removing some of the low-quality wine from the appellation and forcing it to be sold as ordinary wine (its true quality).

At a market equilibrium, it must be that $p_0 = \bar{u}$ so that low-θ consumers are indifferent between consuming ordinary wine and consuming nothing. In addition, the index of the consumer who is indifferent between ordinary and appellation wine must satisfy $\bar{u} - p_0 = \bar{u} + \tilde{\theta}\bar{\mu}_1 - p_1$, which implies that $p_1 = \bar{u} + \tilde{\theta}\frac{\mu_1 s_1}{s_2}$. Market-clearing further implies that $M\int_{\tilde{\theta}}^{1} dF(\theta) = Qs_2$, which implicitly defines $\tilde{\theta}$ as a function of s_2. The average price of wine is then

$$\begin{aligned} p_m &= p_0(1 - s_2) + p_1 s_2 \\ &= \bar{u} + \mu_1 s_1 \tilde{\theta}(s_2). \end{aligned}$$

It is clear that $\tilde{\theta}$ decreases with s_2, so if the reform decreases s_2 to $s_2' < s_2$, we would expect the average price to increase. Note that this result critically depends on the presence of consumer heterogeneity: if all consumers are the same and wine quality does not change, then average price (and welfare) do not change in equilibrium, even if there is a redistribution of volumes towards the ordinary wine category. Let us now show that welfare also increases (in this case there is no reason to distinguish gross from net welfare as we assume away any quality enhancement). We have

$$\begin{aligned} \Delta W &= -M\int_{\tilde{\theta}}^{\tilde{\theta}'} \theta\frac{\mu_1 s_1}{s_2} dF(\theta) + M\int_{\tilde{\theta}'}^{1} \theta\mu_1 s_1\left(\frac{1}{s_2'} - \frac{1}{s_2}\right) dF(\theta) \\ &= Q\mu_1 s_1\left[\frac{\int_{\tilde{\theta}'}^{1} \theta dF(\theta)}{\int_{\tilde{\theta}'}^{1} dF(\theta)} - \frac{\int_{\tilde{\theta}}^{1} \theta dF(\theta)}{\int_{\tilde{\theta}}^{1} dF(\theta)}\right] \\ &> 0 \end{aligned}$$

while the change in price is simply $\Delta p_m = \mu_1 s_1\left(\tilde{\theta}' - \tilde{\theta}\right) > 0$. Therefore, in this case both price and welfare increase. But without further restrictions on the cumulative density function $F(\theta)$, it is not possible to determine whether the observed relative price increase attributable to the reform under- or -overstates the associated change in welfare, although both have the same sign.

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Figure 1 Welfare effects of asymmetric information in the appellation wine market

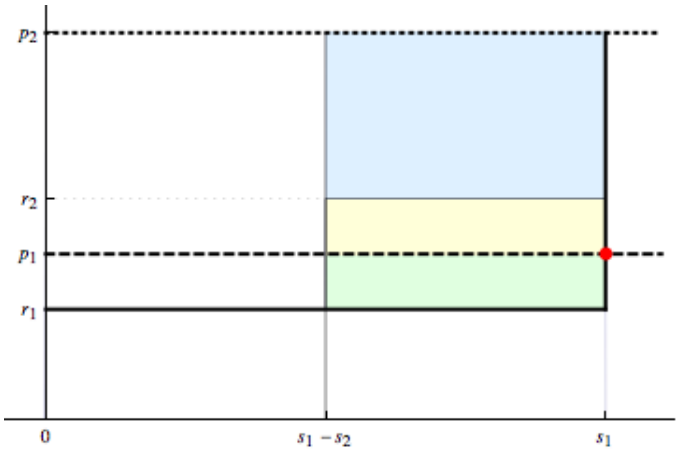
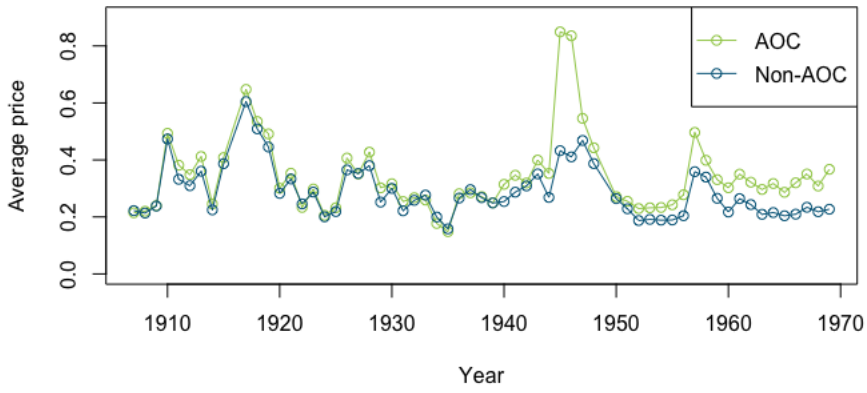
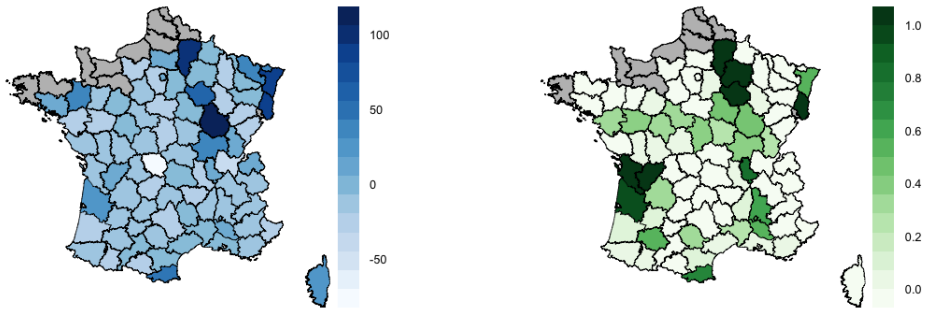


Figure 2 Average wine prices in AOC and non-AOC departments



Note: Average prices are calculated using production weights and conditioning on departments without missing data. Production weights are constant over time and calculated as the average departmental wine production over the period. AOC departments (22) are departments with a 1969 share of vineyards eligible for AOC larger than 25%. Non-AOC departments (32) are departments with a 1969 share of vineyards eligible for AOC smaller than 2.5%.

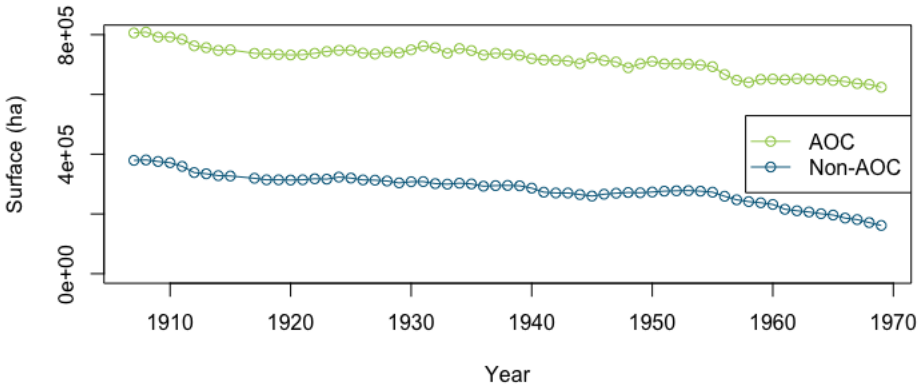
Figure 3 Trends in departmental real wine prices over the period 1910-1965



(a) Price trend (b) AOC share

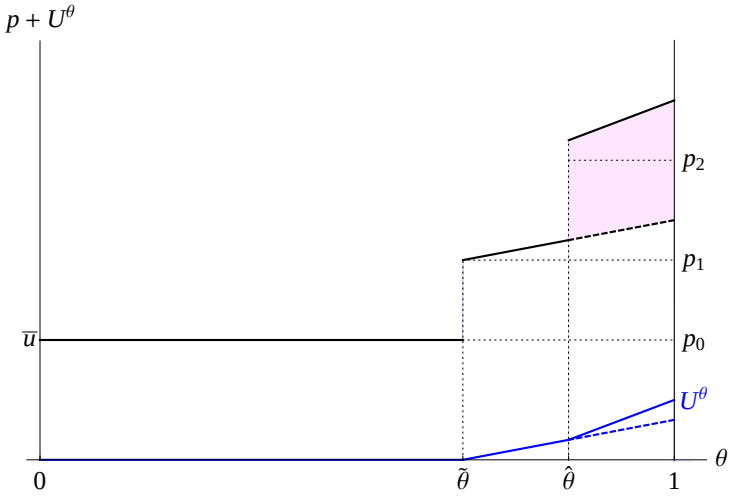
Note: Price trends are computed using changes in 25-year averages from the endpoints of the period and are expressed in relative terms. The share of vineyards eligible for AOC is calculated as of 1965. Gray departments: no data available.

Figure 4 Area in vineyards in AOC and non-AOC departments



Note: Areas excludes departments with missing data. AOC departments (22) are departments with a 1969 share of vineyards eligible for AOC larger than 25%. Non-AOC departments (34) are departments with a 1969 share of vineyards eligible for AOC smaller than 2.5%.

Figure 5 Consumer utility and welfare under full information and asymmetric information



Note: Full information equilibria are represented with solid lines. Dashed lines represent outcomes, under asymmetric information, for consumers purchasing controlled appellation wine under full information.

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Table 1 Trends regressions

	Price trend				Output trend	
	1927–1956		1907–1936		1927–1956	
	(1)	(2)	(3)	(4)	(5)	(6)
AOC share	91.30***	79.47***	-7.28	-4.76	3.58	-0.23
	(16.42)	(20.38)	(5.74)	(7.40)	(7.62)	(8.60)
Vignoble FE	No	Yes	No	Yes	No	Yes
Observations	72	72	72	72	72	72

Note: The sample is limited to departments with enough information to compute price and output trends over the two periods 1907–1936 and 1927–1956. Standard errors are indicated in brackets. *** indicates statistical significance at the 1% level or better. The *vignoble* control includes 16 different wine regions.

Table 2 Effect of the AOC eligible share on the real price of wine, 1907–1969

	Dep. var.: log average real price of wine									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
AOC Share1	0.409***	0.451***	0.440***	0.437***	0.429***	0.371***	0.427***	0.417***	0.410***	0.402***
	(0.043)	(0.044)	(0.044)	(0.045)	(0.044)	(0.043)	(0.045)	(0.045)	(0.046)	(0.045)
AOC Share5	–	–	–	–	–	1.018***	1.272***	1.273***	1.345***	1.348***
						(0.178)	(0.211)	(0.213)	(0.228)	(0.225)
log(Production)	-0.041***	-0.041***	–	–	–	-0.039***	-0.043***	–	–	–
	(0.011)	(0.013)				(0.011)	(0.013)			
log(Production$_{-1}$)	–	–	-0.027**	–	–	–	–	-0.029**	–	–
			(0.012)					(0.012)		
log(Production)×*vignoble*	No	No	No	Yes	No	No	No	No	Yes	No
log(Production$_{-1}$)×*vignoble*	No	No	No	No	Yes	No	No	No	No	Yes
Year×*vignoble* FE	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Observations	4,500	4,500	4,412	4,500	4,412	4,500	4,500	4,412	4,500	4,412

Note: All regressions include year FE. Standard errors allow for spatial correlation up to the fourth neighboring departments and assume no time correlation. The panel is unbalanced and includes all departments for which price data is available for at least half of the sample years. Price data is missing for the years 1916 and 1949.

Table 3 Effect of the AOC eligible share on the real price of wine, 1911–1960

	Dep. var.: log average real price of wine									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
AOC Share1	0.293***	0.324***	0.320***	0.317***	0.315***	0.258***	0.302***	0.298***	0.293***	0.293***
	(0.050)	(0.052)	(0.051)	(0.052)	(0.051)	(0.051)	(0.053)	(0.052)	(0.053)	(0.052)
AOC Share5	–	–	–	–	–	0.969***	1.303***	1.288***	1.401***	1.337***
						(0.232)	(0.293)	(0.295)	(0.303)	(0.305)
log(Production)	-0.071***	-0.068***	–	–	–	-0.069***	-0.070***	–	–	–
	(0.011)	(0.014)				(0.011)	(0.014)			
log(Production$_{-1}$)	–	–	-0.046***	–	–	–	–	-0.048***	–	–
			(0.014)					(0.014)		
log(Production)×*vignoble*	No	No	No	Yes	No	No	No	No	Yes	No
log(Production$_{-1}$)×*vignoble*	No	No	No	No	Yes	No	No	No	No	Yes
Year×*vignoble* FE	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Observations	3,572	3,572	3,556	3,572	3,556	3,572	3,572	3,556	3,572	3,556

Note: All regressions include year FE. Standard errors allow for spatial correlation up to the fourth neighboring departments and assume no time correlation. The panel is unbalanced and includes all departments for which price data is available for at least half of the sample years. Price data is missing for the years 1916 and 1949.

Table 4 Effect of the AOC eligible share on the real price of wine, 1921–1950

	Dep. var.: log average real price of wine									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
AOC Share1	0.237***	0.228***	0.223***	0.207***	0.209***	0.194***	0.201***	0.196***	0.180***	0.183***
	(0.064)	(0.065)	(0.064)	(0.063)	(0.061)	(0.064)	(0.065)	(0.064)	(0.063)	(0.061)
AOC Share5	–	–	–	–	–	1.577***	2.111***	2.103***	2.148***	2.114***
						(0.430)	(0.540)	(0.548)	(0.524)	(0.549)
log(Production)	-0.068***	-0.074***	–	–	–	-0.066***	-0.075***	–	–	–
	(0.017)	(0.021)				(0.017)	(0.021)			
log(Production$_{-1}$)	–	–	-0.034	–	–	–	–	-0.035	–	–
			(0.022)					(0.022)		
log(Production)×*vignoble*	No	No	No	Yes	No	No	No	No	Yes	No
log(Production$_{-1}$)×*vignoble*	No	No	No	No	Yes	No	No	No	No	Yes
Year×*vignoble* FE	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Observations	2,172	2,172	2,164	2,172	2,164	2,172	2,172	2,164	2,172	2,164

Note: All regressions include year FE. Standard errors allow for spatial correlation up to the fourth neighboring departments and assume no time correlation. The panel is unbalanced and includes all departments for which price data is available for at least half of the sample years. Price data is missing for the year 1949.

Table 5 Effect of the AOC eligible share on the real price of wine, 1931–1940

	Dep. var.: log average real price of wine									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
AOC Share1	0.172***	0.151**	0.170**	0.161**	0.173**	0.135**	0.131*	0.151**	0.141**	0.153**
	(0.063)	(0.067)	(0.070)	(0.071)	(0.072)	(0.062)	(0.067)	(0.069)	(0.071)	(0.072)
AOC Share5	–	–	–	–	–	2.731***	3.325***	3.285***	3.286***	3.329***
						(1.000)	(0.994)	(0.964)	(1.020)	(0.968)
log(Production)	-0.097***	-0.117***	–	–	–	-0.084***	-0.116***	–	–	–
	(0.026)	(0.034)				(0.026)	(0.033)			
log(Production$_{-1}$)	–	–	-0.076**	–	–	–	–	-0.070**	–	–
			(0.031)					(0.034)		
log(Production)×*vignoble*	No	No	No	Yes	No	No	No	No	Yes	No
log(Production$_{-1}$)×*vignoble*	No	No	No	No	Yes	No	No	No	No	Yes
Year×*vignoble* FE	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Observations	753	753	752	753	752	753	753	752	753	752

Note: All regressions include year FE. Standard errors allow for spatial correlation up to the fourth neighboring departments and assume no time correlation. The panel is unbalanced and includes all departments for which price data is available for at least half of the sample years.

Table 6 Effect of the AOC eligible share on the real price of wine, 1938–1969

	Dep. var.: log average real price of wine				
	(1)	(2)	(3)	(4)	(5)
AOC Share1	0.187**	0.312**	0.316**	0.324**	0.314**
	(0.092)	(0.133)	(0.135)	(0.142)	(0.140)
log(Production)	0.005	0.016	–	–	–
	(0.019)	(0.022)			
log(Production$_{-1}$)	–	–	0.042**	–	–
			(0.021)		
log(Production)×*vignoble*	No	No	No	Yes	No
log(Production$_{-1}$)×*vignoble*	No	No	No	No	Yes
Year×*vignoble* FE	No	Yes	Yes	Yes	Yes
Observations	2,267	2,267	2,261	2,267	2,261

Note: All regressions include year FE. Standard errors allow for spatial correlation up to the fourth neighboring departments and assume no time correlation. The panel is unbalanced and includes all departments for which price data is available for at least half of the sample years.

Table 7 Effect of AOC recognition on acreage and yield

	Dep. var.:					
	log acreage			log yield		
	(1)	(2)	(3)	(4)	(5)	(6)
	1921–1950	1911–1960	1907–1969	1921–1950	1911–1960	1907–1969
AOC Share1	0.118***	0.118***	0.375***	0.031	0.015	0.081**
	(0.028)	(0.029)	(0.040)	(0.055)	(0.044)	(0.039)
Observations	2,247	3,646	4,577	2,247	3,645	4,575

Note: All regressions include year by *vignoble* FE. Standard errors allow for spatial correlation up to the fourth neighboring departments and assume no time correlation. The panel is unbalanced and includes all departments for which price data is available for at least half of the sample years.

Table 8 Effect of the AOC eligible share on the real price of wine, with and without "double appellation"

	Dep. var.: log average real price of wine					
	(1)	(2)	(3)	(4)	(5)	(6)
	1929–1942	1928–1943	1927–1944	1929–1942	1928–1943	1927–1944
AOC Share1	0.129**	0.088	0.117*	0.137**	0.086	0.114*
	(0.064)	(0.064)	(0.065)	(0.061)	(0.064)	(0.065)
log(Production)×*vignoble*	Yes	Yes	Yes	No	No	No
$\log(\text{Production}_{-1})$×*vignoble*	No	No	No	Yes	Yes	Yes
Year×*vignoble* FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,051	1,197	1,344	1,049	1,194	1,339

Table 9 Other robustness checks, 1907–1969

	Dep. var.: log average real price of wine							
	w/o 1945–47				w/o Champagne dpts.			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
AOC Share1	0.423***	0.415***	0.397**	0.388***	0.324***	0.313**	0.283***	0.273***
	(0.047)	(0.046)	(0.048)	(0.047)	(0.037)	(0.036)	(0.037)	(0.036)
AOC Share5			1.326***	1.366***			1.455***	1.459***
			(0.224)	(0.212)			(0.224)	(0.223)
log(Production)×*vignoble*	Yes	No	Yes	No	Yes	No	Yes	No
log(Production$_{-1}$)×*vignoble*	No	Yes	No	Yes	No	Yes	No	Yes
Observations	4,272	4,187	4,272	4,187	4,256	4,172	4,256	4,172

Note: All regressions include *vignoble*-by-year FE. Standard errors allow for spatial correlation up to the fourth neighboring departments and assume no time correlation. The panel is unbalanced and includes all departments for which price data is available for at least half of the sample years.