How Big is the "Lemons" Problem? Historical Evidence from French Wines

Pierre Mérel, University of California, merel@primal.ucdavis.edu
Davis Ariel Ortiz-Bobea Cornell University
Emmanuel Paroissien INRAE, France A

Invited Paper prepared for presentation at the **2021 AAEA/ASSA Annual Meeting VIRTUAL, January 3-5, 2021**

How Big is the "Lemons" Problem? Historical Evidence from French Wines

Pierre Mérel
University of California, Davis

Ariel Ortiz-Bobea
Cornell University

Emmanuel Paroissien
INRAE, France

Abstract
This paper provides empirical evidence on the welfare losses associated with asymmetric information about product quality in a competitive market. When consumers cannot observe product characteristics at the time of purchase, atomistic producers have no incentive to supply costly quality. We compare wine prices across administrative districts around the enactment of historic regulations aimed at certifying the quality of more than 250 French appellation wines to identify welfare losses from asymmetric information. We estimate that these losses amount to more than 7% of total market value, suggesting an important role for credible certification schemes.

Keywords: asymmetric information, adverse selection, quality uncertainty, welfare, wine appellation

---

> [The customer] requesting *bordeaux*, *bourgogne*, or *champagne* does not expect [...] to be offered a wine that is merely produced in Gironde, Burgundy, or Champagne; they also seek the qualities, the bouquet, and the virtues a worthy reputation has ascribed to wines claiming these famous names (Capus, 1947).[1]

In his foundational paper, Akerlof (1970) formalized the notion that a consumer's inability to ascertain quality differences in products may "drive the good product out of the market," resulting in a socially undesirable outcome. If buyers cannot distinguish good products from bad, they will value a product's quality as average. This may keep sellers of the good product from trading, even if consumers' willingness to pay for the good product exceeds their reservation value. In equilibrium, a "lemons" or adversely

Acknowledgments: We thank Olivier Allais, Orley Ashenfelter, Jean-Marc Bourgeon, Guillaume Daudin, Thibault Fally, Pierre Fleckinger, Jonathan Goupille-Lebret, Laurent Linnemer, Kevin Novan, Ashish Shenoy, Stéphane Turolla, Bertrand Villeneuve, Michael Visser, as well as seminar participants at CREST, Université Paris-Dauphine, GATE-ENS Lyon, GAEL, INRA (ALISS, EcoPub and SMART-LERECO units), Iowa State University, Purdue University, University of Alberta, University of California Davis, University of California Berkeley, the 2019 EEA-ESEM Conference, the 68th Congress of the French Economic Association, the 2019 ADRES Conference, the 10th TSE Conference on "IO and the Food Industry," and the 13th AAWE Conference. We are also grateful to Florian Humbert, Martin Baussier, and François Roncin for their insights regarding the historical delimitation of French wine appellations.

E-mail: merel@primal.ucdavis.edu (Mérel); ao332@cornell.edu (Ortiz-Bobea);
paroissienemmanuel@gmail.com (Paroissien)

[1] Translated from French by the authors.

selected market emerges whereby products of low quality are sold but good products remain in the hands of sellers, despite having higher social value in those of buyers.

Adverse selection has been shown to exist in a variety of contexts. Yet, empirical evidence of its welfare significance remains elusive. One notable exception is insurance markets, which have been the object of much recent scrutiny. In such markets, it is virtually impossible to estimate the welfare effects of selection by directly comparing outcomes under differing degrees of information asymmetry, as individuals retain private information about their riskiness. Instead, welfare calculations often rely on statistics identified from a combination of exogenous price variation and structural assumptions (Einav et al., 2010). Jin and Leslie (2003) overcome this limitation in the context of restaurant hygiene by studying the effects of a mandatory disclosure policy on quality provision, but the absence of price data precludes them from identifying welfare gains. The present paper addresses these challenges by exploiting changes in information asymmetry induced by a policy shift in a setting where prices and quantities are observed.

We study the French wine market in the first three quarters of the 20th century. In this market, products are highly differentiated and supplied atomistically by more than one million producers. This structure, along with the lack of reliable third-party information about wine quality, makes it particularly difficult for producers to establish individual reputations, and thus be rewarded for the costly provision of quality. Using a historic policy change intended to mitigate informational asymmetry between wine buyers and sellers, we provide evidence of adverse selection in quality provision, and quantify its welfare implications.

Our study differs from most empirical work on the welfare effects of asymmetric information in two critical ways. First, we leverage actual changes in the informational setting regarding product quality at the level of an entire market as the source of identifying variation. Second, we document an original type of adverse selection. Not only can asymmetric information cause market unraveling by inducing owners of high-quality goods to hold on to them (Hendren, 2013, 2017), it also can deter sellers from undertaking socially valuable quality investments (Kim, 1985; Winfree and McCluskey, 2005). Thus, although the market equilibrium may involve a large volume of goods traded, there may be welfare gains forgone from not 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 that codified production rules and implemented official controls for fine wines claiming a reputable geographical appellation—like *bordeaux*, *bourgogne*, or *champagne*. We show that this pioneering law, the first of its kind to be adopted in the world and the enduring template for regulations pertaining to geographical indications, had profound and durable economic impacts on the French wine market.

Due to its reliance on collective reputations as a primary signal of quality, the French wine market is an ideal setting to study the effects of asymmetric information on market efficiency. Wine is a highly differentiated product, partly due to the

complexity of its production process. Beyond careful attention to the delicate chemical reactions that transform crushed grapes into wine, the quality of the final product crucially depends on the suitability of the grape varietal to the climate and soil of the vineyard. As such, the area of origin can play a salient role in signalling quality, which explains why fine wines have traditionally been marketed using geographical appellations, even when sold under a private brand. Yet, origin labeling may not, without an enforceable quality standard, be sufficient to overcome informational asymmetries (Leland, 1979; Combris et al., 1997; Fleckinger, 2007; Castriota and Delmastro, 2015).[2] As wine trade expands from geographically contained locales where local customs are easily preserved[3] to national and global markets, atomistic producers may be increasingly tempted to plant high-yielding but unsuitable grape varietals, expand production into inappropriate terrains, or cut costs by lowering quality while continuing to claim a theretofore reputable origin. And indeed the history of wine production is riddled with anecdotes of such deceptive but transiently profitable behavior.[4] Whether these anecdotes add up to economically meaningful effects, and if so, whether a minimum quality standard may be effective at restoring quality and improving market efficiency, are more debatable propositions, which the present paper seeks to address.

To this end, we assemble a panel of yearly average wine prices received by producers in each department—a French administrative unit roughly the size of a US county—for the period 1907–1969. We pair it with detailed cartographic data reflecting the share of a department's vineyard acreage that became eligible for *appellation d'origine contrôlée* (hereafter AOC), the official designation for

[2]For instance, in 1935 there were more than 65,000 winegrowers in the Bordeaux region alone. Although a few detailed classifications, such as the Bordeaux Wine Official Classification of 1855, already existed, they focussed on the most prestigious vineyards and covered only a small fraction of wines sold under a geographical indication. As a result, most of the wines sold under regional appellations such as *bordeaux* or *bourgogne* were in effect supplied by a large number of individual producers with little to no brand recognition. Important factors contributing to information asymmetry in the appellation wine market are the inherent variability in quality due to weather (i.e., the vintage effect), the fact that the quality of fine wines may only reveal itself after long periods of time, the fact that a particular wine, even if sold under a private brand, may not be consistently available at a given retail point due to low volumes, the fact that there is a large number of brands to choose from even within an appellation, and the fact that consumers typically seek diversity in the set of wines they purchase (i.e., they may not seek to identify a preferred brand and stick to it, but rather to consume an evolving selection of wines, e.g., by curating a wine collection). All these factors make it very difficult for buyers to effectively retaliate against low-quality suppliers.

[3]These customs are referred to as "local, loyal, and constant uses" in the French legislation on appellations.

[4]Capus (1947) recounts the story of a winegrower who, prior to the 1935 reform, had decided to graft his red wine vineyard, located on unfavorable clay soils within the geographical limits of the *barsac* appellation, with grapes designed to produce a white wine that could, at the time, be lawfully sold under that name. When told that the grafted vineyard could never produce wine of a quality deserving of this prestigious name, the winegrower responded that since his plot was located within the delimited area, he would not be violating any rules, and that all winegrowers in the region were planning to do the same.

appellation wines created by the 1935 law.[5] The 274 AOCs present during our study period were defined by a series of governmental decrees enacted between 1936 and 1968. Thus, our departmental measure of AOC eligibility grows gradually as more AOCs are recognized over time.

To evaluate the effect of the reform, we regress the departmental average price of wine on the time- and space-varying share of eligible vineyard acreage. We control for time-invariant unobservable factors through department fixed effects and for time-varying factors through year fixed effects differentiated by broad wine region. We also control for wine production to capture natural swings in wine prices arising from weather shocks and to ensure that our estimated effect reflects shifts in demand rather than movements along a demand curve.[6]

Causal interpretation of our estimate requires AOC eligibility to be orthogonal to unobserved drivers of price across departments in the same wine region and year, after controlling for department fixed effects and production shocks. We provide several pieces of evidence in support of this assumption. First, we show that price trends during the 30 years preceding the reform were uncorrelated with eventual AOC recognition. Second, using an event-study framework, we demonstrate the absence of upward or downward price trends in treated departments in the years before treatment. Third, we show that our estimated effect is robust to considerable reductions in our sample, either in its cross-sectional or time-series dimensions, that enable us to exploit different margins of treatment. Finally, we rule out the hypothesis that our estimated treatment effect was caused by post-war income growth, rather than the AOC reform.

Our analysis yields an estimate of the marginal effect of AOC eligibility on the departmental wine price equal to 42%. That is, a department in which 100% of vineyards became eligible for AOC designation experienced a 42% increase in price on average. This estimate represents an intention-to-treat effect as not all eligible vineyards claimed an AOC; using ancillary data on AOC acreage and volume, we estimate that over the period 1951–1969, AOC status led to an increase in price roughly equal to 1.6 times the average wine price.

Of course, the fact that the average price of wine moved in tandem with the share of vineyard acreage that became eligible for AOC does not, by itself, imply that the reform had an impact on quality. Our analysis therefore considers alternative explanations. First, we do not find any evidence that the reform decreased wine production, which implies that the price increase in eligible departments cannot be attributed to a reduction in quantity. Second, the fact that we use *average*

[5]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 most likely led to a worsening, not an improvement, of the asymmetric information problem (Capus, 1947; Simpson, 2004). This may partly explain why Haeck et al. (2019), who study the impact of these pre-1935 reforms, obtain mixed results.

[6]Our findings are robust to the removal of the production control.

prices calculated across all wine segments within a department—as opposed to wine prices for individual vineyards[7]—makes it unlikely that the observed effect of AOC recognition on price could have been caused by the mere sorting of wines without any actual change in quality, that is, the shift from a pooling equilibrium where wines of differing qualities are indistinguishable at purchase, to a separating equilibrium where higher-quality wines are sold at a higher price. Using information on the departmental share of wines sold under appellation before and after the reform, we formally reject that hypothesis. We also reject a related hypothesis according to which the increase in average price was caused by the *déclassement* (or demotion) of wines within a department, that is, the denial of the use of an appellation for wines sold under appellation prior to the reform.[8] Finally, we provide evidence against the hypothesis that the price increase was due to increased producer concentration in the appellation wine market. Consequently, we attribute the relative increase in the average wine price in AOC departments to shifts in demand arising from improvements in the quality for AOC wines—as the reform intended.[9] The observed price increase then provides a direct measure of the increase in buyers' marginal willingness to pay for wine that can be used for welfare analysis.

Our preferred estimate suggests that the lemons effect had substantial economic impacts on the French wine market. At the end of our study period, the share of French vineyards eligible for AOC recognition reached 32%. Together with our estimated effect on the average wine price, this share implies a *gross* welfare gain of at least 13% of total market value due to the reform. This value represents a lower bound as it ignores the additional utility for infra-marginal buyers of AOC wine. It represents a gross, rather than net, welfare gain because it does not account for the opportunity costs of quality improvements for wines sold under the AOC designation.

We assess these costs using a revealed-preference approach that relates temporal variation in the national share of vineyards claiming AOC status (out of AOC eligible acreage) to the national price premium associated with AOC wines, which we estimate using our panel data. We use national revenue per capita as an instrument for the price premium. Our estimate of the elasticity of relative AOC acreage with respect to the price premium implies quality costs that represent no more than 47% of the increase in market value. Put together, our demand-side and supply-side estimates imply that the reform increased economic welfare by at least 7%, suggesting that the lemons

[7] To be sure, historical prices are not available at the level of the individual vineyard.

[8] In a vertically differentiated market where consumers have heterogeneous tastes for quality, prices in each market segment are determined by the willingness to pay of marginal consumers. As a result, the mere reallocation of quantities from one segment to another through relabeling can affect the price average calculated across all segments, even if quality does not change. In that case, welfare gains are not precluded, but are limited to those associated with reallocation of product across consumers, reflecting improved matching. See Appendix A.

[9] Our main estimated effect is robust to the exclusion of years around WWII when the French wine market is believed to have been disrupted, notably due to forced government procurement.

problem may severely affect market performance in vertically differentiated markets with atomistic supply, even when the volume of trade is large.

Our paper directly relates to a rich literature seeking empirical evidence of adverse selection in real-world markets. Some studies have focussed on the trade of used vehicles (Bond, 1982; Genesove, 1993; Lewis, 2011), in line with Akerlof's original setting; they do not find strong evidence of adverse selection. A richer strand of literature has investigated insurance markets (Puelz and Snow, 1994; Cutler and Reber, 1998; Cawley and Philipson, 1999; Chiappori and Salanié, 2000; Cardon and Hendel, 2001; Finkelstein and Poterba, 2004; Einav et al., 2010; Einav and Finkelstein, 2011; Bundorf et al., 2012; Handel, 2013; Hackmann et al., 2015; Panhans, 2019; Finkelstein et al., 2019). The quantitative evidence on adverse selection is mixed (Einav and Finkelstein, 2011), and welfare effects typically fall within a few percent of market value (Handel, 2013). Closer to our setting, Jin and Leslie (2003) examine the effects of quality information provision on firms' choices of quality in the context of restaurant hygiene. Although they do not observe prices, like us they exploit a policy change that mitigated information asymmetry, and find evidence of quality improvements.[10]

Our paper also relates to an empirical literature exploiting wine quality signals to analyze markets for differentiated products (Ashenfelter, 2008; Ali et al., 2008; Cross et al., 2011; Crozet et al., 2012). In related work, Gergaud and Ginsburgh (2008) study the effect of *terroir*, that is, natural endowments such as soils and climate, on the quality of wines produced in Haut-Médoc, and find virtually no effect. Their result does not contradict ours; they compare wines *within* an AOC, whereas our paper speaks to quality differences between AOC and non-AOC wines.[11]

Finally, we contribute to a broader literature on the impact of information disclosure on economic outcomes. A series of experimental studies have shown how improved access to and control of information can increase market efficiency by lowering search costs and limiting corruption (Jensen, 2007; Jensen and Miller, 2018; Andrabi et al., 2017; Duflo et al., 2013), or instead generate perverse selection effects (Dranove et al., 2003). In an extensive review, Dranove and Jin (2010) note that although *there are many examples in which quality disclosure has allowed consumers to find sellers who best meet their needs [...] there is less evidence that sellers respond by boosting quality*. Our study contributes to filling this gap.

The rest of the paper is organized as follows. Section 1 provides some historical and institutional background. In Section 2, we develop a simple model of quality provision in a vertically differentiated market with asymmetric information. We use

[10] More recently, Bai (2018) conducts an experiment in the retail market for watermelons in a Chinese city. Her study focusses on product grading, so welfare gains arise from allocative improvements and incentives to screen product at wholesale, rather than from upstream quality changes like the ones documented here.

[11] In addition, *terroir* merely reflects exogenous determinants of quality, whereas AOC recognition depends on both natural factors and producers' behavior.

our conceptual framework to guide the interpretation of our empirical estimates. Section 3 describes how we collect and construct our data. Section 4 presents our price analysis, which provides a lower bound on demand-side effects. Section 5 presents our cost and welfare estimates. Section 6 concludes.

1. Historical and institutional background

Long before any regulation on wine appellations was adopted, the names of France's most renown wine regions were commonly used as appellations to identify the wines produced therein. Free-riding and malpractice became widespread during the acute production shortage of the late 19th century.[12] This crisis generated strong incentives to increase production while lowering quality. Producers were often aided in this enterprise by the rapid progress of chemistry.[13] Malpractice was so prevalent that in 1889, French authorities passed a law defining wine as the exclusive product of grape juice fermentation. During that episode, quality vineyards were especially harmed since the general trend was to produce lower quality wines at higher yields, and at the time there existed no legal definition of wine appellations (Stanziani, 2003). Unsurprisingly, counterfeiting was common, as famous names were often usurped by producers located in other wine regions or used without consideration for the production techniques and attendant wine characteristics that had brought reputation to the place (Jacquet, 2005).

In 1905, France adopted its first general law on the prevention of fraud and falsification. One of its provisions created a legal basis for the French administration to delineate the geographical limits of each wine appellation by way of administrative decrees. This task was defined in a 1908 amendment to the 1905 law. A few appellations were delimited immediately, 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). This top-down definition of appellation regions proved problematic to many stakeholders. It is often cited as a leading cause of the Champagne Riots of 1911, as producers in excluded regions felt they had been wrongly denied the appellation. Administrative delineations were also contested 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 based solely on broad delimitations at the level of the municipality, irrespective of the type of terrain, grape varietal, or production practices. Not surprisingly, unscrupulous

[12] 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.

[13] A common way to increase volume while maintaining alcohol content was to add sugar to the must and dilute with water. Some wines were even fabricated from raisins. Various chemicals were used to speed up fermentation, add color, or control spoilage (Stanziani, 2003).

producers located in eligible municipalities started to market mediocre wines under famous appellations. This situation raised concerns among higher-quality producers who were often supportive of stricter eligibility criteria (Capus, 1947).

In an attempt to correct the shortcomings of previous legislation, a 1919 law removed the authority to define appellation wines from the executive branch and gave it to the courts. Any stakeholder who considered they were being harmed by the abusive use of a place name could file a lawsuit. Courts were given the right to not only define geographical boundaries but also to take account of "local, loyal, and constant uses." However, most judges refrained from defining production practices, and in effect, for most appellations the court only specified broad geographical boundaries, just as the former administrative decrees.[14] 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 the "appellation scandal," that is, the proliferation of unwarranted appellation names, which further eroded the reputation of historical appellations (Capus, 1947).

Our study investigates the economic consequences of a law enacted in 1935, whose stated goal was to guarantee the quality of appellation wines by delimiting eligible areas at the parcel—rather than municipality—level, codifying eligible practices, and implementing official quality control. The law introduces a category of appellation wines named AOC, without, at first, eliminating existing appellations. These new appellations are to be defined by decree. But unlike the early administrative delimitations, the provisions of the AOC decree are not dictated by the administration. Instead, the decree sanctions a set of production requirements that emanate from a committee composed of, by order of importance, representatives of local wine associations and wholesalers, members of Parliament, and representatives of the administration—the CNAO.[15] As such, the definition of the requirements applicable to each AOC is left to a technical body of experts that includes representatives of each broadly defined wine region. In order for an appellation to be granted AOC status, the relevant local producer organization first petitions the CNAO, who then makes a decision whether to recognize the wine as AOC and if so, under which conditions.[16]

[14] Another law passed in 1927 explicitly allowed courts to restrict grape varietals and eligible soil types in the definition of an appellation, but these precisions were left optional, and very few judgements included such restrictions (Ministère de l'agriculture, 1937; Capus, 1947).

[15] *Comité national des appellations d'origine*, known today as the INAO.

[16] Humbert (2011) provides the list of items that producer organizations petitioning for AOC status needed to forward to the CNAO. In addition to its bylaws, the producer organization was asked to provide information related to geology, climate, appropriate varietals, a tentative list of eligible parcels, a description of typical vineyard and winemaking practices, a description of common distributional channels, a tentative minimum alcohol content, as well as historical areas, yields, and volumes under the appellation since 1920.

In case of recognition, a government decree gives the CNAO's decision the force of law.

In contrast to pre-existing appellations, subsequently referred to as "plain appellations" (*appellations simples*), AOCs are subject to official control. Wines can claim an AOC if they are grown on an eligible parcel according to specific practices and meet a set of verifiable criteria. Note that the AOC is not compulsory as producers may elect to sell their wines as ordinary wines, or under a plain appellation if they can claim one based on vineyard location. Typical requirements for an AOC, beyond parcel and terrain eligibility, are the grape varietal, a maximum yield per hectare, minimum levels for alcohol and sugar contents, and specific pruning practices.[17] Importantly, a parcel may be eligible for several AOC designations. For instance, a parcel located on appropriate terrain in the Pauillac municipality would be eligible for the following appellations, ranked from the most common to the most exclusive: *bordeaux*, *bordeaux supérieur*, *médoc*, *haut-médoc*, and *pauillac*.

Soon after the 1935 law, many appellations were officially recognized by an AOC decree: 78 AOCs were created in 1936 and 69 others in 1937. These 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. This coexistence, 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 an AOC to transition to the new requirements without completely relinquishing the use of the appellation. However, this regime 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, wine producers in half of the AOCs had successfully obtained the elimination of plain appellations. However, large regional appellations like *bordeaux* and *bourgogne* survived the creation of their AOC counterpart as no consensus was found in their respective local organizations 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 following year. Thus, the only surviving plain appellations were those for which no AOC had been created.

Although AOC control today is done through third-party certifiers, during the study period it was directly performed by government agents. At the winegrower level, official controls were conducted by technical agents of the CNAO commissioned by the Ministry of Agriculture. These agents would verify compliance with respect to terrain, grape varietals, vine pruning and winemaking practices (Humbert, 2011). For instance, Capus (1947) relates that in 1942, 120 pruning infractions were reported

[17] The indication of the alcohol content on AOC wines did not become mandatory until 1999 (Council of the European Union, 1999).

in Champagne, leading to 56 sanctions. In addition to these controls, agents of the fraud repression service of the Ministry of Agriculture were in charge of controlling appellation wines at the wholesale and retail levels. Capus (1947) recounts that thanks to such control, in 1945 the CNAO intervened in 113 wine appellations lawsuits on behalf of producers. Various anecdotes further suggest that AOC regulations had a positive impact on self-discipline. For instance, in 1944 late rains damaged the quality of an otherwise abundant harvest, which resulted in a large share of the AOC harvest being redirected by producers into the ordinary wine market, as the wine did not reach the desired alcohol content. Finally, a potentially important lever to control the quality of AOC wines was the use of expert tasting. Although such testing was made compulsory for all AOC wines only in 1974, its implementation for individual AOCs started in 1946. By 1969, more than a fourth of all AOC designations were subject to mandatory expert tasting (Humbert, 2011).

The AOC designation quickly became the standard for premium quality wines. By 1940, 177 different AOCs had been created and the production of AOC wines exceeded that of plain appellation wines (Humbert, 2011). 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 the wine market

In this section we develop a model of the wine market that allows us to illustrate the mechanisms through which AOC recognition could affect wine prices and discuss how available data can be leveraged to recover welfare effects.

2.1. Set up

We assume that vineyard acreage is inelastic and that yields can vary over space but remain unaffected by the AOC reform. We later show that these assumptions are most reasonable when evaluated against the data. We thus focus on the impact of the reform on wine quality, ignoring quantity effects.

There are two categories of wines, (i) ordinary wines grown in places where climate and soils only allow the production of low-quality wine, and (ii) appellation wines grown in places endowed with beneficial natural factors, the effects of which may be further enhanced by appropriate production practices, such as varietal choice, winemaking techniques, etc. The second category of wine is distinguished from the first at wholesale and retail by the prominent use of the name of the place from which the wine originates—the appellation. In contrast to appellation wines, ordinary wines are assumed to have a fixed quality that cannot be enhanced through costly practices.[18]

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

On the consumer side, we consider a Mussa-Rosen model of vertical differentiation whereby tastes for quality are parameterized by an index $\theta \in [0,1]$, perhaps reflecting income differences, and $F(\theta)$ denotes the c.d.f. of θ. Each consumer demands 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.[19]

Wine quality is denoted $\mu_0 = 0$ for ordinary wine, $\mu_1 \geq \mu_0$ for an appellation that is not an AOC (i.e., a plain appellation), and $\mu_2 \geq \mu_1$ for an AOC. We denote p_0 the price of ordinary wine, p_1 the price of (plain) appellation wine, and p_2 the price of AOC wine.

Before any regulation on production practices is enacted, a market equilibrium does not involve any costly production 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 appellation. We denote by σ_1 the share of vineyard acreage used to produce appellation wine, and by $\sigma_0 = 1 - \sigma_1$ the share used for the production of ordinary wine. We denote by y_1 the yield of appellation (and AOC) wine, and by y_0 the yield of ordinary wine. The share of appellation wine in total wine production is therefore $s_1 = \frac{\sigma_1 y_1}{\sigma_1 y_1 + (1-\sigma_1) y_0} = \frac{\sigma_1 y_1}{y_m}$, where y_m is the average yield (unaffected by the reform).

After the reform, the AOC label is granted to appellation wines produced using costly quality-enhancing practices. The reform therefore generates a difference between two types of appellations, plain appellations and AOCs, that may sell at different prices. We denote by σ_2 the share of vineyard acreage eligible for AOC after regulation. We assume $\sigma_2 \leq \sigma_1$, with the strict inequality corresponding to the case where not all vineyards previously dedicated to the production of appellation wine may claim an AOC, perhaps due to terrain.[20] We further denote by κ the share of vineyards eligible for AOC that are eventually used to produce AOC wine (i.e., the "conversion rate"). This conversion rate is determined endogenously by the cost structure for quality enhancement (which we leave unspecified for now but parameterize in Section 5) and the equilibrium price premium $p_2 - p_1$. The share of total wine production sold under AOC after the reform is therefore $s_2 = \frac{\sigma_2 \kappa y_1}{y_m}$. Denoting $\delta_y \equiv \frac{y_1}{y_m}$, we have $s_2 = \sigma_2 \kappa \delta_y$.

[19] We neglect any potential influence of price on perceived quality, a phenomenon that has been shown to exist in an experimental setting where subjects tasted wines with different price information treatments (Plassmann et al., 2008).

[20] We could further differentiate the valuations of plain appellations and AOC wines before the reform, based on the idea that vineyards declared eligible for an AOC likely benefit from more favorable natural factors than those only worthy of a plain appellation. This refinement would complicate the model without adding anything to our argument.

2.2. Market equilibria

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 plain appellation wine and AOC 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 $M \int_{\hat{\theta}}^{1} dF(\theta) = Qs_2$ after the reform. Before the reform, 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 informational setting. 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 after the reform.

The increase in gross welfare (ignoring the additional costs of quality provision) due to the reform is 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 AOC wine:

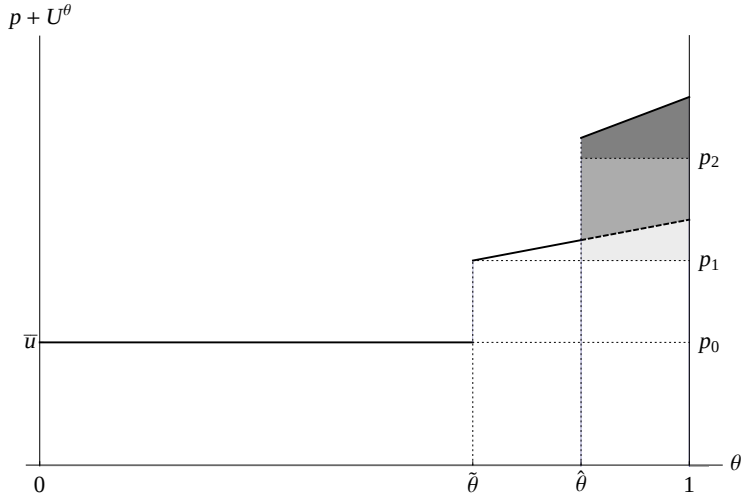
$$\Delta \mathrm{GW} = M \int_{\hat{\theta}}^{1} (\mu_2 - \mu_1) \theta dF(\theta) = Qs_2(p_2 - p_1) \times \frac{\int_{\hat{\theta}}^{1} \theta dF(\theta)}{\hat{\theta} \int_{\hat{\theta}}^{1} dF(\theta)}.$$

We call *increase in market value*, and denote ΔMV, the value $Qs_2(p_2 - p_1)$. It is equal to the increase in price for AOC wines multiplied by the quantity of AOC wine sold. Since $\frac{\int_{\hat{\theta}}^{1} \theta dF(\theta)}{\hat{\theta} \int_{\hat{\theta}}^{1} dF(\theta)} > 1$, it is clear that ΔMV represents a lower bound to the increase in gross welfare ΔGW.

Figure 1 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 $p_2 = \frac{5}{2}$. Lines represent gross welfare (ignoring supply costs) in equilibrium. The dashed line depicts gross welfare for high-θ consumers before the reform. The darkly shaded area represents the increase in gross welfare resulting from regulation. The lightly shaded rectangle represents ΔMV. Note that the framework accommodates the limit case where consumers have identical tastes. Gross utility is then identical across consumers purchasing the same quality, and $\Delta \mathrm{GW} = \Delta \mathrm{MV}$.

One goal of our analysis is to provide an empirical measure of ΔMV, the lower bound on the change in gross welfare. Although we observe Q and have partial information on s_2, we cannot observe $p_2 - p_1$. However, we observe the average price of wine before and after the reform. After the reform, the average price of wine can be

Figure 1 Gross welfare pre- and post-reform



Note: Post-reform equilibria are represented with solid lines. Dashed lines represent pre-reform outcomes for consumers purchasing AOC wine.

written as:[21]

$$p_m = (1-s_1)p_0 + (s_1-s_2)p_1 + s_2p_2 = \underbrace{p_0 + s_1(p_1-p_0)}_{(A)} + \underbrace{\sigma_2\kappa\delta_y(p_2-p_1)}_{(B)}. \quad (1)$$

The terms (A) in Equation (1) depend only on the appellation share, but not on the eligible share σ_2, while term (B) depends on σ_2 and thus on the extent of regulation. The effect of the reform on the average wine price is $\Delta p_m \equiv \sigma_2\kappa\delta_y(p_2-p_1) = s_2(p_2-p_1)$. Therefore, $\Delta\text{MV} = Q\Delta p_m$, and

$$\frac{\Delta\text{MV}}{\text{MV}} = \frac{Qs_2(p_2-p_1)}{Q[(1-s_1)p_0+s_1p_1]} = \frac{\Delta p_m}{p_m} \approx \Delta\log p_m \quad (2)$$

where $\Delta\log p_m$ represents the change in the logarithm of the average price attributable to the AOC reform.

A regression of $\log p_m$ on the share σ_2 of vineyard acreage eligible for AOC (with appropriate controls) will yield the partial derivative $\frac{\partial\log p_m}{\partial\sigma_2}$, which multiplied by the ultimate share of vineyard acreage eligible after the reform becomes a predictor of

[21] If non-eligible appellation wines and the share $1-\kappa$ of eligible wines end up being sold as ordinary wines rather than plain appellations, perhaps because there is no plain appellation available after the reform, the average valuation for ordinary wine will increase to $\bar{p}_0 = \frac{(1-s_1)p_0+(s_1-s_2)p_1}{1-s_2}$, so that the average wine price will still be $p_m = p_0 + s_1(p_1-p_0) + s_2(p_2-p_1)$. This case is functionally similar to the previous one.

$\Delta \log p_m$ and thus of $\frac{\Delta MV}{MV}$. We can further interpret the coefficient on σ_2, say β, as the price premium relative to the average price of wine, modulated by the yield ratio and multiplied by the AOC take-up rate, that is, an intention-to-treat effect. This is because $\log p_m = \log(p_0 + s_1(p_1 - p_0) + \sigma_2 \kappa \delta_y (p_2 - p_1))$, and thus $\beta \equiv \frac{\partial \log p_m}{\partial \sigma_2} = \frac{\kappa \delta_y (p_2 - p_1)}{p_m}$.

Although we could imagine using time-series variation in the average wine price at the national level to identify the effect of the reform on $\log p_m$, an obvious concern is that the estimated effect may be confounded by time effects affecting the wine market at the same time as the reform. Instead, our empirical strategy is to compare the evolution of the average wine price across French departments, which were affected by the reform differentially both in the extent of AOC eligibility and in the rollout of AOC recognition over time. Section 4 details our strategy to obtain an unbiased estimate of β.

A second goal of our analysis is to identify the costs of quality improvements induced by the reform. We denote these costs ΔC. Assuming profit-maximizing behavior on the part of wine suppliers, conversion costs cannot exceed the increase in market value, that is, $\Delta C \leq \Delta MV$. Section 5 explains our strategy to estimate $\frac{\Delta C}{\Delta MV}$, putting additional structure on the model and using a revealed-preference approach. Combining our demand- and supply-side estimates then yields a lower bound to the net welfare effect of the reform.

3. Data

Our dataset combines several sources. We obtain departmental average wine prices, areas in vineyards, and wine production from France's *Statistique agricole annuelle*, an agricultural yearbook published by the Ministry of Agriculture and only available in print for the historical period. We focus on the period 1907-1969. This window excludes the period, starting in the 1860s, when France's vineyards were destroyed by phylloxera, a pest that affects native European vines. It further excludes an ensuing period of generalized fraud through wine adulteration, which ended with the adoption of the 1905 law against fraud and falsification and the creation of the fraud repression service in 1907. Our analysis ends in 1969, one year before the adoption of the first European regulation pertaining to the common organisation of the market in wine. This is also the last year for which price data at the level of the French department was ever reported in the agricultural yearbook. All price data is missing for the year 1949.

The wine price is evaluated through departmental surveys conducted at the winegrower (*récoltant*) level (Ministère des Finances, France, 1908) and should be interpreted as a weighted average calculated across all wines, even in years when the yearbook reports wine production separately for ordinary and appellation wines.[22] We

[22]For the years 1907–1914, separate average prices are reported for "ordinary" and "superior quality" wines. The distinction is based on prices (with a cutoff of 50 Fr./hl), not on whether the wine bears an appellation. See Section 4.3.3.

do not observe the vineyard area dedicated to AOC production at the department level, although in later years, the volume of AOC wine is reported.

We construct the time-varying share of vineyards eligible for AOC status in a department from multiple sources. The first one is a set of more than 400 governmental decrees enacted during the sample period and defining (or modifying) each AOC. These decrees provide us information about the date of recognition and the area eligible, as they typically indicate which municipalities (*communes*) are eligible for a given appellation (this area may cross departmental boundaries). An example of AOC decree is shown in Appendix B for the *côtes du rhône* appellation.

Historical records of which parcels within an eligible *commune* are eligible for an AOC are kept in the cadastral archives of each of France's 35,000 municipalities. Reconstructing the precise historical record of eligible parcels would require visiting each municipality and digitizing the spatial boundaries, which is prohibitive. Instead, we make use of a recent effort by France's *Institut national de l'origine et de la qualité* (INAO) to precisely map out eligible parcels. In April 2019, the INAO released a series of shapefiles indicating the current geographical delimitations of most of France's current AOCs, at the parcel level. (Notable exceptions include *champagne* and *vins doux naturels*.) The delimitations are based solely on terrain, not actual practices, therefore they reflect eligibility rather than compliance. We only consider delimitations for AOCs that were recognized during our sample period.

Several AOC delimitations have changed since their first definition, with modifying decrees either excluding or adding municipalities. We account for such changes by only considering areas located in municipalities eligible for AOC production at any given point in time.[23] If a municipality eligible for an AOC in a given year does not have any eligible area in the 2019 INAO shapefile, either because it is not eligible as of 2019 or because the shapefile is incomplete, we consider the entire area covered by the municipality.[24]

Finally, because eligible areas often include land not actually in vineyards (for instance, they may include hedgerows or access roads, or, in the cases specified above, the entire municipality), we intersect these delimitations with 100 m land cover data showing areas planted in vineyards in the years 1990, 2000, 2006, 2012, or 2018. The land use information comes from satellite imagery and these are the only years for which it is available. We intersect the two files by first rasterizing the INAO shapefile and then overlaying it with the land use file. Each pixel covers 1 ha of land.[25]

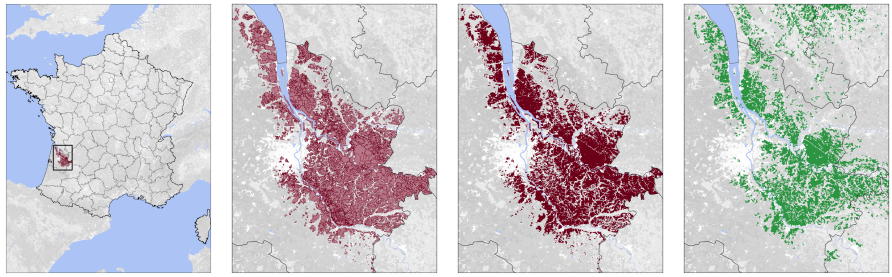
Figure 2 depicts the selection of the eligible area for the AOC *bordeaux*, entirely located within the Gironde department. Panel (b) depicts the shapefile from the INAO, showing the contours of eligible parcels as polygons. Panel (c) shows the pixelation

[23] We thank Florian Humbert for sharing data on changes in eligible municipalities.

[24] We do not proceed with this adjustment for the regional appellations *bourgogne*, *bourgogne-aligoté*, *bourgogne-passe-tout-grains*, and *alsace* as their AOC decrees do not provide a precise list of eligible municipalities. Instead, we rely entirely on the INAO shapefile showing eligible parcels.

[25] Our main results are robust to the omission of the land cover filter. See Table D.5 in Appendix D.

Figure 2 The area eligible for the *bordeaux* AOC



(a) Location in France (b) Eligible polygons (c) Eligible pixels (d) Vineyards

Note: Department boundaries are shown as they were during the period of investigation.

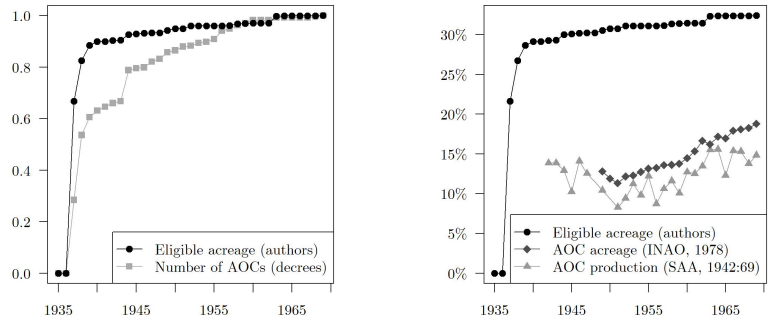
of the eligible area, and panel (c) shows the pixels planted in vineyards from the land use dataset. The intersection of the areas selected in panels (c) and (d) represents our measure of the vineyard area eligible for *bordeaux*.

To construct the share of vineyards eligible for AOC recognition at the level of a department, our unit of analysis, we divide the area eligible for at least one AOC in any given year (while being grown in vineyards) by the maximum of the area planted in vineyards during the period 1907–1969, which we obtain from the agricultural yearbooks. Given the general downward trend in vineyard areas over the period (see Figure 5 below), this maximum area is typically equal to the area at baseline. The calculated eligible share represents our best estimate of the historical share of vineyards eligible for AOC. For each AOC, we use the year following the year of enactment of the decree as the starting date for counting AOC eligibility. Additional details about the construction of the eligibility share are provided in Appendix C.

Table 1 Summary statistics

Variable (unit)	Mean	Median	Std. dev.	Min.	Max
Price (1969 Franc per hectoliter)	108.9	92.5	87.1	8.4	1,784.8
Production (million liters)	70.6	20.4	156.7	0.0	1,538.3
Acreage (thousands hectares)	18.4	7.6	30.3	0.0	199.0
Yield (hectoliters per hectare)	29.2	27.0	14.8	0.5	258.0
Share of acreage eligible for at least one AOC	0.067	0.000	0.202	0.000	1.000
Share of acreage eligible for at least three AOC	0.016	0.000	0.089	0.000	0.899
Share of acreage eligible for at least five AOC	0.002	0.000	0.020	0.000	0.213

Figure 3 Temporal rollout of AOC recognitions and AOC production



(a) Cumulative distribution (b) National share

Note: The count of decrees represented in this figure includes the 34 Burgundy *premiers crus* created in 1943 but excludes the 577 *climats* relative to these *premiers crus*. Similarly, it excludes the 64 municipality names which can be attached to the AOCs *beaujolais* and *mâcon*.

Table 1 shows summary statistics for a set of variables relevant to our analysis. Figure 3 depicts the temporal rollout of AOC recognitions and, whenever available, the national vineyard area under AOC and the national AOC wine production.[26]

4. Price analysis

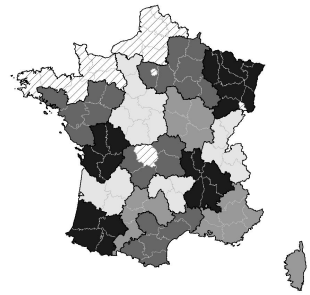
We begin with a discussion of our identification strategy. We then present our empirical findings, including the effect of AOC recognition on the average wine price and its interpretability in terms of quality improvements.

4.1. Identification strategy

We exploit two sources of variation to identify the effects of the reform on the average wine price: variation in the exposure of a department to the reform (through its eligible share of vineyards) and variation in the timing of the decrees taken in application of the 1935 law. Most AOC decrees were enacted during the years 1936 and 1937, although several were adopted later, notably those pertaining to the Alsace region in 1962. Importantly, the reform affected wine-producing departments unevenly: many had no AOC area, some had complete AOC eligibility, and many had only a share of their vineyards eventually recognized as eligible. This cross-sectional variation provides

[26]The vineyard area under AOC was obtained from estimates reported in INAO (1978) and corresponds to vineyards producing AOC wine.

Figure 4 Definition of regions



Note: Delineations in light gray represent departments. Delineations in black represent regions. Hatched departments are excluded from the analysis because they produced little to no wine during the period.

both an extensive and an intensive margin of treatment that allow us to control for common shocks to departmental wine prices through year fixed effects.

A key 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 in force at the same time that demand factors, say expanding export markets, are affecting wine prices, then the effect of foreign demand might be mistakenly attributed to regulation if it happens to affect treated and untreated departments differently. One strategy to control for such potentially confounding factors is to further differentiate the year fixed effects by broad wine region, such as "Loire" or "Midi." To define these regions, we largely follow the classification adopted by the INAO, making sure that each region is large enough to include at least a couple of departments, our cross-sectional units of analysis.[27] Our dataset includes 15 regions and 76 departments, depicted in Figure 4.

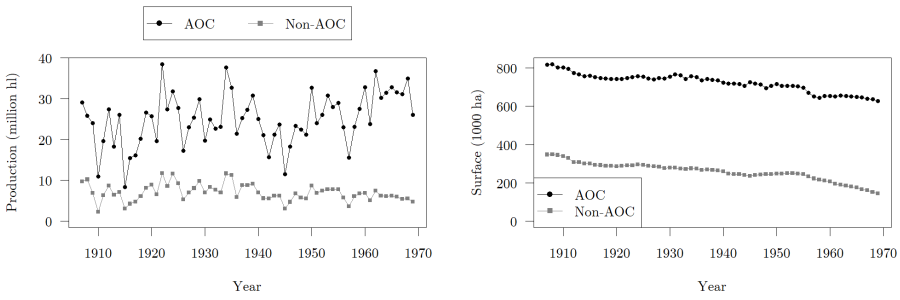
Our main specification can be spelled out as follows:

$$\log p_{it} = \alpha_i + \gamma_{rt} + \boldsymbol{\beta}'\mathbf{s}_{it} + \boldsymbol{\delta}'\mathbf{x}_{it} + \varepsilon_{it} \tag{3}$$

where p_{it} denotes the average price of wine in department i in year t, r indicates the unique wine region to which department i belongs, α_i is a department fixed effect, γ_{rt} is a region-by-year fixed effect, $\mathbf{x}_{it}$ is a vector of quantity controls, and $\mathbf{s}_{it}$ is a vector of treatment variables capturing the extent of AOC recognition. 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 three or more AOCs. The vector $\boldsymbol{\beta}$ captures the effects of interest. In our

[27] These wine regions are different from the French administrative units called *régions*.

Figure 5 Wine output and productive acreage in AOC and non-AOC departments



(a) Wine output (b) Productive acreage

Note: Areas excludes departments with missing data. AOC departments (23) are departments with a 1969 share of vineyards eligible for AOC larger than 20%. Non-AOC departments (32) are departments with a 1969 share of vineyards eligible for AOC smaller than 2.5%. 11 departments with an intermediate share are not represented.

main set of regressions, we only include the share of acreage eligible for one or more AOCs as the treatment variable, but we explore richer models in Appendix E.

We include controls for quantity produced, either in year t or in year $t-1$, because wine production is highly dependent on weather. Indeed, departmental output displays wide fluctuations from year to year (see Figure 5). These fluctuations are not due to planting decisions, as vineyard acreage has moved smoothly over time, but rather to yield effects caused by weather shocks. Conditional on region-by-year fixed effects, output variations can therefore be considered exogenous to price, and we thus interpret Equation (3) as an inverse demand equation.[28] The coefficient δ represents the derived demand flexibility for wine at the departmental level. The coefficient β represents the shift in marginal willingness to pay for wine, conditional on output. Note that removing quantity controls from the regression will not qualitatively change our estimate of β.

Controlling for region-by-year fixed effects means that our identification relies on differences, within a region, in 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 vineyard area being eligible for a given appellation and, to some extent, from different dates of adoption of decrees for different appellations. Our key identifying assumption is that within a wine region, treated and untreated departments would have followed parallel price movements after AOC recognition if not for the recognition itself. Given the limited geographical span of our regions, we find it

[28] Milhau (1948) uses a similar regression to identify the demand for wine during the period 1919–1933 at the national level, explicitly treating aggregate realized output as exogenous to price.

unlikely that unobservables correlated with the AOC share within a region-year could confound the effect of regulation.

One concern, however, is that recent price trends could have been a factor in the decision of the CNAO to grant AOC status, or in the decision of producer groups to seek such status. In fact, information on prices was not part of the petition process. As explained in Humbert (2011), the bulk of the application consisted of a description of the natural factors and production practices specific to the appellation, in addition to historical production records. The only economic criterion considered was a description of distribution channels (see footnote 16). Indeed, the very first round of AOC recognitions included both small, prestigious appellations such as *romanée-conti* or *pauillac* and broad regional appellations such as *bordeaux* that sold at much lower prices. It thus seems unlikely that price levels, let alone price trends, could have influenced AOC status. In Section 4.3.3, we provide multiple pieces of empirical evidence in support of our identifying assumption, including an event study demonstrating the absence of upward or downward price trends prior to AOC recognition.

Another possible concern linked to the continuous nature of our treatment variable is that even if the timing of recognition was not related to unobserved determinants of price, the size of the area recognized could have been. For instance, one could imagine that appellations with stronger producer associations would be likely to experience larger price increases and also lobby for a larger eligible area. However, the 1935 law and ensuing AOC decrees restricted the ability of producer associations to influence the size of the eligible area whenever the appellation had previously been recognized by a court ruling pursuant to the 1919 law, which was the case for the majority of AOCs recognized during the period (Humbert, 2011). Specifically, the 1935 law stated that CNAO could not expand eligible areas beyond the delineations previously determined by courts. Areas within these delineations could be excluded, but AOC decrees stated that such exclusions would be determined based on specific geological factors. For instance, the decree reproduced in Appendix B states that all lowlands and all modern alluvial soils are to be excluded from the eligible area of the *côtes-du-rhône* appellation. These exclusions were typical and are found in many other AOC decrees. It thus seems unlikely that producer associations could have lobbied to meaningfully affect eligible areas, being bound by past court decisions and natural terrain.

4.2. Inference

Our specification includes region-by-year fixed effects. These fixed effects flexibly control for yearly shocks common to departments located in the same wine region, notably those due to weather shocks that could affect quality independently of quantity (which is explicitly controlled for). On average, there are five departments in each region. Our preferred standard errors assume that, conditional on these geographically differentiated yearly shocks and other included regressors, there is no residual correlation in errors across departments. Nonetheless, we allow for serial correlation

across years within a department through the use of department-level clusters. We view department-clustered standard errors as conservative enough, particularly given the small number of departments within each region. Further, because we sample all departments in all regions, there is no sampling design justification for clustering at the region level (there are no relevant regions absent from our data set that we wish to draw inference about). Instead, we view our sampling as occurring in the time dimension, in which case department-level clusters seem appropriate (Abadie et al., 2017).

For comparison purposes, we also report two other types of standard errors: (i) standard errors computed using the method of Conley (1999) adapted for panel data,[29] and (ii) two-way standard errors that allow for serial correlation within a department and contemporaneous correlation across departments in the same region. Unlike the department-clustered and two-way standard errors, Conley errors do not account for serial correlation of the error term.

4.3. Results

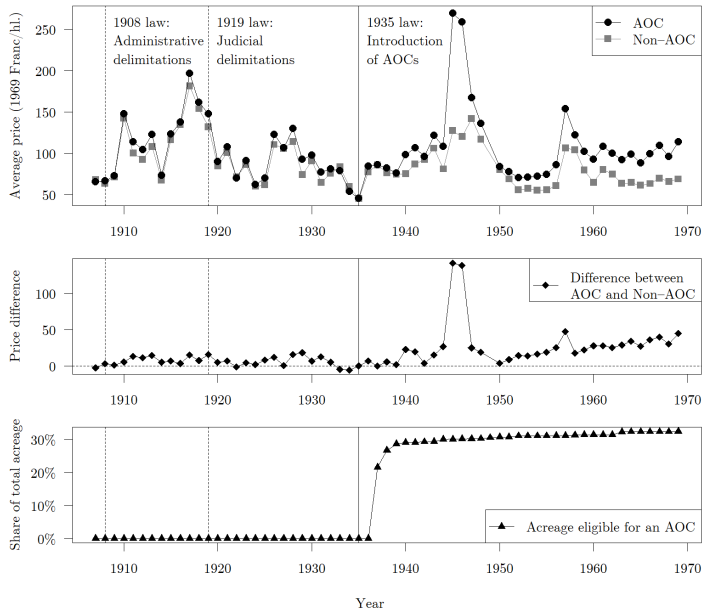
Before discussing our main results and considering competing explanations for the observed price effect, we present suggestive evidence that AOC recognition positively affected the trajectory of wine prices at the department level. Robustness checks that exclude selected years or selected departments are provided in Appendix D. In addition to these robustness checks, a detailed heterogeneity analysis is provided in Appendix E. This analysis provides estimates that vary across time, space, and layers of AOC eligibility (accounting for the hierarchical structure of AOC recognitions). It also provides a formal test that the effect of AOC eligibility on the departmental price can be considered to be linear.

4.3.1. Suggestive evidence. The top panel of Figure 6 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 20% by 1969) and those with low eventual AOC share (defined as those with an eligible share lower than 2.5%). A few departments with intermediate share are not represented. The middle panel of the figure plots the evolution of the difference between the two averages, and the bottom panel shows the evolution of the share of acreage eligible to an AOC.

Figure 6 shows that the two categories of departments had very similar prices before the AOC reform, even after the appellation laws of 1908 and 1919. The two price series only start to diverge after the AOC reform, with higher values in departments with high eventual AOC share, particularly in the immediate aftermath of

[29] The Conley errors are to spatial data what Newey-West errors are to time-series data. Here we apply the Newey-West weighting scheme to neighboring relationships.

Figure 6 Average real wine prices in AOC and non-AOC departments



Note: Average real wine 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 pre-reform period from 1907 to 1936. AOC (resp. non-AOC) departments (23, resp. 29) have a 1969 share of eligible vineyards larger than 20% (resp. smaller than 2.5%). Eleven departments with intermediate share are not represented in the top and middle panels.

WWII.[30] The price spikes observed in 1945 and 1946 in AOC departments are due to a shortage caused by an exceptionally small harvest in 1945 in AOC regions.[31]

The figure provides visual support for the "parallel trends" assumption implicit in difference-in-differences designs.[32] What the figure does not capture, but our main regression will, is any differential price trends *within* the two broad categories defined here (that is, the intensive margin of treatment along the AOC share dimension), and the fact that recognition did not happen simultaneously in all treated departments (the intensive margin of treatment along the time dimension).

To further investigate the parallel trends assumption, we compare two simple price trend regressions based on different subsamples of years with equal span: 1907–1936

[30] Our estimates are not driven by data from that period. See Table D.3.

[31] A severe frost in May 1945 killed the young shoots right after bud burst. In Gironde where *bordeaux* is produced, production was divided by three compared to 1944.

[32] Average prices in the departments with 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.

Table 2 Trends regressions

	Price trend (%)				Output trend (%)	
	1927–1956		1907–1936		1927–1956	
	(1)	(2)	(3)	(4)	(5)	(6)
AOC share	74.16	71.96	-6.93	-3.92	5.79	-13.25
	(27.07)	(26.28)	(6.56)	(6.93)	(11.68)	(22.86)
Region FE		✓		✓		✓
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 pre-reform (1907–1936) and pre-post-reform (1927–1956) periods. The length of the pre-post-reform period was chosen to match that of the pre-reform period. Heteroskedasticity-robust standard errors are reported in brackets.

(pre-reform) and 1927–1956 (pre-post-reform). 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 2. 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 the wine region to purge the regression of effects common to all departments located in the same 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 regional effects. In contrast, columns (3) and (4) show that if we consider price trends during the pre-reform 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 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 quantity.

4.3.2. Panel analysis. The results from the estimation of Equation (3) appear in Table 3 and Appendix Tables D.1 and D.2. Each table uses a different time window to identify the effects of AOC recognition, from the widest (1907–1969, the entire data set) to the narrowest (1921–1950). Each table displays results with different sets of controls. Every regression includes department and year fixed effects. Except for column (6), all columns control for production in some way. For a given time window, estimates of the effect of the AOC eligibility share on the departmental price are quite similar across specifications, even when omitting the production controls.

We do not expect coefficient estimates to be stable across time windows. As periods change, so does the set of appellations that are recognized in the sample. Because AOC recognition may cause different price increases in different regions, our coefficient estimate, which captures an average effect, may vary according to the period used. In addition, it may take time for reputations to build. Despite these considerations, our results show a statistically significant and economically

Table 3 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)
AOC share	0.395 (0.043) [0.088] {0.092}	0.427 (0.044) [0.083] {0.089}	0.417 (0.044) [0.083] {0.090}	0.424 (0.045) [0.084] {0.090}	0.413 (0.045) [0.083] {0.090}	0.409 (0.044) [0.085] {0.091}
log(Production)	-0.041 (0.011) [0.012] {0.014}	-0.042 (0.012) [0.015] {0.017}	–	–	–	–
log(Production$_{-1}$)	–	–	-0.024 (0.011) [0.016] {0.017}	–	–	–
log(Production)×Region				✓		
log(Production$_{-1}$)×Region					✓	
Region×Year FE		✓	✓	✓	✓	✓
Observations	4,572	4,572	4,483	4,572	4,483	4,572

Note: All regressions include year FE. Standard errors: () Conley; [] department-clustered; {} two-way. The panel includes all departments for which price data is available for at least half of the sample years.

meaningful effect of AOC recognition on the average wine price in all periods, even after conditioning on quantity produced. In the largest sample, the regression with the richest set of controls implies a 42% increase in the average departmental wine price associated with full AOC eligibility (column (4) of Table 3, using contemporaneous rather than lagged quantity as a control). Estimates from alternative specifications lie between 40% and 43%. The estimates reported in Table D.1 for the period 1911–1960 lie between 28% and 31%, while those reported in Table D.2 for the period 1921–1950 lie between 19% and 22%.

4.3.3. Evidence in support of the counterfactual comparability assumption. Our identifying assumption is that, conditional on region-by-year effects and quantity, no unobserved determinants of price correlate with the AOC eligible share. One could be concerned however that departments eligible for AOC recognition were on a different price trajectory than control departments. That is, although our region-by-year fixed effects control for trends common to all departments within a region, unobserved factors that would have systematically propped up prices in treated departments after the reform 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

Table 4 Effect of the later AOC eligible share on the real price of wine, pre-reform periods

	Dep. var.: log average real price of wine								
	1907–1936					1907–1926		1917–1936	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
AOC share	-0.054	-0.006	-0.023	-0.004	-0.023	0.067	0.037	-0.129	-0.120
	(0.056)	(0.054)	(0.054)	(0.055)	(0.054)	(0.061)	(0.064)	(0.069)	(0.069)
	[0.069]	[0.084]	[0.085]	[0.084]	[0.083]	[0.083]	[0.079]	[0.060]	[0.066]
	{0.079}	{0.096}	{0.096}	{0.096}	{0.094}	{0.097}	{0.096}	{0.085}	{0.090}
log(Production)	-0.054	-0.064							
	(0.016)	(0.015)							
	[0.014]	[0.015]	–	–	–	–	–	–	–
	{0.016}	{0.018}							
log(Production$_{-1}$)	–	–	-0.046	–	–	–	–	–	–
			(0.013)						
			[0.018]						
			{0.020}						
log(Production)×Region				✓		✓		✓	
log(Production$_{-1}$)×Region					✓		✓		✓
Region×Year FE		✓	✓	✓	✓	✓	✓	✓	✓
Observations	2,249	2,249	2,138	2,249	2,138	1,493	1,389	1,498	1,482

Note: All regressions include year FE. Standard errors: () Conley; [] department-clustered; { } two-way. The panel includes all departments for which price data is available for at least half of the sample years.

almost one upon recognition.[33] Another concern could be that producer groups who successfully petitioned for AOC status were better organized, which could correlate with their ability to supply higher-quality wine in the post-reform period, irrespective of AOC status.

We take a multi-pronged approach to analyzing such possibilities. First, we run falsification tests of the relationship between AOC recognition and the average wine price using data from the pre-reform period. Specifically, we artificially set the share of AOC vineyards to its value fifteen years later. Since we begin counting AOC recognition the year after the decree is enacted, and the first decrees were enacted in 1936, from 1907 to 1921 (15 years) our AOC share remains equal to zero and the artificial treatment period goes from 1922 to 1936 (15 years). Results are shown in Table 4 and confirm that eventual AOC recognition was uncorrelated with price patterns before the actual treatment period began. That is, AOC and non-AOC departments do not appear to have been following different price trends prior to the reform. The table also shows results obtained from models where the share of eligible vineyards is artificially set equal to its value 20 years later (columns (6) and (7)) or 10 years later (columns (8) and (9)). If anything, the results in columns (8) and (9) suggest a negative correlation between eventual AOC recognition and pre-reform price trends right before the reform, although statistical significance is dependent on which standard error is used. This relative erosion of wine prices in departments ultimately eligible for AOC recognition is consistent with historical accounts of increasing abuses in the appellation wine market in the years leading to the reform (Capus, 1947).

[33] To confound our effect, such a taste would have to be unrelated to AOC recognition, however.

Second, we use an event-study design to more closely examine price trends in the years leading to AOC recognition in treated departments. To that effect, we need to assign a "treatment year" to every department with eventual AOC eligibility. We use the share eligible as of 1969 (denoted s_{i1969}) as a benchmark share and assign treatment to the first year when the AOC eligible share in department i exceeded $0.25 s_{i1969}$. We note that in most departments, the eligible share rose from zero to a value close or equal to s_{i1969} within a couple of years, so assigning the treatment year this way is relatively innocuous.[34] We then follow the design of Allcott et al. (2019) and estimate the following regression on the entire sample, including untreated departments (i.e., those with $s_{i1969} = 0$):[35]

$$\log p_{it} = \mathbb{B}_{it}\left(\beta_0 s_{i1969} + \sum_{\substack{y=-15 \\ y\neq 0}}^{+32} \mathbb{C}_{ity}\beta_y s_{i1969}\right) + \alpha_i + \gamma_{rt} + \boldsymbol{\delta}'\mathbf{x}_{it} + \varepsilon_{it}$$

where $\mathbb{B}_{it}$ is an indicator variable taking on the value one if observation (i,t) is part of a window of time spanning 15 years prior and up to 32 years after the treatment year of department i, and $\mathbb{C}_{ity}$ is another indicator variable taking on the value one if year t occurs y years after the treatment year for department i (with the convention that if y is negative, year t must occur $|y|$ years *prior* to treatment). The omitted category in the summation is $y = 0$, so that the coefficients β_y represent the effect of AOC recognition y years after it occurs, relative to its effect in the year of recognition. Untreated departments do not participate directly in identification of the β_y coefficients, however they help identify the controls.

Figure 7 shows the estimates of the β_y coefficients, together with confidence intervals computed using the department-clustered standard errors. The figure clearly shows that wine prices did not increase immediately prior to AOC recognition.[36] They do not seem to have decreased in a significant fashion either. We do not find the absence of upward trend prior to recognition to be surprising. As explained in Capus (1947) and Humbert (2011), the AOC system was initially designed to strengthen production requirements for existing appellations, rather than reward areas with a recent history of quality or price improvements. It is therefore unlikely that recent price trends were a consideration in the granting of AOC status. The absence of upward price trends prior to treatment should also allay concerns that AOC status was preferably granted to appellations with more effective producer groups who would have managed to improve quality absent AOC recognition.

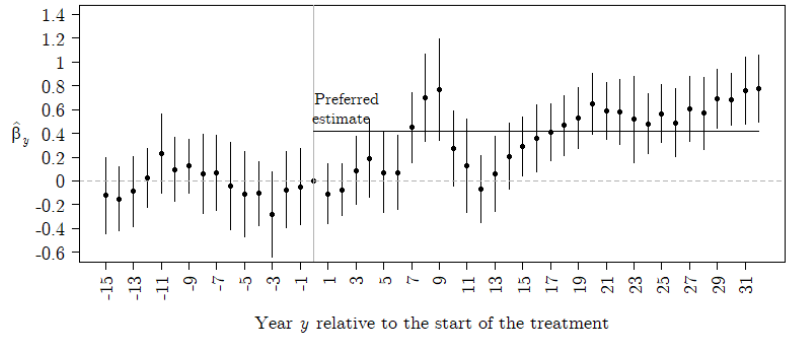
As a third piece of evidence that our estimated effects are not driven by unobserved correlated factors, we restrict the sample to the post-1937 period: by that date, the

[34] Using $0.5 s_{i1969}$ or 0 as the threshold defining the start of the treatment leads to the same results.

[35] Using only treated departments for the estimation leads to similar results. See Figure D.1 in Appendix D.

[36] We provide several possible explanations for the upward trend in the treatment effect in Appendix E.1.

Figure 7 Event study of the effect of AOC recognition on the average wine price



Note: Bars indicate 95% confidence intervals based on department-clustered standard errors. The preferred estimate is from the specification reported in Table 3, column (4).

Table 5 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)	(6)
AOC share	0.234	0.352	0.355	0.365	0.352	0.362
	(0.096)	(0.136)	(0.137)	(0.144)	(0.141)	(0.136)
	[0.078]	[0.145]	[0.135]	[0.161]	[0.145]	[0.140]
	{0.099}	{0.179}	{0.172}	{0.197}	{0.181}	{0.175}
log(Production)	0.004	0.014				
	(0.019)	(0.022)				
	[0.022]	[0.026]	–	–	–	–
	{0.023}	{0.029}				
log(Production$_{-1}$)	–	–	0.039	–	–	–
			(0.022)			
			[0.026]			
			{0.028}			
log(Production)×Region				✓		
log(Production$_{-1}$)×Region					✓	
Region×Year FE		✓	✓	✓	✓	✓
Observations	2,267	2,267	2,261	2,267	2,261	2,267

Note: All regressions include year FE. Standard errors: () Conley; [] department-clustered; { } two-way. The panel includes all departments for which price data is available for at least half of the sample years.

most important AOCs had already been defined, so that the residual variation in the AOC eligible share, conditional on the departmental fixed effects, comes from later rounds of AOC recognition, notably that of Alsace wines. Results are displayed in

Table 5. Although the point estimate is slightly smaller than in the full sample, the effect of the AOC share remains large (37% in column (4)) and statistically significant. For the estimated effects to be spurious, unobserved factors would thus need to be systematically correlated with waves of AOC recognition.

Next, we investigate whether the set of departments used as controls is a significant driver of our results. If unobserved factors unrelated to AOC recognition affected wine prices in AOC departments differently than in non-AOC departments within a region after the reform, we would expect that removing non-AOC departments from the sample would change the estimated effect of AOC recognition. We thus remove all departments for which the eventual AOC share (by 1969) lies below 2.5%, as well as all departments with missing data. There are 42 such departments out of 76 used in the full sample, therefore this procedure removes more than half of the departments. Because departments with zero or very small eligible share are excluded, identification now relies on comparisons of price changes across moderately and more intensively treated departments within the same region, which are plausibly more similar to each other and less likely to be differentially affected by factors unrelated to AOC recognition after the reform. Results are displayed in Table 6 and show that the coefficient estimates on the AOC eligible shares are still statistically significant and of similar magnitudes as those obtained using the entire sample of departments.[37] For instance, column (4) shows an average effect of AOC recognition equal to 36%, as opposed to 42% in the full sample.

Finally, we consider the hypothesis according to which prices in AOC departments rose after the reform due to rapidly rising per-capita income during the post-war era (a period of economic growth known as the *Trente Glorieuses*, "The Glorious Thirty"), coupled with the fact that high-quality wines, unlike ordinary wines, could be considered luxury goods. Indeed, as incomes rise, the demand for high-quality wine (relative to ordinary wine) would be expected to increase. To the extent that AOC eligibility proxies for the share of high-quality wine produced in a department, the estimated price effect could be reflecting the effect of rising per-capita income, in addition to (or in place of) any effect of AOC recognition on actual wine quality.[38]

To test this hypothesis, we collect the time series of income per capita at the national level calculated in Piketty (2001) for the years present in our sample. We then interact the logarithm of this time-varying income measure with three department-varying measures of the potential for high-quality wine production, and add the interaction as a control in our main regression. We also allow our space- and time-varying measure of AOC eligibility to interact with per-capita income.

Our first measure of a department's potential for quality is the share of departmental wine production considered to be of "superior quality" in France's

[37] The results still hold if we include departments with missing data in the regression.

[38] In the model of Section 2, a rise in per-capita income would cause a shift of the θ-distribution towards higher values, which, keeping M, Q, and s_1 constant, would translate into a higher value of p_1 and a higher average price, even in the absence of quality improvements.

Table 6 Effect of the AOC eligible share on the real price of wine, excluding non-AOC departments

	Dep. var.: log average real price of wine					
	(1)	(2)	(3)	(4)	(5)	(6)
AOC share	0.383	0.385	0.373	0.363	0.363	0.371
	(0.053)	(0.047)	(0.047)	(0.047)	(0.046)	(0.045)
	[0.111]	[0.106]	[0.106]	[0.109]	[0.107]	[0.106]
	{0.116}	{0.109}	{0.109}	{0.112}	{0.110}	{0.109}
log(Production)	-0.108	-0.059				
	(0.026)	(0.030)				
	[0.025]	[0.039]	–	–	–	–
	{0.028}	{0.042}				
$\log(\text{Production}_{-1})$	–	–	-0.018	–	–	–
			(0.024)			
			[0.034]			
			{0.036}			
log(Production)×Region				✓		
$\log(\text{Production}_{-1})$×Region					✓	
Region×Year FE		✓	✓	✓	✓	✓
Observations	2,108	2,108	2,074	2,108	2,074	2,108

Note: The period is 1907–1969. All regressions include year FE. Standard errors: () Conley; [] department-clustered; {} two-way. The panel excludes departments with missing price data.

Statistique agricole annuelle. That information is available for the years 1907–1914, so we average production across these years to construct a time-independent measure of high-quality wine production potential. In these early yearbooks, wines used to be considered of "superior quality" if they sold at a price higher than 50 fr./hl, irrespective of any appellation (Ministère des Finances, France, 1908). Arguably, this classification provides a more objective measure of quality than AOC eligibility, which some may view as normative, bureaucratic, or subject to regulatory capture. Nonetheless, this measure of quality is positively correlated with our measure of AOC eligibility (e.g., correlation coefficient $\rho \approx 0.55$ when using the AOC share as of 1941, 5 years after the first AOCs were introduced). The results are shown in columns (1)–(2) of Table 7 and suggest a clear effect of AOC recognition, even conditioning on the quality-revenue interaction. To help in interpretation, we have demeaned the log-income variable using its average value across years in the post-reform period (1937–1969), therefore the coefficient on the AOC share represents the marginal effect of AOC recognition evaluated at this mean log-income value.

The second measure of a department's potential for quality comes from France's *Journal Officiel* for the year 1936, which reports the volumes of wines declared under (plain) appellation by department in 1935. This information is only available for that particular year in the pre-reform period. The share of wine sold under appellation

Table 7 Controlling for changes in income

	Dep. var.: log average real price of wine					
	(1)	(2)	(3)	(4)	(5)	(6)
AOC share (β_1)	0.403	0.386	0.448	0.435	0.422	0.420
	(0.042)	(0.042)	(0.054)	(0.055)	(0.062)	(0.061)
	[0.101]	[0.100]	[0.130]	[0.134]	[0.077]	[0.075]
	{0.104}	{0.104}	{0.136}	{0.140}	{0.089}	{0.088}
AOC share×Income deviation (β_2)	0.560	0.532	0.566	0.561	0.570	0.573
	(0.075)	(0.076)	(0.094)	(0.094)	(0.131)	(0.128)
	[0.167]	[0.167]	[0.245]	[0.246]	[0.152]	[0.148]
	{0.171}	{0.171}	{0.248}	{0.250}	{0.180}	{0.175}
VQS share$_{1907-1914}$×Income deviation	0.134	0.171				
	(0.173)	(0.165)				
	[0.408]	[0.412]	–	–	–	–
	{0.420}	{0.424}				
PA share$_{1935}$×Income deviation			0.205	0.198		
			(0.097)	(0.098)		
	–	–	[0.288]	[0.292]	–	–
			{0.294}	{0.299}		
AOC share$_{1941}$×Income deviation					-0.039	-0.065
					(0.133)	(0.132)
	–	–	–	–	[0.208]	[0.204]
					{0.231}	{0.227}
log(Production)×Region	✓		✓		✓	
log(Production$_{-1}$)×Region		✓		✓		✓
Joint significance test: $\beta_1 = \beta_2 = 0$	16.140	14.960	11.982	10.602	30.877	31.916
Observations	4,350	4,276	4,138	4,056	4,572	4,483

Note: All regressions include region-by-year FE. Standard errors: () Conley; [] department-clustered; {} two-way. The panel includes all departments for which price data is available for at least half of the sample years. Columns (1)–(2) exclude a couple of departments for which production data is not available for the period 1907–1914. Columns (3)–(4) exclude departments covered by Cognac and Armagnac, whose production is omitted in the 1935 appellation production data. The joint significance test uses the department-clustered covariance matrix. The critical value is $\chi^2_{95\%}(2) = 5.991$.

in 1935 is constructed by dividing the appellation volume by the total volume of wine produced, as reported in the agricultural yearbook. As explained in Section 1, before the reform the use of appellations was largely unrestricted (except for broad delineations of eligible areas), so the share of wine sold under appellation in 1935 represents a measure of quality more closely related to that of an unregulated market than the AOC eligible share.[39] Results from regressions that include a control interacting the 1935 plain appellation share with per capita income are shown in columns (3)–(4) of Table 7. Although the 1935 share is positively correlated with our

[39]The 1935 data on appellation wine production are missing for Charente and Charente-Maritime, the main producers of *cognac*. We suspect these data are not reported due to the nature of that appellation, which is not a wine but a brandy. We exclude these departments from the analysis reported in Table 7. We also exclude the other two departments with parcels eligible for the appellation *cognac*, as well as the departments producing the other brandy appellation, *armagnac*.

AOC share ($\rho = 0.81$ in 1941), results are consistent with those reported in the first two columns and suggest a clear (and large) incremental effect of AOC recognition.

Finally, to account for the fact that the years leading to the 1935 reform saw an increase in the number of "unwarranted" appellations, we use a more restrictive definition of quality potential by considering the share eligible for AOC designation 5 years after the first recognitions took place, namely the AOC share as of 1941. The results are shown in columns (5)–(6) of Table 7 and confirm the role of AOC recognition in the determination of the departmental price.

Taken as a whole, these results suggest that AOC recognition caused a sizeable appreciation in average wine prices at the department level. Our preferred estimate indicates a rate of increase of the average wine price with respect to the share eligible for AOC of 42%. This estimate implies that in a department where 100% of vineyards became eligible for at least one AOC (like Gironde), the average wine price increased by 42%.

4.3.4. Ruling out alternative explanations. The results of Sections 4.3.2 and 4.3.3 suggest a clear effect of AOC recognition on the departmental wine price. Whether the increase in the 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 channels to consider: first, the reform could have reduced overall wine acreage and/or yields in regulated areas, and therefore the quantity of wine produced in treated departments. Second, the reform could have reshuffled volumes of wines away from the appellation market into the ordinary wine market. We investigate these channels in the following discussion. We also discuss the possibility that the reform may have changed market structure.

Acreage and yield effects

It is difficult to imagine how acreage in vineyards could have been reduced by the reform because it did not force producers to uproot existing vineyards. 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 negative effects of the reform on either acreage or yield in the data. Instead, regression results reported in Table 8 show that the share of AOC recognition had a positive and statistically significant effect on productive vineyard acreage over the period 1907–1969.

These effects are consistent with the view (confirmed by Figure 5) that wine acreage decreased more over time in non-AOC regions than in AOC regions. One potential explanation for the observed differential trends in acreage may be that the AOC reform increased the profitability of wine making in treated areas and therefore had an effect on the extensive margin of wine production. If this were the case, this additional supply of wine would be direct evidence of the increase in market value attributable to the resolution of the lemons problem, as described in Akerlof's

Table 8 Effect of AOC recognition on productive acreage and yield, 1907–1969

	Dep. var.:		
	log acreage	log yield	log production
	(1)	(2)	(3)
AOC share	0.376	0.042	0.438
	(0.048)	(0.042)	(0.063)
	[0.117]	[0.088]	[0.161]
	{0.123}	{0.092}	{0.165}
Observations	4,653	4,647	4,681

Note: All regressions include region-by-year FE. Standard errors: () Conley; [] department-clustered; {} two-way. The panel includes all departments for which price data is available for at least half of the sample years.

original model of adverse selection whereby high-quality sellers do not sell product in equilibrium. As appealing as this explanation may seem, we are unwilling to entirely attribute the relative acreage increase in AOC departments to the resolution of the lemons problem, the main reason being that AOC vineyards were largely exempt from restrictions on new plantings applicable to the ordinary wine market starting in 1953 (Humbert, 2011). It is thus likely that the lesser decline in vineyard acreage observed in AOC regions was at least partially driven by these exemptions.

Table 8 indicates no clear effect of AOC recognition on yield. The estimate is small, positive, and statistically insignificant. Although many AOC decrees specify maximum yields, it thus appears that reducing yield was not the principal channel through which quality improvements were achieved. In a way, the absence of a negative effect of AOC recognition on average departmental yield is consistent with available information. For instance, the large regional *bordeaux* and *bourgogne* AOCs, when created, imposed a maximum yield of 50 and 45 hl/ha, respectively. The average yield over the ten years prior to regulation were 32 hl/ha in Gironde—the department where *bordeaux* is produced—and 28 hl/ha in the departments covered by the *bourgogne* AOC.

Finally, Table 8 shows that the combined effects of AOC recognition on acreage and yield resulted in a positive effect on quantity produced. Therefore, the increase in wine price observed in departments with higher eligible share cannot be attributed to a decrease in wine output following the reform.

Reshuffling

The second main effect that the reform could potentially have had on wine quantities is reallocative. It is conceivable that some wines that used to be sold under appellation before the reform were later denied the use of the AOC and thus had to be sold either under a less prestigious name, if available, or as ordinary wine (an effect known as *déclassement*). Initially, the "double appellation" regime allowed wines to be sold under a plain appellation *of the same name* as a recognized AOC, as long as they met the geographical requirements associated with the use of the

denomination (that is, the rules already applicable prior to the reform). During that initial period, it is thus unlikely that the reform led to substantial *déclassement* as wines could continue to be marketed pursuant to the old rules. This tolerance was formally abolished in 1942 however, which implies that wines not meeting the more comprehensive AOC requirements could no longer claim the appellation, even if they originated in an eligible region. It is therefore likely that the reform ultimately resulted in the reallocation (or "reshuffling") of some volume of wine away from the appellation market into the ordinary wine market.

If consumers have a homogeneous taste for quality, such movements from one segment of the wine market 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 market segment. 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.

However, we formally show in Appendix A that if consumers are heterogeneous with respect to their taste for quality, average price could increase as a result of the *déclassement* of wines alone, *even if the reform has no effect on quality*. In that case, we show that welfare increases as well through a reallocation effect, as higher-quality wines are more selectively chosen by quality-valuing consumers. However, the relationship between the relative increase in price and the relative increase in welfare is more elusive than in the case where the price increase is due to an increase in the quality of AOC wines. In addition, while reshuffling *could* cause a price increase, it could also cause a price decrease, so the net contribution of the reshuffling effect to our overall effect remains ambiguous.

In order to assess whether the positive and significant effect of AOC recognition on the average wine price found above is driven by reshuffling, rather than quality improvements, we leverage additional data to assess the extent to which appellation wines were forced into the ordinary wine market after the reform.

As indicated in Section 4.3.3, France's *Journal Officiel* for the year 1936 reports the volumes of wines declared under appellation in the year 1935, by department. We pair these data with production data from the agricultural yearbook to construct a measure of the volume share of wines sold under (plain) appellation right before the reform. (We only have data for 1935, but this year, together with 1934, had historically high shares of appellation wines because producers were trying to escape the constraints of the new *Statut Viticole* applicable to ordinary wines (Capus, 1947). Therefore this approach overestimates the share of wines sold under appellation over the entire pre-reform period.) We compare these departmental appellation shares to the departmental share of wine production declared as AOC or plain appellation after the "double appellation" regime ended. This information is available starting in 1942 from the agricultural yearbook.[40] We then identify departments for which the share

[40]For the years 1942–1947, the volume of wine sold under plain appellation is missing. As a result, our post-reform appellation share understates the true volume of wine sold under appellation. We exclude

Table 9 Effect of the AOC eligible share on the real price of wine, excluding departments with plausible reshuffling

	Dep. var.: log average real price of wine							
	1916–1955				1907–1969			
	Selected departments		All departments		Selected departments		All departments	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
AOC share	0.405	0.397	0.244	0.250	0.657	0.641	0.424	0.413
	(0.109)	(0.112)	(0.055)	(0.055)	(0.061)	(0.062)	(0.045)	(0.045)
	[0.138]	[0.145]	[0.077]	[0.077]	[0.087]	[0.089]	[0.084]	[0.083]
	{0.162}	{0.170}	{0.087}	{0.087}	{0.100}	{0.103}	{0.090}	{0.090}
log(Production)×Region	✓		✓		✓		✓	
log(Production$_{-1}$)×Region		✓		✓		✓		✓
Observations	1,819	1,802	2,910	2,893	3,147	3,081	4,572	4,483

Note: All regressions include region-by-year FE. Standard errors: () Conley; [] department-clustered; {} two-way. The panel includes all departments for which price data is available for at least half of the sample years.

decreased by more than 5% (that is, for instance, a share going from 40% to 37% or less), and exclude these from the sample if the share of vineyards eligible for AOC during the post-reform years (our regressor of interest) was nonzero.[41] The idea is that in departments with AOC recognition, a post-reform appellation share lower than the pre-reform appellation share could have plausibly been caused by *déclassement*. The 5% tolerance is meant to account for variations in volumes due to weather, as well as for the fact that the 1935 share likely overstates the share that prevailed during the broader pre-reform period. As such, we believe this approach to be conservative.[42]

Table 9 shows estimation results for two different sample periods: 1916–1955 and 1907–1969. In each case, departments included in the regression are selected based on a post-reform appellation share computed over years present in the sample, that is, 1942–1955 or 1942–1969. We consider the shorter time window 1916–1955 because as the AOC system becomes more popular among producers over time, the share of wine under appellation may increase in a department, potentially offsetting the effect of *déclassement*. Indeed, fewer departments are excluded when looking at the longer time period. For comparison purposes, the table also shows coefficient estimates for the full sample of departments over the same time periods. The decrease in sample size once we remove departments with a decline in the appellation share indicates that our procedure removes a sizable portion of the initial sample. Indeed, key departments are excluded, notably, for the 1916–1955 sample, the *bordeaux* region, most of the *bourgogne* and *côtes-du-rhône* regions, as well as a large share of the *champagne*

fewer departments, yet obtain comparable results, when computing the post-reform appellation share using only the years 1948 and onwards.

[41] All departments with a decreasing share of appellation wines actually had a positive share eligible for AOC during the post-reform years, so this second filter is not selective.

[42] We also ran regressions based on tolerance levels of either 0% or 10%. The results were very comparable.

region.[43] Nonetheless, irrespective of the period considered, the estimates in Table 9 suggest that if anything, the estimated effect is stronger when removing those departments with plausible reshuffling. Therefore, it is unlikely that our estimated positive effect is driven by the mere reallocation of wines across market segments following the reform.

The results of Table 9 also enable us to investigate the hypothesis that the relative price increases in AOC departments were driven by the sorting of wines along departmental boundaries, rather than by quality improvements. Indeed, if some departments were denied the use of an appellation to the benefit of others, so that the reform merely served to signal pre-existing quality differences *across* departments, then we would expect that excluding departments with decreasing appellation share would reduce the estimated effect of eligibility on price. Our results do not support this hypothesis, and instead give credence to the interpretation that the relative price increase was driven by quality improvements for eligible wines.

Changes in market structure

Another contributing factor to the relative rise in the wine price in AOC departments could be a change in market structure. Specifically, wine merchants could be exercising oligopsony power towards atomistic wine producers, depressing the producer price while suppressing quantity. If the AOC reform allowed a consolidation of wine production that increased the countervailing power of winegrowers, it is plausible that the producer price, and quantity, would increase following the reform, consistent with some of the patterns presented in Table 3 and Table 8. Although economic welfare would increase, this effect would be conceptually and quantitatively different from that of a quality-driven shift in demand. While quality-driven welfare gains stem principally from the difference in the demand and supply prices for quality improvements, gains from reduced oligopsony power stem from an increase in the quantity of wine towards the competitive level.

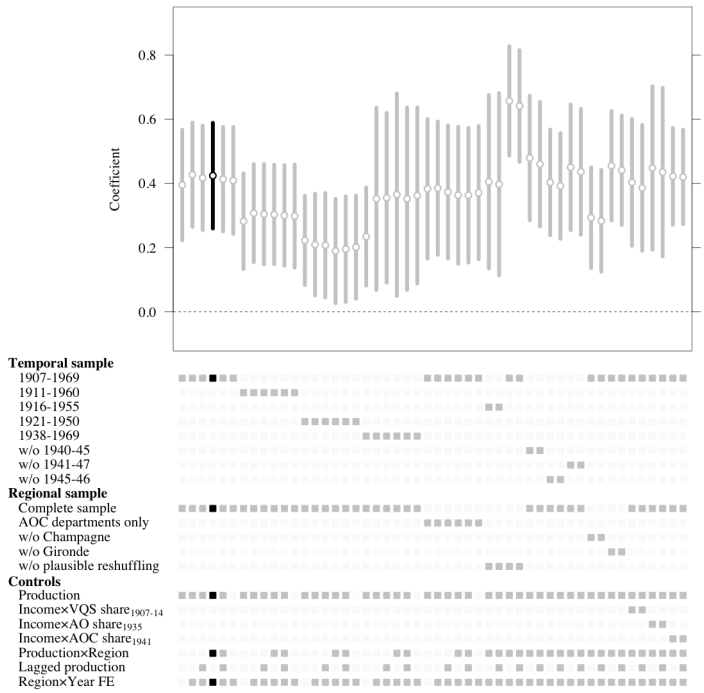
There are several reasons to believe that changes in market power were not at play here. First, producer organizations, like the appellations themselves, largely predated the 1935 reform and were not created by it. Thus, collective action among producers was possible prior to the reform.

Second, if the reform increased concentration in wine production, we might expect an effect of AOC recognition on the number of winegrowers. To verify this, we regress the logarithm of the number of winegrowers reporting harvest in a department, available from the statistical yearbooks, on the share of vineyards eligible for AOC, controlling for region-by-year fixed effects.[44] The point estimate on the AOC share

[43] We exclude departments located in the *cognac* and *armagnac* areas from the regressions reported in columns (1), (2), (5), and (6). See footnote 39.

[44] A 1907 law meant to combat the dilution of wine with water forced winegrowers to report their harvest in their municipality each year.

Figure 8 Summary of estimates of the AOC share effect



Note: Bars indicate 95% confidence intervals based on department-clustered standard errors. The preferred model is highlighted in black.

is 0.031 and is not statistically significant with any of our standard error estimates, suggesting little effect of AOC recognition on the number of winegrowers.

Even if the number of winegrowers in a department did not change due to the reform, some winegrowers may have left the appellation market to produce ordinary wine. In that case, the countervailing power of winegrowers selling appellation wine could have increased, leading to higher producer prices. To investigate this possibility, consider the regressions of Table 9 that exclude departments in which the share of wine sold as appellation wine decreased after the reform, plausibly due to some winegrowers switching to ordinary wine production. If increased concentration in the appellation wine market was the driving factor behind the price effect, we would expect this effect to be lower once we exclude such departments. But the table tells the opposite story, as the price effect appears larger in departments with stable appellation share, no matter the window of time considered.

4.3.5. Summary of estimated price effects. Our finding that the AOC reform increased wine prices in treated departments is robust to close to 50 variations of the baseline model. Figure 8 provides a visual summary of the various estimates of

the effect of the AOC share on the departmental wine price discussed above and in Appendices D and E. Our preferred estimate, which implies an effect of full recognition of 42%, is highlighted in black.

Our argument that this considerable price increase was brought up by an increase in quality, as the reform intended, relies on having ruled out an array of alternative mechanisms. Admittedly, it is impossible to rule out everything, but providing direct evidence of quality improvements is difficult too, and in our historical setting close to impossible. Wine quality is multidimensional, which is why AOC regulations provide obligations of means, e.g., soil selection or vineyard practices, along results-oriented metrics like alcohol content or maximum yields. Not one single indicator, even expert ratings (which are not available for the period), can capture quality as ultimately valued by consumers. In fact, market price is perhaps the most comprehensive metric we can imagine.

One may still believe that the quality of appellation wines did not improve upon AOC recognition, despite the large share of eligible winegrowers selecting into AOC production (see Figure 3, panel (b)). To believe so would require also believing two things. First, that the AOC constraints were non-binding, or had no relation to quality, or were not enforced. Section 1 provides many pieces of evidence against these hypotheses. Second, that buyers were durably fooled into paying higher prices for an identical good, perhaps because AOC recognition acted as a marketing gimmick. Appendix F shows wine bottle labels for the same appellation wine, pre- and post-reform. The reform resulted in the addition of the qualifier "appellation contrôlée" to the product denomination on an otherwise comparable label. We only show three examples, and for prestigious wines (we were not able to find images of old labels for more common AOCs), but wine sellers were free to use other marketing devices, such as stylized depictions of an estate, to suggest quality attributes on labels, before and after the reform. Importantly, the 1935 law did not create an official certification seal to be displayed on products. It seems unlikely to us that modest changes to the aspect of actual labels could durably deceive consumers into believing that quality had improved if it had not.[45]

[45]Early episodes of consumer defiance against AOC wines during wartime, when wine was scarce, prices were regulated, and fraud was common, are recounted in a series of newspaper articles cited in Humbert (2011). As one of several examples, the regional newspaper *Lyon Républicain* published the following opinion in 1943: "the wine appellation regime may have been an amusing pleasantry at the time when wine was flowing. It has become a scandal under the current taxation regime. We are made to drink despicable *piquettes* at exorbitant prices. Many ordinary wines from the Midi are equal to or better than appellations." ("Taxation" refers here to the commandeering, distribution, and price system put in place during the war, not to an actual tax. Wine consumption was restricted to 4 liters per person per month. The first three liters were provided as ordinary wine at a low price. Due to limited supplies of ordinary wine, in 1942 the government switched to appellation wine for the fourth liter, which was sold at a much higher price (Lucand, 2017), hence the complaint "we are made to drink etc.".)

5. Costs and welfare effects

At the end of our study period, the overall share of vineyards eligible for at least one AOC was 32% across all French departments. Together with an estimated effect of AOC recognition of 42%, this figure implies a relative increase in market value of about 13%. As explained in Section 2, the (absolute) increase in market value underestimates the increase in gross welfare if consumer preferences for quality are heterogeneous.

To obtain a lower bound of the effet of the reform on net economic welfare, one must further estimate the opportunity costs of quality provision, that is, the conversion costs for vineyards claiming and AOC after the reform. We rely on a revealed-preference approach to estimate these costs. Specifically, we regress the AOC conversion rate, defined as the share of eligible acreage used for AOC production (available at the national level for selected years), on an estimate of the yearly price premium. To address price endogeneity, we exploit variation in national income, notably its rise after WWII amidst reconstruction efforts and massive industrialization, in order to identify the supply curve. Integrating below the supply curve then yields our cost estimate. Because our price regressor is estimated, we resort to a model-based bootstrap for statistical inference. While this estimation is conducted on few data points, with sufficient structure and appropriate inference it provides relevant information on the size of the conversion cost.

The AOC conversion rate in year t, denoted κ_t, is constructed using ancillary data on AOC acreage reported by the INAO at the national level for the years 1948–1969 (INAO, 1978) and shown in Figure 3. The yearly conversion rate is the observed AOC acreage divided by the eligible AOC acreage at the national level. Our regressor is a time-varying measure of the AOC price premium estimated from our panel data by allowing the coefficient β in Equation (3) to vary flexibly by year. Using the notation of Section 2, the average price can be written as:

$$p_m = p_0 + s_1(p_1 - p_0) + \sigma_2 \kappa \delta_y (p_2 - p_1).$$

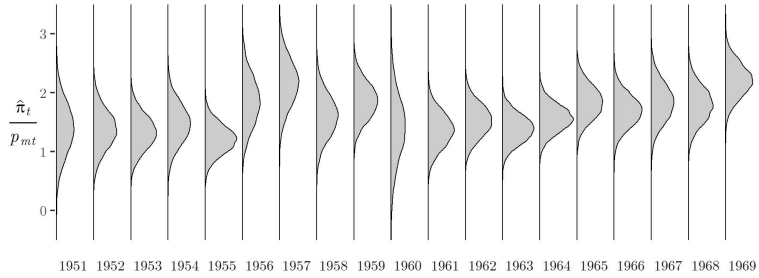
Letting the treatment effect vary by year, our empirical model estimates a family of coefficients $\hat{\beta}_t = \left(\frac{\partial \log p_m}{\partial \sigma_2}\right)_t = \frac{\kappa_t \delta_{yt}(p_2-p_1)_t}{p_{mt}} = \frac{s_{2t}}{\sigma_{2t}} \frac{(p_2-p_1)_t}{p_{mt}}$. We can then recover the yearly AOC premium as:

$$\hat{\pi}_t \equiv \widehat{(p_2 - p_1)}_t = \hat{\beta}_t \frac{\sigma_{2t}}{s_{2t}} p_{mt}.$$

The national-level variables p_{mt} and σ_{2t} are readily computed using departmental-level information. In addition, between the years 1942 and 1969 (except in 1948 and 1950), the agricultural yearbook reports the volume of AOC wines produced in each department. This allows us to compute the volume share s_{2t}, and thus $\hat{\pi}_t$.[46] Because

[46] Because we estimate our panel regression on the set of 63 departments without missing data, we also compute p_{mt}, σ_{2t}, and s_{2t} on this same set of departments.

Figure 9 AOC premium relative to the average price



Note: The densities are computed using bootstrap estimates of the relative premium $\frac{\hat{\pi}_t}{p_{mt}}$. We resort to a model-based bootstrap allowing for serial correlation within a department. First, we estimate β_t on the sample of 63 departments without missing data. Then, we conduct the two following steps $N = 10{,}000$ times: 1) resampling the 63 series of correlated residuals with replacement, and 2) estimating the series of β_t and π_t. The average of the estimates of $\frac{\hat{\pi}_t}{p_{mt}}$ across the years 1951–1969 is 1.63.

the AOC conversion rate is only available starting in 1948, price data is missing for 1949, and the AOC volume data is missing for the years 1948 and 1950, we estimate a single coefficient for the treatment years 1937–1950, and individual coefficients afterwards. Figure 9 shows the bootstrap density of the resulting yearly estimators, expressed relative to the yearly average price. Over the period 1951–1969, the ratio of the price premium to the average wine price averaged 1.63, suggesting a significant appreciation for wines claiming an AOC.

Having obtained an estimate of the price premium $\hat{\pi}_t$, we run the following regression,

$$\log(\kappa_t) = \alpha + \beta_\kappa \log(\hat{\pi}_t) + \nu_t,$$

instrumenting the logarithm of the price premium with the logarithm of per capita income. The coefficient β_κ gives an estimate of the elasticity of supply of AOC wine with respect to the price premium. The need for an instrument arises for two main reasons. First, κ_t and π_t are simultaneously determined by supply and demand conditions in year t. We thus expect simultaneity bias in the OLS estimator. Second, the regressor π_t is not observed but estimated, which may cause attenuation bias. Both effects would cause the OLS estimator to be biased downward. As should be clear from Table 7, per capita income appears to be an essential driver of the average wine price during the period of investigation. This is not surprising, as wine consumption was quite high at the time (about 130 liters/year per capita during the 1950s according to ancillary data (Brousse, 1959; Piketty, 2001), compared to about 50 liters/year today), and it is reasonable to assume that as consumers get wealthier, their willingness to pay for higher-quality wine increases. The identifying assumption is that income per capita only affects the AOC conversion rate through its effect on the price premium. Even if this assumption is violated, we expect any direct effect of per capita income on the conversion rate to be positive, because as producers get wealthier they are

Table 10 Supply-side estimates

	Dep. var.: log conversion rate		
	(1)	(2)	(3)
$\beta_\kappa^{\text{OLS}}$	0.216	0.164	0.142
	[0.042, 0.268]	[-0.016, 0.229]	[-0.020, 0.212]
β_κ^{IV}	0.738	0.826	0.886
	[0.356, 2.264]	[0.341, 3.805]	[0.320, 3.524]
First stage	0.727	0.636	0.677
	[0.227, 1.490]	[0.102, 1.440]	[0.117, 1.546]
$\frac{\beta_\kappa^{\text{OLS}}}{\beta_\kappa^{\text{OLS}}+1}$	0.178	0.141	0.124
	[0.041, 0.212]	[-0.016, 0.186]	[-0.021, 0.175]
$\frac{\beta_\kappa^{\text{IV}}}{\beta_\kappa^{\text{IV}}+1}$	0.425	0.452	0.470
	[0.265, 0.702]	[0.267, 0.837]	[0.255, 0.818]
Lag on $\hat{\pi}_t$	0	1	2
Observations	19	18	17

Note: The main estimates are obtained by conducting the procedure on the raw data. For inference, we use a model-based bootstrap allowing for serial correlation within a department. We first estimate β_t on the sample of 63 departments without missing data. Then, we conduct the following steps N = 10,000 times: 1) resampling the 63 series of correlated residuals with replacement; 2) estimating the series of β_t and π_t; 3) obtaining the OLS and the IV estimates of β_κ. []: confidence interval composed of the 0.025% quantile and the 0.975% quantile of the N bootstrap estimates. A bootstrap Hausman test rejects the exogeneity assumption at the 1% level.

better able to invest in quality, for instance by replanting their vineyards with approved grape varietals. In that case, the instrumental variable estimate of β_κ would be biased upwards, so that the true elasticity is bounded below by the OLS estimate and above by the IV estimate.[47]

Assuming a constant-elasticity relationship $\kappa_t = C\pi_t^{\beta_\kappa}$ for some constant $C > 0$, the supply of AOC wine also has the constant elasticity form (with the same elasticity), ignoring any effect at the extensive margin (see Section 4.3.4). A notable property of this constant-elasticity supply function is that the ratio of the area below the supply curve (that is, opportunity costs) to the value of the product at any quantity is simply equal to $\frac{\beta_\kappa}{\beta_\kappa+1}$. The value of the product is the price premium multiplied by the AOC quantity, that is, what we have called the change in market value ΔMV. The opportunity costs are the conversion costs ΔC. Denoting ΔW the change in net welfare, we thus have:

$$\frac{\Delta \text{W}}{\text{MV}} \geq \frac{\Delta \text{MV}}{\text{MV}}\left(1 - \frac{\Delta \text{C}}{\Delta \text{MV}}\right) = \frac{\Delta \text{MV}}{\text{MV}}\left(1 - \frac{\beta_\kappa}{\beta_\kappa + 1}\right) \geq \frac{\Delta \text{MV}}{\text{MV}}\left(1 - \frac{\beta_\kappa^{\text{IV}}}{\beta_\kappa^{\text{IV}} + 1}\right).$$

[47] The probability limit of the IV estimate is $\beta_\kappa^{\text{IV}} = \beta_\kappa + \frac{\sigma_{z\nu}}{\sigma_{\hat{\pi}z}}$, where $\sigma_{z\nu}$ is the covariance between the instrument and the error term, and $\sigma_{\hat{\pi}z}$ is the covariance between the regressor and the instrument. Our first stage confirms that $\sigma_{\hat{\pi}z} > 0$, so that if $\sigma_{z\nu} > 0$, $\beta_\kappa^{\text{IV}} > \beta_\kappa$.

where the first inequality is explained by the fact that ΔMV ignores the increase in utility for infra-marginal buyers of AOC wine, and the second inequality is explained by the fact that $\beta_\kappa^{\mathrm{IV}}$ either overestimates β_κ, or is consistent for it.

Table 10 reports our OLS and IV estimates of β_κ, along with bootstrap confidence intervals, for specifications that allow for various lags in the response of the conversion rate to the price premium. The choice of lag does not matter much for the estimate of the ratio $\frac{\beta_\kappa}{\beta_\kappa+1}$. However, the OLS and IV estimates are different, with the OLS estimate being smaller and not always statistically significant. The IV estimate lies between 0.425 and 0.470 and is statistically significant at the 5% level. Using the most conservative estimate of $\frac{\beta_\kappa}{\beta_\kappa+1}$ leads to a lower bound of the net welfare effect of about 7% of total market value.

6. Conclusion

This article provides empirical evidence suggesting that the quality of French wines sold under appellation prior to a pioneering 1935 law was below the social optimum, and that the reform allowed producers to profitably adopt quality-enhancing practices. Using a panel approach with fixed effects, we estimate that the average wine price increased by 42% in departments whose vineyards became eligible for AOC recognition.

In order to interpret this remarkable appreciation as stemming from an increase in wine quality, we rule out that AOC recognition negatively affected the quantity of wine produced in treated departments. We then show that the reshuffling of previous appellation wines towards the ordinary wine market did not contribute to the observed price increase. In the end, the most parsimonious explanation for the large and significant price increase in treated departments is that the reform had the intended effect, that is, it provided incentives to atomistic producers to supply costly quality that was ultimately valued by consumers.

Although treated departments are different from control departments in the sense that they benefit from natural factors that are conducive to producing higher-quality wine, we provide several arguments in support of the counterfactual comparability assumption necessary for a causal interpretation of our estimated price effect. First, we show that eventual AOC status was uncorrelated with price patterns during the pre-reform period. Second, we show that exploiting only the period after the first wave of AOC recognitions leads to a comparable estimate. So does exploiting only the intensive margin of AOC eligibility. Finally, we show that the large estimated effect of AOC eligibility on price does not merely reflect the differential impact of rising post-war incomes on the prices of wines originating in historically famous locations.

Ignoring the costs of supplying higher quality, our price estimate implies that welfare in the French wine market increased by at least 13% relative to market value due to the AOC reform. Accounting for these costs leads to a lower bound on the net welfare effect equal to 7% of market value. These estimated effects are consistent with

the existence of a lemons-type market failure prior to the reform and resonate well with historical accounts of widespread abuse in the appellation wine market during the first decades of the 20th century, as recounted for instance by Capus (1947) in a way reminiscent of the market unraveling phenomenon familiar to economists:

> One should remain aware of the extraordinary anarchy that prevailed before 1935 [in the appellation wine market]: no discipline, no organization to speak of, but instead a tendency toward carelessness, encouraged by the demagogy of many an elected official. Inferior wines were given a real advantage by being allowed to compete alongside high-quality wines; this confusion led to the depreciation of the latter and the discouragement of their producers, who were poorly rewarded for their efforts to maintain quality.

References

Abadie, Alberto, Susan Athey, Guido W Imbens, and Jeffrey Wooldridge (2017). "When Should You Adjust Standard Errors for Clustering?" NBER Working Paper No. 24003, National Bureau of Economic Research.

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

Ali, Héla Hadj, Sébastien Lecocq, and Michael Visser (2008). "The Impact of Gurus: Parker Grades and *en Primeur* Wine Prices." *The Economic Journal*, 118(529), F158–F173.

Allcott, Hunt, Rebecca Diamond, Jean-Pierre Dubé, Jessie Handbury, Ilya Rahkovsky, and Molly Schnell (2019). "Food Deserts and the Causes of Nutritional Inequality." *Quarterly Journal of Economics*, 134(4), 1793–1844.

Andrabi, Tahir, Jishnu Das, and Asim Ijaz Khwaja (2017). "Report Cards: The Impact of Providing School and Child Test Scores on Educational Markets." *American Economic Review*, 107(6), 1535–1563.

Ashenfelter, Orley (2008). "Predicting the Quality and Prices of Bordeaux Wine." *The Economic Journal*, 118(529), F174–F184.

Bai, Jie (2018). "Melons as Lemons: Asymmetric Information, Consumer Learning and Seller Reputation." Working Paper, Harvard Kennedy School.

Bond, Eric W (1982). "A Direct Test of the "Lemons" Model: The Market for Used Pickup Trucks." *American Economic Review*, 72(4), 836–840.

Brousse, Henri (1959). "La consommation des boissons en France de 1950 à 1958." Centre de Recherche et de Documentation sur la Consommation, France.

Bundorf, M Kate, Jonathan Levin, and Neale Mahoney (2012). "Pricing and Welfare in Health Plan Choice." *American Economic Review*, 102(7), 3214–48.

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

Cardon, James H and Igal Hendel (2001). "Asymmetric Information in Health Insurance: Evidence from the National Medical Expenditure Survey." *RAND Journal of Economics*, 32(3), 408–427.

Castriota, Stefano and Marco Delmastro (2015). "The economics of collective reputation: Evidence from the wine industry." *American Journal of Agricultural Economics*, 97(2), 469–489.

Cawley, John and Tomas Philipson (1999). "An Empirical Examination of Information Barriers to Trade in Insurance." *American Economic Review*, 89(4), 827–846.

Chiappori, Pierre-André and Bernard Salanié (2000). "Testing for Asymmetric Information in Insurance Markets." *Journal of Political Economy*, 108(1), 56–78.

Combris, Pierre, Sebastien Lecocq, and Michael Visser (1997). "Estimation of a hedonic price equation for Bordeaux wine: Does quality matter?" *The Economic Journal*, 107(441), 390–402.

Conley, T G (1999). "GMM Estimation with Cross Sectional Dependence." *Journal of Econometrics*, 92(1), 1–45.

Council of the European Union (1999). "Council Regulation (EC) No 1493/1999 of 17 May 1999 on the common organisation of the market in wine." *Official Journal of the European Communities*, L 179 (14.7.1999).

Cross, Robin, Andrew J Plantinga, and Robert N Stavins (2011). "What is the Value of Terroir?" *American Economic Review*, 101(3), 152–56.

Crozet, Matthieu, Keith Head, and Thierry Mayer (2012). "Quality Sorting and Trade: Firm-Level Evidence for French Wine." *Review of Economic Studies*, 79(2), 609–644.

Cutler, David M and Sarah J Reber (1998). "Paying for Health Insurance: The Trade-Off between Competition and Adverse Selection." *Quarterly Journal of Economics*, 113(2), 433–466.

Dranove, David and Ginger Zhe Jin (2010). "Quality Disclosure and Certification: Theory and Practice." *Journal of Economic Literature*, 48(4), 935–63.

Dranove, David, Daniel Kessler, Mark McClellan, and Mark Satterthwaite (2003). "Is More Information Better? The Effects of 'Report Cards' on Health Care Providers." *Journal of Political Economy*, 111(3), 555–588.

Duflo, Esther, Michael Greenstone, Rohini Pande, and Nicholas Ryan (2013). "Truth-telling by Third-Party Auditors and the Response of Polluting Firms: Experimental Evidence from India." *Quarterly Journal of Economics*, 128(4), 1499–1545.

Einav, Liran and Amy Finkelstein (2011). "Selection in Insurance Markets: Theory and Empirics in Pictures." *Journal of Economic Perspectives*, 25(1), 115–38.

Einav, Liran, Amy Finkelstein, and Mark R Cullen (2010). "Estimating Welfare in Insurance Markets Using Variation in Prices." *Quarterly Journal of Economics*, 125(3), 877–921.

Finkelstein, Amy, Nathaniel Hendren, and Mark Shepard (2019). "Subsidizing Health Insurance for Low-Income Adults: Evidence from Massachusetts." *American Economic Review*, 109(4), 1530–67.

Finkelstein, Amy and James Poterba (2004). "Evidence on Adverse Selection: Equilibrium Signaling and Cross-Subsidization in the Insurance Market." *Journal of Political Economy*, 112(1), 183–208.

Fleckinger, Pierre (2007). "Regulating Collective Reputation Markets." Working paper, Mines ParisTech, France.

Genesove, David (1993). "Adverse Selection in the Wholesale Used Car Market." *Journal of Political Economy*, 101(4), 644–65.

Gergaud, Olivier and Victor Ginsburgh (2008). "Natural Endowments, Production Technologies and the Quality of Wines in Bordeaux. Does Terroir Matter?" *The Economic Journal*, 118(529), F142–F157.

Hackmann, Martin B, Jonathan T Kolstad, and Amanda E Kowalski (2015). "Adverse Selection and an Individual Mandate: When Theory Meets Practice." *American Economic Review*, 105(3), 1030–66.

Haeck, Catherine, Giulia Meloni, and Johan Swinnen (2019). "The Value of Terroir: A Historical Analysis of the Bordeaux and Champagne Geographical Indications." *Applied Economic Perspectives and Policy*, 41(4), 598–619.

Handel, Benjamin R (2013). "Adverse Selection and Inertia in Health Insurance Markets: When Nudging Hurts." *American Economic Review*, 103(7), 2643–2682.

Hendren, Nathaniel (2013). "Private Information and Insurance Rejections." *Econometrica*, 81(5), 1713–1762.

Hendren, Nathaniel (2017). "Knowledge of Future Job Loss and Implications for Unemployment Insurance." *American Economic Review*, 107(7), 1778–1823.

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

INAO (1978). "Bulletin de l'INAO." Nouvelle série, numéro 9, 3ème trimestre.

Jacquet, Olivier (2005). *Les syndicats viti-vinicoles en Bourgogne de 1884 à la mise en place des AOC*. Ph.D. thesis, Université de Bourgogne, France.

Jensen, Robert (2007). "The Digital Provide: Information (Technology), Market Performance, and Welfare in the South Indian Fisheries Sector." *Quarterly Journal of Economics*, 122(3), 879–924.

Jensen, Robert and Nolan H Miller (2018). "Market Integration, Demand, and the Growth of Firms: Evidence from a Natural Experiment in India." *American Economic Review*, 108(12), 3583–3625.

Jin, Ginger Zhe and Phillip Leslie (2003). "The Effect of Information on Product Quality: Evidence from Restaurant Hygiene Grade Cards." *Quarterly Journal of Economics*, 118(2), 409–451.

Kim, Jae-Cheol (1985). "The Market for "Lemons" Reconsidered: A Model of the Used Car Market with Asymmetric Information." *American Economic Review*, 75(4), 836–843.

Leland, Hayne E (1979). "Quacks, lemons, and licensing: A theory of minimum quality standards." *Journal of Political Economy*, 87(6), 1328–1346.

Lewis, Gregory (2011). "Asymmetric Information, Adverse Selection and Online Disclosure: The Case of eBay Motors." *American Economic Review*, 101(4), 1535–1546.

Lucand, Christophe (2017). *Le vin et la guerre: Comment les nazis ont fait main basse sur le vignoble français*. Armand Colin, France.

Macchiavello, Rocco (2010). "Development Uncorked: Reputation Acquisition in the New Market for Chilean Wines in the UK." CEPR Discussion Paper 7698, Center for Economic Policy Research.

Macchiavello, Rocco and Ameet Morjaria (2015). "The Value of Relationships: Evidence from a Supply Shock to Kenyan Rose Exports." *American Economic Review*, 105(9), 2911–45.

Milhau, Jules (1948). "Le prix du vin et les revenus viticoles." *Études et conjoncture – Union française / Économie française*, 3(2), 65–74.

Milhau, Jules (1949). "L'évolution du prix du vin au cours de la campagne 1947–1948." *Études et conjoncture – Union française / Économie française*, 4(2), 57–62.

Ministère de l'agriculture (1937). "Circulaire aux inspecteurs et agents de la répression des fraudes relative aux appellations d'origine contrôlées." *Journal Officiel de la République Française*, 28 Février 1937, 2569–2571.

Ministère des Finances, France (1908). "Bulletin de Statistique et de Législation Comparée." Trente-deuxième année, tome soixante-troisième (Janvier à juin 1908), Imprimerie Nationale, Paris.

Panhans, Matthew (2019). "Adverse Selection in ACA Exchange Markets: Evidence from Colorado." *American Economic Journal: Applied Economics*, 11(2), 1–36.

Piketty, Thomas (2001). *Les hauts revenus en France au XXe siècle*. Hachette.

Plassmann, Hilke, John O'Doherty, Baba Shiv, and Antonio Rangel (2008). "Marketing Actions Can Modulate Neural Representations of Experienced Pleasantness." *Proceedings of the National Academy of Sciences*, 105(3), 1050–1054.

Puelz, Robert and Arthur Snow (1994). "Evidence on Adverse Selection: Equilibrium Signaling and Cross-Subsidization in the Insurance Market." *Journal of Political Economy*, 102(2), 236–257.

Simpson, James (2004). "Selling to Reluctant Drinkers: the British Wine Market, 1860–1914." *Economic History Review*, 57(1), 80–108.

Stanziani, Alessandro (2003). "La falsification du vin en France, 1880-1905: un cas de fraude agro-alimentaire." *Revue d'histoire moderne contemporaine*, 50(2), 154–186.

Winfree, Jason A and Jill J McCluskey (2005). "Collective reputation and quality." *American Journal of Agricultural Economics*, 87(1), 206–213.

Appendix A: Model with exogenous quality

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 *déclassement* (keeping constant the total quantity of wine sold). Indeed, wines previously sold under an appellation that did not meet the

requirements for the AOC had to be sold either under a less prestigious appellation, if available, or as ordinary wine. If large 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 intrinsic quality of "true" appellation wines. The share of true 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 $\tilde{\theta}$ to increase and 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). Denoting by $\tilde{\theta}'$ the index of the indifferent consumer after the reform, we have

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

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. Also note that the only source of the welfare increase here is allocative efficiency as lower-quality (ordinary) wine is being redirected towards low-θ consumers.

Of course, the reason behind the welfare increase here is that the reform is able to sort out low-quality wine from the appellation market and redirect it to the ordinary wine market, so information improves. What if instead the reform arbitrarily redirects high-quality wine towards the ordinary wine market? To investigate this scenario, we now assume that before the reform $s_2 = s_1$ but after the reform $s_2' < s_1$, that is, only a portion of the high-quality wine has a right to the appellation. Average quality in the ordinary wine market is $\mu_0 = 0$ before the reform and $\bar{\mu}_0 = \frac{\mu_0(1-s_1)+\mu_1(s_1-s_2')}{1-s_2'} = \frac{\mu_1(s_1-s_2')}{1-s_2'}$ after the reform.

Market-clearing in the wine market determines the taste parameter of the lowest-θ wine consumer, $\underline{\theta}$, through the equality $M\int_{\underline{\theta}}^{1} dF(\theta) = Q$. Market-clearing in the appellation market determines the taste parameter of the consumer indifferent between ordinary and appellation wine: $M\int_{\tilde{\theta}}^{1} dF(\theta) = Qs_1$, and similarly after the reform: $M\int_{\tilde{\theta}'}^{1} dF(\theta) = Qs_2'$, so that $\tilde{\theta}' > \tilde{\theta}$. Consumers with taste parameter above $\tilde{\theta}'$ are consuming high-quality wine before and after the reform. Consumers with taste parameter between $\tilde{\theta}$ and $\tilde{\theta}'$ switch from high-quality wine to a mixture or low- and high-quality wine of quality $\bar{\mu}_0$. Low-θ wine consumers switch from low-quality wine to that same wine mixture. Therefore, the effect on net welfare is

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

so that welfare decreases. It is possible (though not necessary) that average price decreases as well. For instance, if the distribution of the taste parameter is assumed to be uniform, then it is easy to show that $\Delta p_m = -\frac{Q}{M}(s_1 - s_2')(1-s_1) < 0$. For an example where average price increases, consider the case where the density of θ is given by $f(\theta) = \frac{\theta^{0.1}(1-\theta)^{0.1}}{\int_0^1 \theta^{0.1}(1-\theta)^{0.1} d\theta}$, $\frac{Q}{M} = 0.99$, $s_1 = 0.5$, and $s_2' = 0.4$.

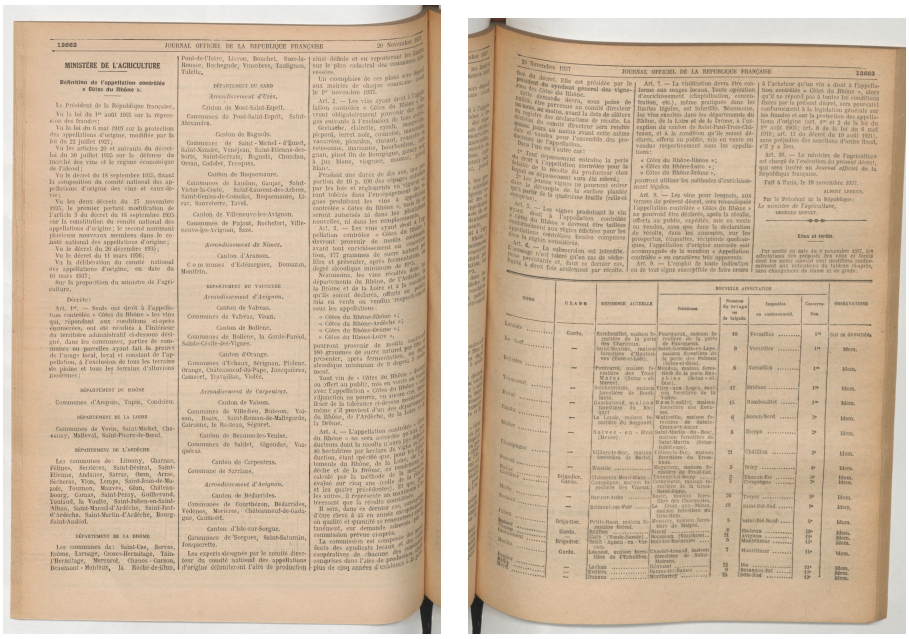
Appendix B: Example of AOC decree

Figure B.1 depicts the decree for the *côtes-du-rhône* appellation, enacted in 1937.

Appendix C: Construction of the eligible shares

Here, we explain in detail how we construct our measure of AOC eligibility at the department level. Formally, denote by i a department, by m a municipality, by t a year,

Figure B.1 The *côtes-du-rhône* decree



by l an AOC, and by p a one-hectare pixel. Let us further denote:

$$\mathbb{1}^l_{mt} = \begin{cases} 1 & \text{if municipality } m \text{ is eligible for AOC } l \text{ per regulation in force in year } t \\ 0 & \text{otherwise} \end{cases}$$

$$\mathbb{1}^l_{p} = \begin{cases} 1 & \text{if AOC } l \text{ is not covered by the 2019 INAO map} \\ & \text{or if pixel } p \text{ belongs to AOC } l \text{ per the 2019 INAO map} \\ & \text{or if pixel } p \text{ belongs to a municipality } m \text{ not eligible for AOC } l \\ & \quad \text{per the 2019 INAO map} \\ 0 & \text{otherwise} \end{cases}.$$

$$\mathbb{1}_{p} = \begin{cases} 1 & \text{if pixel } p \text{ was grown in vineyards in 1990, 2000, 2006, 2012, or 2018} \\ 0 & \text{otherwise} \end{cases}$$

Given that we start counting recognition in the year following an AOC decree, the indicator $\mathbb{1}^l_{mt}$ equals zero from 1907 until the year in which a decree for AOC l is enacted that includes municipality m as eligible, and one thereafter. If m is excluded from that AOC by a modifying decree enacted during the sample period, the change is assumed to take place the year following the publication of the modifying decree.

Denoting by $m(p)$ the municipality to which pixel p belongs, we also define $N_{pt} = \sum_l \mathbb{1}^l_{m(p)t} \mathbb{1}^l_p \mathbb{1}_p$ as the number of distinct AOCs for which pixel p was eligible in

year t.[48] Denoting by Σ_{is} the area in vineyards (under production or not) in department i in year s and by $P(i)$ the set of pixels in department i, we construct our main regressor as

$$s_{it}^{k} \equiv \frac{\sum_{p \in P(i)} \mathbb{1}_{N_{pt} \geq k}}{\max_s \Sigma_{is}}$$

which indicates the share of department i's vineyards eligible for k or more AOCs as of year t. Our main set of regressions only use s_{it}^{1}, the share of vineyards eligible for at least one AOC, but in Appendix E we also consider s_{it}^{k}, $k = 3, 5$, in order to investigate whether prices are influenced by the number of AOCs that an area can claim. For five departments largely covered by broad regional AOCs, our proxy of the acreage eligible for at least one AOC eventually becomes greater than the maximum area in vineyards over the sample period.[49] In these cases, we set the share of eligible acreage equal to one.

Lastly, we verify that our proxy is consistent with the AOC production data reported in the *Statistique agricole annuelle* from 1942 onwards. For three departments, we find the share of eligible acreage to be unreasonably small relative to the share of AOC production. We correct these shares using ancillary data on current AOC acreage reported in the 2010 edition of the French wine guide *Guide Hachette*.[50] Conversely, four departments have a nonzero eligible acreage yet report zero AOC wine production. We can rationalize these discrepancies, however. Three of them are

[48] In doing so, we consider different *denominations* within the same AOC as different AOCs. For instance, the original denomination *pommard* created in 1936 and the more prestigious denomination *pommard premier cru* created in 1943 belong, strictly speaking, to the same appellation *pommard*. But since they have different production requirements, we count them as two distinct AOCs. We do not double-count AOCs recognizing different colors of wine. For instance, if a parcel is eligible for producing both red and white AOC wine, we only count one AOC, the idea being that a given wine can only be sold under one color. As a result, the multiplicity of AOCs for a given parcel arises solely from the hierarchical structure of the AOC system.

[49] These departments are Aisne, Aube, Charente, Gironde, and Marne.

[50] Specifically, our algorithm yields an eligible acreage share equal to zero in Ain and Haute-Savoie, although both departments report a small AOC production. This is because the AOC *seyssel*, which has eligible parcels in these departments, has no pixel planted in vineyards in the land use data. For Pyrénées-Atlantiques, our algorithm attributes a share of eligible acreage more than three times smaller than the share of AOC production. One possibility is that AOC yields are three times larger than non-AOC yields in that department (and even more if not all eligible producers comply), which is doubtful. A more likely explanation is that the AOC *jurançon* has too few planted pixels in the land cover data (only 1% of the eligible pixels are reported as planted in vines). Since *seyssel* and *jurançon* are still produced in non-negligible volumes today, the land use data clearly fails to identify all pixels in vines in the regions covered by these appellations, perhaps due to their relatively high altitude and the declivity of the terrain. Hence, we use the average cultivated acreage reported in the wine guide, which leads to shares of eligible acreage (respectively 0.3, 1.1 and 9.3% for Ain, Haute-Savoie, and Pyrénées-Atlantiques) that are in line with the average shares of AOC production (respectively 0.3, 3.8, and 6.0%) over the available years. An alternative correction strategy is to consider all eligible pixels in the INAO maps as being planted, which leads to qualitatively identical regression estimates. Our results also hold when using the data without any correction and when excluding these three departments. Finally, Isère, a department located in the Alps, reports an infinitesimal AOC wine production, however we failed to find any official AOC in use in this department. Our results are robust to the exclusion of that department.

only eligible for the brandy AOCs *cognac* and *armagnac*, for which the corresponding wine production is not reported as AOC (perhaps because the AOC is granted to the final liqueur but not to the wine itself). The fourth one is Haute-Marne, where only two municipalities are eligible for the AOC *champagne*. AOC production in this department was thus either very small and neglected in the reports, or reported in an adjacent department.

Appendix D: Robustness checks

D.1. Results with shorter time windows

Table D.1 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)
AOC share	0.282 (0.050) [0.076] {0.082}	0.307 (0.052) [0.078] {0.088}	0.304 (0.052) [0.080] {0.090}	0.303 (0.052) [0.079] {0.089}	0.300 (0.052) [0.080] {0.090}	0.298 (0.052) [0.082] {0.092}
log(Production)	-0.070 (0.011) [0.014] {0.015}	-0.069 (0.013) [0.016] {0.017}	–	–	–	–
log(Production$_{-1}$)	–	–	-0.042 (0.013) [0.016] {0.017}	–	–	–
log(Production)×Region				✓		
log(Production$_{-1}$)×Region					✓	
Region×Year FE		✓	✓	✓	✓	✓
Observations	3,644	3,644	3,627	3,644	3,627	3,644

Note: All regressions include year FE. Standard errors: () Conley; [] department-clustered; {} two-way. The panel includes all departments for which price data is available for at least half of the sample years.

Table D.1 shows results of our main panel regression obtained on the sample of years 1911–1960. Table D.2 shows results obtained on the sample of years 1921–1950.

D.2. Results on other subsamples

Tables D.3 and D.4 provide results for samples that exclude selected years or selected departments. Table D.3 investigates the robustness of our estimated effects to the

Table D.2 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)
AOC share	0.222 (0.066) [0.071] {0.078}	0.209 (0.068) [0.081] {0.093}	0.207 (0.067) [0.083] {0.094}	0.189 (0.067) [0.083] {0.094}	0.195 (0.066) [0.084] {0.095}	0.201 (0.067) [0.082] {0.094}
log(Production)	-0.069 (0.017) [0.019] {0.021}	-0.068 (0.020) [0.025] {0.026}	–	–	–	–
log(Production$_{-1}$)	–	–	-0.024 (0.019) [0.023] {0.025}	–	–	–
log(Production)×Region				✓		
log(Production$_{-1}$)×Region					✓	
Region×Year FE		✓	✓	✓	✓	✓
Observations	2,172	2,172	2,164	2,172	2,164	2,172

Note: All regressions include year FE. Standard errors: () Conley; [] department-clustered; {} two-way. The panel includes all departments for which price data is available for at least half of the sample years.

removal of (i) the German occupation years 1940–1945, (ii) the post-war years 1945–1946, during which there was a sharp increase in wine prices in AOC departments (e.g., Gironde), and (iii) the years 1941–1947, during which ordinary wines as well as certain AOC wines were subject to administered prices (a regime known as *taxation*) and requisition.[51] Table D.4 shows results for samples that exclude (i) the four departments of the *champagne* appellation, which had production requirements enacted (without official control) as soon as 1927, and (ii) Gironde, the department where *bordeaux* wines are exclusively produced and the home department of Joseph Capus, the assemblyman who promoted the 1935 law.

Results obtained when removing selected years are in line with those for the full sample, irrespective of the window of time omitted from the sample.

Results without *champagne* departments make sense to us. Unlike other appellations, *champagne* does not have sub-regional appellations, therefore the vast majority of eligible vineyards 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 per hectoliter. To the extent that

[51] Taxation lasted after the liberation and ended with a decree of 4 September 1947, see Milhau (1949) and Humbert (2011).

Table D.3 Exclusion of selected years

	Dep. var.: log average real price of wine					
	w/o 1940–45		w/o 1945–46		w/o 1941–1947	
	(1)	(2)	(3)	(4)	(5)	(6)
AOC share	0.479	0.460	0.403	0.392	0.450	0.436
	(0.047)	(0.046)	(0.045)	(0.045)	(0.048)	(0.048)
	[0.099]	[0.099]	[0.084]	[0.084]	[0.100]	[0.100]
	{0.105}	{0.105}	{0.091}	{0.091}	{0.107}	{0.107}
log(Prod)×Region	✓		✓		✓	
log(Prod_{-1})×Region		✓		✓		✓
Observations	4,133	4,049	4,420	4,334	4,054	3,970

Note: All regressions include region-by-year FE. Standard errors: () Conley; [] department-clustered; {} two-way. The panel includes all departments for which price data is available for at least half of the sample years.

Table D.4 Exclusion of selected departments

	Dep. var.: log average real price of wine			
	w/o *champagne* dpts.		w/o Gironde	
	(1)	(2)	(3)	(4)
AOC share	0.293	0.283	0.455	0.441
	(0.037)	(0.037)	(0.047)	(0.047)
	[0.080]	[0.081]	[0.087]	[0.087]
	{0.083}	{0.084}	{0.094}	{0.094}
log(Production)×Region	✓		✓	
log(Production_{-1})×Region		✓		✓
Observations	4,324	4,239	4,510	4,422

Note: All regressions include region-by-year FE. Standard errors: () Conley; [] department-clustered; {} two-way. The panel includes all departments for which price data is available for at least half of the sample years.

champagne wine benefited relatively more than other appellations from AOC recognition, which is plausible, this effect would entirely be captured by the AOC eligibility share capturing the first layer of recognition, s^1_{it}. Including *champagne* departments in estimation would then tend to pull the estimate on the AOC eligible share towards a slightly higher value than when these departments are omitted. Finally, results without *bordeaux* wines are very similar to the results for the full sample, suggesting that the reform was effective at promoting quality well outside of Gironde.

D.3. Other robustness checks

Table D.5 shows the results of our main regression when the treatment variable is constructed without using the satellite data on vineyard acreage (which is post-1969)

to filter eligible areas. Because eligible parcels include portions of land where vines cannot be planted, such as access roads, and because some of the AOC areas rely on municipal delimitations (due to missing data in the INAO file, see Appendix Section C), we would expect this alternative measure of eligible areas to overestimate the area where producers truly had the opportunity to produce AOC wines. As expected, the point estimates are smaller than the main estimates reported in Table 3, but they are close, and statistically significant.

Table D.5 Main regression without using planted acreage as a filter for the AOC share

	Dep. var.: log average real price of wine					
	(1)	(2)	(3)	(4)	(5)	(6)
AOC share	0.309 (0.032) [0.069] {0.071}	0.358 (0.034) [0.072] {0.076}	0.348 (0.034) [0.072] {0.076}	0.359 (0.035) [0.070] {0.075}	0.346 (0.035) [0.071] {0.075}	0.339 (0.034) [0.074] {0.077}
log(Production)	-0.039 (0.011) [0.012] {0.013}	-0.046 (0.012) [0.015] {0.017}	–	–	–	–
log(Production$_{-1}$)	–	–	-0.028 (0.011) [0.015] {0.017}	–	–	–
log(Production)×Region				✓		
log(Production$_{-1}$)×Region					✓	
Region×Year FE		✓	✓	✓	✓	✓
Observations	4,572	4,572	4,483	4,572	4,483	4,572

Note: All regressions include year FE. Standard errors: () Conley; [] department-clustered; {} two-way. The panel includes all departments for which price data is available for at least half of the sample years.

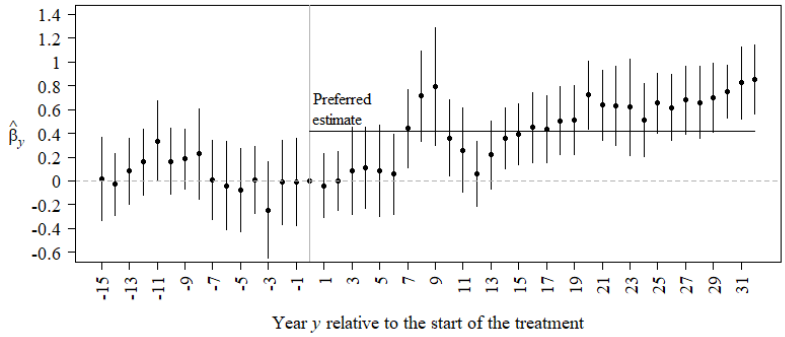
Figure D.1 shows the results of the event study conducted only on departments with a nonzero eligible share at the end of our sample period. The pattern is qualitatively identical to the one shown in Figure 7.

Appendix E: Heterogeneity analysis

E.1. Heterogeneity across time

We would expect that the new regulatory apparatus introduced by the 1935 reform took some time to generate discernable effects on the French wine market. Such expectation is grounded on both supply-side and demand-side considerations. First, some of the production requirements introduced in AOC decrees could have required

Figure D.1 Event study, treated departments only



Note: Bars indicate 95% confidence intervals based on department-clustered standard errors. The preferred estimate is from the specification reported in Table 3, column (4).

sizable upfront investments, notably grape varietal requirements for vineyards that were previously planted in unapproved varieties. In addition, tasting requirements for wines marketed under AOC were introduced very gradually, beginning in 1946 (Humbert, 2011). Both features would imply a lag between initial AOC recognition and the actual increase in wine quality. Second, even if producers were able to rapidly increase quality, it could have taken time for consumers to update their beliefs as wine quality is subject to the vagaries of climate, making quality assessment difficult within just a few years.[52] Finally, some eligible but perhaps high-cost producers may have chosen to delay changes in production practices until they could better assess the extent to which the market would reward their investments towards quality. This last point would be consistent with the AOC eligibility and acreage trends shown in Figure 3, which clearly suggest that the compliance rate for eligible producers (i.e., the AOC acreage relative to the AOC eligible acreage) increased over time.

In order to test the proposition that the effect of AOC eligibility on wine prices increased over time, we estimate a variant of Equation (3) where we interact the AOC eligible share with a linear time trend. Results are shown in Table E.1 and suggest that the effect of AOC recognition on the wine price started at about zero in 1937, the year immediately following the first round of AOC decrees, and then increased at a rate of about 2.3% per year in our preferred specification (column (4)). The slope coefficient is precisely estimated.[53]

[52] See Macchiavello (2010) and Macchiavello and Morjaria (2015) for empirical evidence on the progressive nature of reputation building.

[53] We also estimated a model with a quadratic, rather than linear, trend but the coefficient on the quadratic interaction term was not statistically significant.

Table E.1 Time-varying effect of the AOC eligible share on the real price of wine

	Dep. var.: log average real price of wine				
	(1)	(2)	(3)	(4)	(5)
AOC share	0.035 (0.064) [0.060] {0.066}	0.036 (0.062) [0.068] {0.076}	0.035 (0.062) [0.069] {0.078}	0.034 (0.060) [0.068] {0.076}	0.036 (0.061) [0.069] {0.077}
AOC share×(t-1937)	0.022 (0.003) [0.005] {0.006}	0.023 (0.003) [0.005] {0.005}	0.023 (0.003) [0.005] {0.005}	0.023 (0.003) [0.005] {0.005}	0.023 (0.003) [0.005] {0.005}
log(Production)	-0.053 (0.011) [0.014] {0.015}	-0.056 (0.011) [0.015] {0.017}	–	–	–
$\log(\text{Production}_{-1})$	–	–	-0.037 (0.011) [0.016] {0.017}	–	–
log(Production)×Region				✓	
$\log(\text{Production}_{-1})$×Region					✓
Region×Year FE		✓	✓	✓	✓
Observations	4,572	4,572	4,483	4,572	4,483

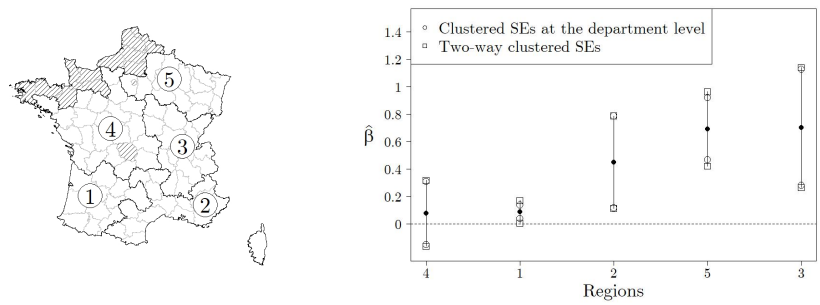
Note: All regressions include year FE. Standard errors: () Conley; [] department-clustered; {} two-way. The panel includes all departments for which price data is available for at least half of the sample years.

E.2. Heterogeneity across space

Given the diversity of wines across France's regions, one may expect that the effect of the reform on the wine price could differ geographically. Indeed, reputable regions differ in their propensity to produce red vs. white wines, still vs. sparkling wines, but also in the way that appellations themselves are organized, with many idiosyncratic factors like the use of *châteaux* to identify prestigious wines in Gironde, the widespread use of municipal appellations in Burgundy, etc.

In order to investigate heterogeneity in the effect of AOC recognition across regions, we estimate a variant of Equation (3) where we interact the AOC eligible share with regional dummy variables. In order to keep the model tractable and well identified under our rich set of geographically differentiated year effects, we choose to group regions according to geographical proximity. This leads us to defining five broad groups of regions, represented in panel (a) of Figure E.1. The spatial heterogeneity of the effect is represented in panel (b) of Figure E.1. Although all coefficients are

Figure E.1 Heterogeneity of the effect across space



(a) Region groupings (b) Estimated effects

Note: These estimates are obtained using the specification with Region×Year fixed effects and demand flexibilities with respect to contemporaneous production differentiated by region. The panel includes all departments for which price data is available for at least half of the sample years. The bounds of the intervals are +/- $\Phi^{-1}(0.975)$ times the chosen standard error of the estimate, with Φ being the cumulative distribution function of the standard normal.

positive, two out of five regions (regions 1 and 4) show small effects that are not always statistically significant, whereas the other three regions show large and significant effects, in excess of 45%.

E.3. Heterogeneity across eligibility layers

As mentioned in Section 1, in many wine regions the AOC system is highly hierarchical and recognizes, besides broadly defined regional or sub-regional appellations, the specificity of communal (municipal) or even sub-communal appellations with prestigious place names. In order to investigate whether recognition of sub-regional, communal or finer appellations commanded an additional premium relative to recognition of broad regional appellations like *bordeaux* or *bourgogne*, we run price regressions that include the share of a department's vineyard acreage eligible for at least k AOCs ($k > 1$), in addition to our main regressor.

Conceptually, it is not clear whether the official recognition of geographically limited and prestigious sub-appellations should influence the departmental wine price to the same extent as the recognition of broad regional appellations. On the one hand, prestigious place names may command a sizable price premium over broad regional appellations. On the other hand, narrowly defined vineyards may not have suffered as much from free-riding problems as larger appellations prior to the reform, as they involved fewer producers who may also have had more to lose from the erosion of the vineyard's reputation. In that respect, it is noteworthy that during the short period of time during which the "double appellation" regime was in effect, many broad regional appellations—unlike small, prestigious vineyards—did not gather enough

Table E.2 Heterogeneity across eligibility layers

	Dep. var.: log average real price of wine					
	(1)	(2)	(3)	(4)	(5)	(6)
AOC share: 1 layer	0.365 (0.055) [0.096] {0.106}	0.379 (0.055) [0.097] {0.106}	0.357 (0.053) [0.098] {0.107}	0.392 (0.046) [0.085] {0.093}	0.403 (0.046) [0.086] {0.093}	0.390 (0.045) [0.086] {0.093}
AOC share: 3 layers	0.214 (0.085) [0.206] {0.214}	0.201 (0.085) [0.204] {0.212}	0.230 (0.084) [0.209] {0.216}	–	–	–
AOC share: 5 layers	–	–	–	0.931 (0.313) [0.760] {0.785}	0.932 (0.316) [0.762] {0.787}	0.864 (0.306) [0.761] {0.784}
log(Production)×Region	✓			✓		
log(Production$_{-1}$)×Region		✓			✓	
Observations	4,483	4,572	4,572	4,483	4,572	4,572

Note: All regressions include region-by-year FE. Standard errors: () Conley; [] department-clustered; {} two-way. The panel includes all departments for which price data is available for at least half of the sample years.

support amongst their members to voluntarily eliminate plain appellation designations in favor of the exclusive use of the AOC (Humbert, 2011). This suggests significant heterogeneity in vineyard practices, and attendant wine quality, across producers claiming a broad regional appellation prior to the reform.

Indeed, Table E.2 shows that the estimate of the effect of multi-layer AOC recognition on the departmental wine price, although positive and sometimes large, is not statistically significant.

E.4. Linearity of the AOC eligibility effect

Our regression model in Equation (3) assumes a linear total effect of AOC eligibility on the log-price of wine. To test whether this linearity assumption is justified by the data, we estimate flexible models that nest the linear model and perform post-estimation specification tests of the linearity assumption. Specifically, we estimate a model where the eligible share enters quadratically on the right-hand side, and a model whereby we discretize the AOC share using three categories: $0 < s_{it} \leq 0.07$, $0.07 < s_{it} \leq 0.40$, and $0.40 < s_{it} \leq 1$. The cut-off points are chosen in order to ensure a balanced number of observations falling in each category. The categorical model estimates coefficients on dummy variables for each category. For the quadratic model, the linearity test is simply the t-test on the quadratic coefficient. For the model with

Table E.3 Tests of the linearity assumption

	Dep. var.: log average real price of wine							
	quadratic				categorical			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
AOC share (β_1)	0.123 (0.113) [0.295] {0.305}	0.085 (0.113) [0.297] {0.306}	0.203 (0.118) [0.285] {0.296}	0.129 (0.118) [0.293] {0.303}	–	–	–	–
(AOC share)^2 (β_2)	0.348 (0.132) [0.335] {0.349}	0.380 (0.133) [0.336] {0.350}	0.253 (0.137) [0.330] {0.346}	0.326 (0.137) [0.335] {0.350}	–	–	–	–
$I_{0<s\leq 0.07}$ (β_1)	–	–	–	–	0.025 (0.021) [0.060] {0.061}	0.028 (0.021) [0.060] {0.060}	0.040 (0.021) [0.059] {0.059}	0.038 (0.022) [0.058] {0.059}
$I_{0.07<s\leq 0.40}$ (β_2)	–	–	–	–	0.147 (0.031) [0.050] {0.053}	0.140 (0.030) [0.050] {0.053}	0.168 (0.032) [0.049] {0.052}	0.152 (0.032) [0.049] {0.052}
$I_{0.40<s\leq 1}$ (β_3)	–	–	–	–	0.263 (0.036) [0.083] {0.087}	0.256 (0.036) [0.084] {0.088}	0.278 (0.037) [0.080] {0.084}	0.265 (0.037) [0.081] {0.086}
log(Prod)	✓				✓			
log(Prod$_{-1}$)		✓				✓		
log(Prod)×Region			✓				✓	
log(Prod$_{-1}$)×Region				✓				✓
Joint significance test: $\beta_1 = \beta_2 = 0$	27.564	26.615	26.208	25.395	–	–	–	–
Linearity test: $\frac{\beta_1}{\mu_1} = \frac{\beta_2}{\mu_2} = \frac{\beta_3}{\mu_3}$	–	–	–	–	2.55	2.22	4.51	3.25
Observations	4,572	4,483	4,572	4,483	4,572	4,483	4,572	4,483

Note: All regressions include region-by-year FE. Standard errors: () Conley; [] department-clustered; {} two-way. The panel includes all departments for which price data is available for at least half of the sample years. The Wald test of linearity in the categorical model uses the mean AOC shares across observations within each category (μ_i). The two specification tests use the department-clustered covariance matrix. The critical value for both tests is $\chi^2_{95\%}(2) = 5.991$.

categorical share variables, the linearity test is a set of linear restrictions involving the mean shares within each category. We report tests statistics constructed using the department-clustered variance-covariance matrix.

Table E.3 shows that the linearity assumption cannot be rejected at standard levels of statistical significance for most specifications, the exception being the test based on a quadratic model using the less conservative spatial-robust standard errors that ignore serial correlation.

Appendix F: Appellation labels pre- and post-reform

Figure F.1 Labels of "Château Latour"

Figure F.1 depicts wine labels of "Château Latour," a famous *pauillac*, for 1934 and 1940 vintages. The AOC is mentioned at the very bottom of the label on the 1940 label.

Figure F.2 Labels of *romanée conti*

Figure F.2 depicts wine labels of *romanée conti*, for 1922 and 1943 vintages. The AOC is mentioned in green on the 1943 label. The label further mentions that the wine was produced from the original French vine. This vine was uprooted in 1945 and replanted with a vine grafted on American rootstock to resist phylloxera.

Figure F.3 Labels of "Château Pavie"

Figure F.3 depicts wine labels of "Château Pavie," a famous *saint émilion*, for 1929 and 1955 vintages. The AOC is mentioned above the depiction of the estate on the 1955 label.